

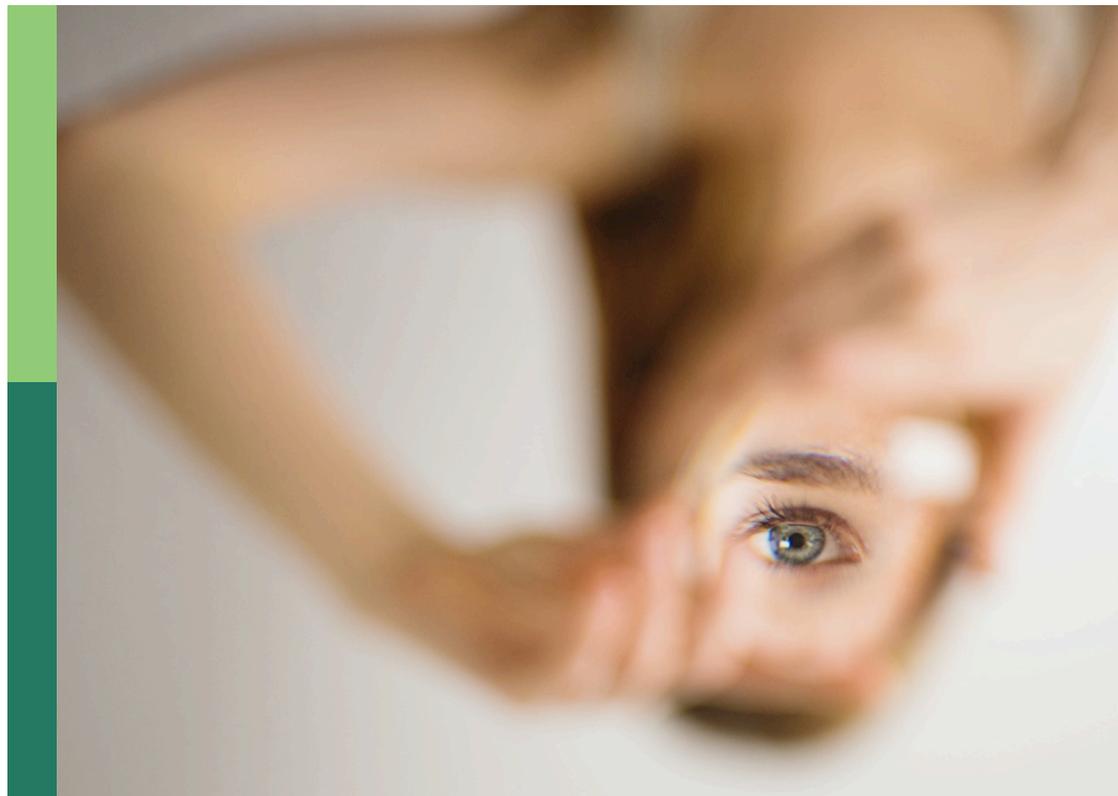
Corporate behaviour and sustainable development

Edited by

Haiyue Liu, Xiaoyu Wang, Yuli Shan, Shiyang Hu and Rui Xue

Published in

Frontiers in Psychology



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ISSN 1664-8714
ISBN 978-2-8325-2056-7
DOI 10.3389/978-2-8325-2056-7

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Corporate behaviour and sustainable development

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Citation

Liu, H., Wang, X., Shan, Y., Hu, S., Xue, R., eds. (2023). *Corporate behaviour and sustainable development*. Lausanne: Frontiers Media SA.

doi: 10.3389/978-2-8325-2056-7

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Sustainable Export Innovation Behavior of Firms Under Fiscal Incentive

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OPEN ACCESS

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 02 September 2021

Accepted: 27 September 2021

Published: 04 November 2021

Citation:

Feng C, Shi B, Yan H, Yang S and
Bai C (2021) Sustainable Export
Innovation Behavior of Firms Under
Fiscal Incentive.
Front. Psychol. 12:769795.
doi: 10.3389/fpsyg.2021.769795

The fiscal imbalance between the central and local governments under fiscal centralization may motivate local governments to pass tax burdens on firms. The causal identification of the tax system reform and the sustainable export innovation behavior of firms are of great significance. This study uses the income tax sharing policy of China to examine the impact of fiscal centralization on the sustainable export innovation behavior of firms. We find that this tax reform has significantly inhibited the increase of the export value-added rate of firms, and has an increasing trend with the share ratio between the Central Government and the local government. Moreover, this effect mainly comes from the crowding-out effect of imported intermediate goods on domestic intermediate goods. The tests show that the above conclusions are consistent with the general logic of local governments. When they face greater downward fiscal pressure, they will further pass the tax burden on local firms and force the firms to promote their export performance to expand the tax base. This short-sighted behavior of replacing “quality improvement” with “quantity increase” is an important factor that affects the sustainable export innovation behavior of firms and the climb in the global value chain.

Keywords: fiscal centralization, sustainable export innovation behavior, income tax sharing reform, China, firm

INTRODUCTION

The sustainable development of firms has always been an important topic, both in theoretical research and firm practice. In particular, the government plays a crucial role. How do the macro policies (i.e., fiscal policies) of a government affect sustainable innovation behavior in exporting firms? In the past decades, China has increasingly participated in the global value chain and become an important manufacturing center and export platform in global production networks. As the largest exporter in the world, China has gained its reputation as a “world factory.” However, China has long been locked into an inherent label of low domestic value-added rate (DVAR) in exports, “made in China” rather than “created in China” in the international market. In the context of current global market consolidation and international trade frictions, the discussion on how to improve the sustainable export innovation behavior of Chinese firms is of great importance. Since the 1990s, the international division of labor has undergone important changes. Specifically, the transfer of processing mode from the inter-industry to intra-industry division of labor has gradually become the mainstream mode of international production and trade development. With the deepening of the international division of labor, the production value-added links of firms

(including design, R and D, manufacturing, assembly, and marketing, etc.) and the rise of global value chains have gradually become important targets of widespread attention by researchers in the industrial sector and academia (Mao and Xu, 2018). At present, most of the literature uses DVAR to represent the degree of sustainable development of domestic export products and reflect the sustainable export innovation ability in the global value chain (Koopman et al., 2012; Upward et al., 2013). For firms, the improvement of DVAR is conducive to obtaining more real trade gains, and it is also an important part of the sustainable innovation behavior of a firm. Therefore, the study on the DVAR of export firms is of great theoretical value and practical significance to understand the sustainable export innovation behavior of firms.

Since the financial crisis broke out in 2008, fiscal centralization has been a common trend across different countries in the world. The reform of income tax revenue sharing in China provides an opportunity for us to explore the impact of fiscal centralization on the sustainable export innovation behavior of firms. The implementation of a scheme on the reform of income tax revenue sharing on January 1, 2002 by the Chinese government is a typical manifestation of centralization of central fiscal. In this reform, firm income taxes shifted from local taxes to the taxes shared by the central and local governments. The proportion of revenues of local governments in the collection of income tax revenues dropped sharply from 50 to 100%, and further dropped to 40% in 2003. It can be seen that tax reforms are important measures in the history of taxation. However, what surprised us is that the existing research pays little attention to this fiscal centralization, and the only research focuses on corporate tax evasion (Fan and Tian, 2013; Tian and Fan, 2016), local tax transfer (Han and Kung, 2015), average labor added value (Li et al., 2018), and firm productivity (Cai et al., 2018), etc.

In this study, this reform is used as a quasi-natural experiment to make a causal inference between fiscal centralization and the DVAR of firms. It is found that for those firms affected by the reform in the “intervention group,” their DVAR decreased significantly after tax sharing, compared with the export firms in the “control group” that pay income tax to the state taxation bureau. The above results are still valid after a set of robustness tests and the consideration of macroeconomic environment. Additionally, by analyzing the influence mechanism, we find that the real cause of the decline in DVAR is not related to the variation of cost markup rate, but mainly the crowding-out effect of the intermediate goods trade under fiscal centralization. However, such a crowding-out effect has a greater impact on processing trade firms that have greater elasticity to the price of intermediate goods but has an insignificant impact on the general trade firms and mixed trade firms that have relatively small elasticity. Additionally, for the local governments, in order to improve their own tax revenue under great fiscal pressure, they will put forward requirements for the export performance of firms under their jurisdiction. At the expense of the decline in DVAR and export investment of local firms, industrial output and total export volume will be promoted. Such a policy guidance mode of “quality” for “quantity” will have a negative impact on

the long-term sustainable development and export innovation behavior of firms.

The marginal contribution of this study may be reflected in the following: first, the intentional consequences and related impacts of fiscal and tax centralization are still inconclusive in academia. This study focuses on micro firm data to explore the effect of fiscal policy on the sustainable innovation behavior of firm export, providing a clear explanation and mechanism analysis to some certain extent. Second, the implementation of fiscal policies tends to be highly endogenous, and the analysis of the economic effects of macro tax rate fluctuations is inevitably influenced by the bias of unobvious omitted variables (Romer and Romer, 2010; Han and Kung, 2015; Li et al., 2018). Based on the exogenous shock of the reform, we construct a difference-in-difference (DID) model using the difference in ownership when export firms are paying taxes. The causal mechanism is identified by the different times of establishment of firms, so as to obtain the “net effect” of fiscal policy more accurately. Third, due to data limitation, previous empirical studies on the sustainable export behavior of Chinese micro firms often combine customs data with the China industry business performance data from 2000 to 2007 (Upward et al., 2013; Zhang et al., 2013; Kee and Tang, 2016; Mao and Xu, 2018). However, at the beginning of the new century, international and domestic economic and political policies changed frequently, many major policies and macro environments, such as the accession of China to the World Trade Organization (WTO), reform in value-added tax (VAT), changes in export tax rebate regulations, and the economic cycle may have an influence on the empirical results. These factors have not been fully considered in the previous study. Therefore, in this study, a set of robustness tests is used to check the potential factors that may cause estimation errors one by one to make a solid confirmation of the final results.

The rest of this article is organized as follows: Section Policy Background and Theoretical Hypothesis introduces policy background and theoretical hypothesis. Section Model Setting, Indicator Calculation, and Data Sources presents the models, indicator calculation, and data. Section Empirical Results and Analysis discusses the results of the empirical and robustness tests. Section Influencing Mechanism explores the mechanism of influence. The last section draws the Conclusions.

POLICY BACKGROUND AND THEORETICAL HYPOTHESIS

Policy Background

Fiscal and tax policies are important measures taken by the government to implement national governance and optimize resource allocation, which is essentially a special distribution relationship formed by the state in participating distribution and redistribution of national income, so as to realize its functions. Because of financial difficulties and planned economy, the financial budget management system was dominated by centralized arrangements for revenue and expenditure. However, it has strictly restricted the independent right of local taxation. After the reform and opening up, in order to

promote the coordinated development of the central and local governments and achieve the core goal of economic growth, the Fiscal Responsibility System came into being. Compared with the previous situation where local governments had no tax autonomy, under the Fiscal Responsibility System, local governments pay a fixed amount of fiscal revenue to the central government and have the right to make budgets and claim the surplus from their autonomous tax revenue (Chen and Gao, 2012; Tian and Fan, 2016). The excessive tax revenue is completely controlled by the local government, which greatly improves the decentralization and autonomy of local tax management. It is not only conducive to the improvement of the tax efforts by local government but also provides incentives for the growth of the tax revenue within the budget. However, such tax incentive can easily lead to the moral hazard of local governments. Hiding the tax sources, reducing the proportion of central tax sharing, and seeking subsidies with low tax declaration will be the “rational” choice of local governments under this system.

Under the pressure of the fiscal crisis, the central government launched the tax-sharing reform at the beginning of 1994. This reform aimed to re-establish the economic management power of the central government over important taxation areas (Zhang, 2008; Chen and Gao, 2012). In this case, the trend of fiscal centralization gradually emerged. On the one hand, the central government has clearly defined the boundaries among the revenue of central tax, local tax, and shared tax. On the other hand, the central government has also begun to tighten its grip on local taxes and shared taxes. In this context, the reform of income tax revenue sharing came into being.

On December 31, 2001, the State Council issued the *Circular of the State Council on Distributing the Scheme on the Reform of Income Tax Revenue Sharing* (No. 37 [2001] of the State Council), which decided to implement the reform in the sharing of revenue from income tax from January 1, 2002 and also regulated the proportion for the central and local governments to share the revenue from income tax. In accordance with the provisions of the *Circular*, the income tax payments of railway transport firms, state-owned post firms, Industrial and Commercial Bank of China Limited, Agricultural Bank of China, Bank of China Ltd., China Construction Bank Corporation, China Development Bank, Agricultural Development Bank of China, Export-Import Bank of China, and China Petroleum and Chemical Corporation, as well as offshore oil and natural gas firms continue to be the revenue of the central government. Other firm income tax and individual income tax are shared by the central and local governments in proportion. Since 2002, the proportion to share revenue from income taxes shall be 50% for the central government and 50% for the local government. Since 2003, the proportion to share revenue from income taxes shall be 60% for the central government and 40% for the local government.

In addition, in order to prevent the dislocation of tax collection and management, after the launch of the reform, the scope of firm income tax collected and managed by the state and local administration of taxation and shall not be changed before 2002. It can be seen that this system is an important measure for the reform of fiscal and tax relations

between the central and local governments. The income tax of newly registered firms and institutions will be collected uniformly by the State Administration of Taxation since the implementation of the reform. The implementation of this reform provides the conditions for us to construct a DID model. In accordance with the *Circular*, firms that are not the Chinese central state-owned established after 2002 shall pay income tax to the Local Administration of Taxation instead of the State Administration of Taxation. However, the income tax of Chinese central state-owned firms and foreign-funded firms continues to be paid to the State Administration of Taxation, which is not influenced by the reform. This means that firms of the same type need to face completely different tax collection administrations because of differences in establishment time. Especially for old firms established before 2002, although the tax collection administration has not changed, the decline in the tax share ratio may also cause them to face completely different taxation efforts before and after the reform. Therefore, we can regard the Chinese central state-owned firms and foreign-funded firms whose income taxation are collected by the State Administration of Taxation as the control group, and the other types of firms established before 2002 as the intervention group (Tian and Fan, 2016), so as to employ the DID method to estimate the impact of the reform of income tax revenue sharing on the DVAR of export firms.

Theoretical Hypothesis

Under the reform of income tax revenue sharing, the grabbing hand of the central government is likely to cause the moral hazard of the local government while dividing and sharing the local taxes, which will have an important impact on the behavior of local firms. The logic behind it is as follows: first, tax sharing will cause the effect of tax burden shifting to local firms. The grip of the central government on local government tax revenue will not only reduce local fiscal revenue but also urge it to exert efforts on local economic performance to make up for the loss. As the main participants in the market, firms are the only choice to afford the tax burden. Han and Kung (2015) find that the reform of income tax revenue sharing will induce local governments to vigorously develop real estate, commerce, and industrial undertakings to make up for the fiscal deficit caused by the decrease in income tax. Second, tax sharing will encourage firms to evade taxes, which is because of the decline in tax law enforcement and tax collection efforts of local governments in attracting investment (Fan and Tian, 2013; Tian and Fan, 2016). To attract the inflow of firm liquidity elements and compete for the income tax base, local governments will have the incentive to reduce the intensity of tax collection and management and help firms to evade tax in the competition of tax sources. Meanwhile, evading tax will significantly reduce the effective tax rate to be paid by firms (Li et al., 2018) as well as corresponding costs and capital constraints of firms (Cai et al., 2018). Therefore, in the dual roles of being “squeezed” and “flattered,” firms enjoy the bonus of reducing cost brought by lightening the tax burden on the one hand, and on the other hand, they have to undertake more responsibilities of production and transformation. We assume that it is the two-way

distortion of firm behavior that has a significant impact on its DVAR and, thus, sustainable export innovation behavior.

When the cost of production and operation of a firm is reduced, its export advantages are highlighted. Lowering the entry barrier to the foreign trade market provides an additional profit space for more firms to participate in the market, so firms with lower productivity can also participate in exporting. In this way, the average productivity of exporting firms will decrease (Yu and Cui, 2018), while the relative competitiveness of incumbent firms will be improved. The increase in the cost markup rate of firms will thus further promote the export value-added rate (Berman et al., 2012). However, compared with domestic-sale firms, export firms whose main business is the export of products and services will undertake more responsibilities to promote export performance after local tax sharing. The two incentives, namely the downward pressure on local fiscal deficit and the increase in profit margin, will further encourage the firms to increase the export and investment demand for intermediate goods. Compared with the constant price of imported intermediate goods, the increase in demand for intermediate goods will inevitably generate an incentive to raise their price. Therefore, the relative price of imported intermediate products will be reduced. Imported intermediate goods, thus, have a crowding-out effect on the market input of domestic intermediate goods, which will further inhibit the increase in the DVAR of firms.

Overall, on the one hand, the DVAR of firms will rise because of the cost markup effect when the central government participates in tax sharing. On the other hand, it will reduce because of the crowding-out effect of intermediate goods. Then, what is the overall effect of the fiscal centralization on the DVAR of firms? We will perform an empirical analysis to investigate the question. Additionally, empirical tests are carried out to examine the two influencing mechanisms.

MODEL SETTING, INDICATOR CALCULATION, AND DATA SOURCES

Model Setting

To investigate the effect of tax sharing on the DVAR of firms, this study uses the tax reform by the central government for firms that are not Chinese central state-owned or foreign-funded in 2002 as a quasi-natural experiment, and uses the DID method to evaluate the causal effect between tax sharing and DVAR of firms. We obtain the “net effect” by comparing the change in the DVAR of different firms before and after the tax sharing reform. Therefore, the following model is established:

$$DVAR_{it} = \alpha + \beta Share_i \times Post_t + \sum Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

where $DVAR_{it}$ represents the export value added-rate of the firm I in the year t ; $Share_i$ represents the firm affected by the tax sharing reform. If a firm is non-state-owned and non-foreign established before 2002, the value of this indicator is 1, otherwise, the value is 0; $Post_t$ is the time dummy variable of tax sharing reform, which is

1 after 2002 and 0 before 2002; $Control$ represents a set of control variables that affect the export value-added rate of the firm; μ_i and δ_t is the firm fixed effect and the year fixed effect respectively; ε_{it} is a random error term. β is used to measure the effect of tax sharing on the DVAR of firms. If $\beta < 0$, it means that tax sharing reduces the DVAR of firms; otherwise, it increases the DVAR of firms. In addition, the standard errors are basically clustered at the firm level.

Of course, model (1) only estimates the average treatment effect of tax sharing reform on the DVAR. In fact, considering the lag of policy implementation, information transmission and firm strategy adjustment, and other factors, tax sharing is not certainly effective in the current period, and the effect of the reform may be delayed and long-term. Based on the above reasons, this study extends model (1) and establishes a dynamic effect model as follows:

$$DVAR_{it} = \theta + \sum_{\tau \in \{2002, 2003, \dots, 2006\}} \theta_{\tau} Share_i \times Post_{\tau} + \sum Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

where $Post_{\tau}$ represents the year dummy variable of τ years after tax sharing reform implementation (where $\tau \in \{2002, 2003, \dots, 2006\}$). θ_{τ} measures the dynamic effect of tax sharing on the DVAR of firms. The description of other variables is the same as the model (1).

Calculation of DAVR of Firms

For the calculation of added-value rate, Hummels et al. (2001) first proposed the Hummels-Ishii-Yi (HIY) method to calculate foreign value-added ratio (FVAR). With the further expansion of research, scholars began to pay more attention to the domestic value-added ratio (DVAR). According to different measurement objects, the methods can be divided into macro-level and micro-level measurement methods. At the macro level, the input-output table is used to calculate the DVAR. The biggest advantage of this method is that it does not need to assume the share of foreign materials in domestic raw materials in advance, and that imported intermediate goods can also include service input. At the micro level, the temporal trend of DVAR can be investigated more comprehensively by this calculation method, which can deepen the analysis of the heterogeneity of firms. Considering the micro-level measurement method can better investigate the impact of exogenous factors on DVAR (Zhang et al., 2013), the wide existence of firm heterogeneity (Melitz, 2003), and for the content of this study, the micro-level measurement method is adopted to measure the DVAR of firms.

Following Upward et al. (2013), Zhang et al. (2013), and Kee and Tang (2016), this study uses the China Industry Business Performance Database and China Customs Trade database to calculate the DVAR of firms, which can be expressed as follows:

$$DVAR_{ijt} = (EX_{ijt}^O + EX_{ijt}^P) - \left(\frac{EX_{ijt}^O + EX_{ijt}^P}{Y_{ijt}} \right) \times (IM_{ijt}^{IO} + IM_{ijt}^{IP}) \quad (3)$$

where i , j , and t represent firm, industry, and time, respectively. EX_{ijt}^O and EX_{ijt}^P represent the general export and the processed

export, respectively. $EX_{ijt}^O + EX_{ijt}^P$ represents the total export of the firm, which can be obtained from the customs trade database. IM_{ijt}^{IO} and IM_{ijt}^{IP} represent the general import of intermediate goods and the processed import of intermediate goods, respectively. $IM_{ijt}^{IO} + IM_{ijt}^{IP}$ measures the total import of intermediate goods by the firms. Y_{ijt} is the output of firms, which is measured by the gross value of industrial output by the firms. It can be obtained directly from the China Industry Business Performance Database.

The current problem is how to obtain the total import of intermediate goods by firms. Since the indicator cannot be obtained directly, it needs to be obtained indirectly. In order to obtain it more accurately, this study explains the relevant problems in the process of treatment: (1) in the sample period, since most Chinese firms rely on the intermediate merchants to import and export, it is necessary to identify the trade intermediaries. Following the previous method, firms whose names include “economy and trade,” “science and trade,” “import and export,” “foreign trade,” and “trade” in the China Custom trade database are defined as trade intermediaries in this study, and the actual import of intermediate goods is adjusted (Ahn et al., 2011); (2) match the BEC product code of the United Nations and product classification code of China customs to identify the intermediate goods, capital goods, and consumption goods included in the imported goods; (3) the foreign content share that Chinese firms use in the input of their domestic intermediate goods is around 5–10% (Koopman et al., 2012). According to the previous research, we assume that the foreign content share in domestic raw material is 5%¹; (4) the existence of trade agents makes firms over import, so the observed value of over import phenomenon is eliminated in this study². Similarly, each index has been Winsorized at the 1% level.

After the above preliminary treatments, and combined with the difference in the mode of intra-firm trade, the calculation formula of DVAR can be further expressed as follows:

$$DVAR_{ijt} = \begin{cases} 1 - \frac{IM_{ijt}^{R,O}|_{BEC} + IM_{ijt}^F}{Y_{ijt}}, & i \in O \\ 1 - \frac{IM_{ijt}^{R,P}|_{BEC} + IM_{ijt}^F}{Y_{ijt}}, & i \in P \\ \Theta_O \times (1 - \frac{IM_{ijt}^{R,O}|_{BEC} + IM_{ijt}^F}{Y_{ijt}}) + \Theta_P \times (1 - \frac{IM_{ijt}^{R,P}|_{BEC} + IM_{ijt}^F}{Y_{ijt}}), & i \in M \end{cases} \quad (4)$$

where O , P , and M represent general trading firms, pure processing trading firms, and mixed trading firms, respectively³. The same assumptions as the previous research are adopted: various raw materials used by firms to produce domestic sales

products and exported products are the same. $IM_{ijt}^{R,O}|_{BEC}$ represents the actual volume of intermediate goods imported by the general trading firm i at period t . $IM_{ijt}^{R,P}$ represents the actual volume of intermediate goods imported by the pure processing trading firm i at period t . IM_{ijt}^F represents the foreign content share in the domestic raw materials used by firm i in the period t . Θ_O and Θ_P represents the share of intermediate goods imported by mixed trading firms in the general trade and pure processing trade.

Selection of Control Variables

In addition to the core explanatory variable, there are many other factors that may influence the DVAR of firms. Therefore, following the relevant literature, this study selects the productivity, age, and market competition of firm as control variables to control the influence of relevant factors, so as to evaluate the net effect of tax sharing on the DVAR of firms. Specifically, the control variables are measured as follows:

(1) Firm age. It is represented by the logarithm of 1 plus the difference value between the year of the current year and the year when the firm started business. (2) Total firm profit. It is expressed by the logarithm of the total profit of firms (10,000 Yuan). (3) Firm scale. It is represented by the logarithm of the total assets of firms. (4) Firm capital intensity. It is measured by the ratio of net fixed assets to the average number of employees in the firm (logarithmic value). (5) Firm export capacity. It is represented by the logarithm of the total export volume of the firm. The more the total exports, the stronger the export capacity of firms, otherwise, the weaker the export capacity. (6) Firm productivity. There are several existing methods to calculate the productivity of firms, such as ordinary least squares (OLS) regression, fixed effects (FE) model, Olley-Pakes (OP) method, Levinsohn-Petrin (LP) method, and Generalized Method of Moments (GMM). Generally, there is a great controversy in calculating the productivity of micro firms with the OLS and FE methods, since they are not effective in solving endogenous bias. Following Yang (2015), the OP method overcomes the endogenous bias and selective bias, so it is used to calculate firm productivity in this study. (7) Weighted average import tariff of firm (*Tariff*). It is used to measure tariff level faced by firms when they import. The specific calculation method is as follows:

$$Tariff_{it} = \log\left(\frac{\sum_{n=1}^m AVERAGE\ Rate^{HS6} \times Value_{it}^{HS6,n}}{Total\ Value_{it}}\right) \quad (5)$$

where $Tariff_{it}$ represents the weighted average import tariff of the firm i in the year t . Assume that the firm i imports a total of m kinds of goods in the period t , $Average\ Rate^{HS6}$ represents the average import tariff of the goods under the first 6-digit HS code of the corresponding customs. $Value_{it}^{HS6,n}$ represents the value of the n -th kinds of goods under the first 6-digit HS code of the import of firms in the period t . $Total\ Value_{it}$ represents the total import of the firm i in the period t . The average import tariff rate of goods under the first 6-digit HS codes of the customs is obtained from the WTO website. However, since the data of the import tariff of China in 2000 is not published on the WTO website, and considering that China has not substantially

¹We assume that the foreign content share in domestic raw material is 10% in the following robustness tests.

²Over importing firms are defined as firms whose actual volume of imported intermediate goods is more than the sum volume of intermediate input.

³The mixed trade firm is a firm that carries out general trade and processing trade at the same time.

TABLE 1 | Descriptive statistics of variables.

Variable	Definition	Mean	Std. dev.	Min.	Max.
DVAR	Domestic value-added ratio	0.8026	0.1938	0.0041	0.9987
Share	Firm affected by the reform	0.2944	0.4558	0	1
Middle	Firm intermediate goods	6.8875	1.6913	1.9692	15.6950
Mkp	Domestic cost markup rate offirm	1.1927	0.0978	0.9041	2.3831
TFP	Firm productivity	6.5295	1.0037	2.6077	10.1619
HHI	Herfindahl-Hirschman index	0.0450	0.7986	0	68.5782
density	Firm capital intensity	0.9629	2.1146	0.0001	126.9433
Tariff	Weighted average import tariff offirm	3.6864	0.6581	0	5.5620
export	Firm export capacity	0.9986	1.6712	-9.2103	9.6291
age	Firmage	2.2981	0.4829	1.6094	4.0604
profit	Total profit offirm	5.3941	1.9796	-1.6094	14.4191
size	Firm scale	10.9179	1.4840	5.3279	18.7282
gdp	Logarithm of GDP	9.0612	0.7657	4.7690	10.1720
open	FDI/GDP	81.4248	63.2174	0.0066	222.3713
government	Government fiscal expenditure/GDP	0.1308	0.0530	0.0691	0.8507
financial	Total regional loans/GDP	0.7701	0.5611	0.0001	2.2522
urban	Total urban population/Total population	0.4952	0.1878	0.0045	0.8870
wage	Logarithm of total urban salary	9.7934	0.3396	8.7819	10.5996

reduced its import tariff from 1997 to 2000 (Yu, 2011), this study uses the arithmetic mean value of the tariff in 1996 and 1997 to measure the level of import tariff in 2000. (8) Herfindahl-Hirschman Index (HHI). This study uses the HHI of firms in the binary industry to measure the degree of market competition faced by firms. The specific measurement method is as follows:

$$HHI_{jt} = \sum_{i \in j} (scale_{it}/scale_{jt})^2 = \sum_{i \in j} (S_{it})^2 \quad (6)$$

where $scale_{it}$ is the scale of firm i in year t , which is measured by sales volume. $scale_{jt}$ is the scale of industry j in year t , which is measured by total sales volume of the industry. S_{it} is the market share of the firm i in the year t . The larger the index is, the higher the degree of market monopoly is; otherwise, the higher degree of market competition is. Meanwhile, we also select variables, such as regional gross domestic product (GDP), government fiscal expenditure, and urbanization level, to measure the main economic factors at the city level. The city factors are controlled below to prevent them from affecting the results of this article. Finally, by matching between major databases, a total of 56,153 firm-level observations are obtained. The descriptive statistics of the specific variables are shown in **Table 1**⁴.

Data Sources

Based on the data from China Industry Business Performance Database and China Customs Trade database from 2000 to 2006, this study mainly evaluates the impact of tax sharing on the DVAR of firms from the micro firm level. We match the data from the two databases in detail, taking the matched samples as the database of analysis. Of course, before matching, we treat the data as follows:

For the China Industry Business Performance Database, we make the following preliminary selections for the original data. The following samples are excluded: (1) non-operating firms; (2) negative or missing values of the variables (total assets of firms, net fixed assets, sales volume, total industrial output, and industrial added value) we used in the process of analyzing; (3) firms with an average number of employees <8; (4) firms that are not Chinese central state-owned and with a sales volume >5 million yuan; (5) firms with a profit margin lower than 0.1% or higher than 99%. In addition, according to Generally Accepted Accounting Principles (GAAP), the following samples are also excluded: (1) firms with current assets greater than total assets; (2) firms with fixed assets greater than total assets; (3) firms with net fixed assets greater than total assets; (4) firms with invalid establishment time; (5) firms with accumulated depreciation less than the depreciation. After the above preliminary treatment, the samples were *Winsorized* at the 1% level.

According to the issue to be studied in this article, we need to merge the treated data from the China Industry Business Performance Database and China Customs Trade database as much as possible. Following Yu (2015), the specific steps of merging the data mainly are as follows: the first step is to match the industry business performance data and customs data of the same year according to the name of firms; the second step is to match the unsuccessfully matched firm samples according to the post code and the last 7 digits of the phone number; the third step is to merge the two matched results. The samples after the above matching are the basis of the data of this study. Of course, in addition to the micro firm data, in order to make the analysis more detailed, the import tariff data of China from 1996 to 2006 is also used, which is obtained from the Tariff Download Facility Database of WTO. Meanwhile, the product and industry codes are used frequently in this study, so the classification by

⁴Table 1 only reports the descriptive statistics of the initial data.

TABLE 2 | Impact of tax sharing reform on the domestic value-added rate (DVAR) of firms.

	DVAR (1)	DVAR (2)	DVAR (3)	DVAR (4)	DVAR (5)	DVAR (6)	DVAR (7)	DVAR (8)
<i>Share</i> × <i>Post</i>	−0.0209*** (0.0023)	−0.0187*** (0.0023)	−0.0214*** (0.0025)	−0.0189*** (0.0024)				
<i>ShareRatio</i> × <i>Post</i>					−0.0050* (0.0026)	−0.0043* (0.0026)		
<i>Share</i> × <i>Post2002</i>							−0.0035 (0.0029)	−0.0026 (0.0029)
<i>Share</i> × <i>Post2003</i>							−0.0083*** (0.0029)	−0.0072** (0.0029)
<i>Share</i> × <i>Post2004</i>							−0.0119*** (0.0031)	−0.0090*** (0.0031)
<i>Share</i> × <i>Post2005</i>							−0.0333*** (0.0031)	−0.0314*** (0.0031)
<i>Share</i> × <i>Post2006</i>							−0.0490*** (0.0034)	−0.0454*** (0.0035)
<i>TFP</i>		0.0397*** (0.0017)		0.0399*** (0.0019)		0.0397*** (0.0017)		0.0396*** (0.0017)
<i>HHI</i>		−0.0001 (0.0014)		−0.0006 (0.0028)		−0.0002 (0.0014)		−0.0002 (0.0014)
<i>density</i>		−0.0010* (0.0006)		−0.0016** (0.0007)		−0.0010* (0.0006)		−0.0008 (0.0006)
<i>Tariff</i>		0.0060*** (0.0017)		0.0066*** (0.0018)		0.0061*** (0.0017)		0.0062*** (0.0017)
<i>export</i>		−0.0082*** (0.0011)		−0.0088*** (0.0013)		−0.0084*** (0.0011)		−0.0079*** (0.0011)
<i>age</i>		0.0091*** (0.0030)		0.0091*** (0.0030)		0.0117*** (0.0030)		0.0072** (0.0029)
<i>profit</i>		−0.0030*** (0.0007)		−0.0031*** (0.0008)		−0.0030*** (0.0007)		−0.0029*** (0.0007)
<i>size</i>		−0.0212*** (0.0024)		−0.0194*** (0.0025)		−0.0218*** (0.0024)		−0.0193*** (0.0024)
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
<i>N</i>	56,153	55,405	48,960	48,285	56,153	55,405	56,153	55,405
<i>F</i>	198.4556	131.2926	169.9500	113.9049	194.6765	129.3505	129.3115	106.3745
<i>R</i> ² -adj	0.0834	0.1132	0.0829	0.1124	0.0808	0.1112	0.0892	0.1185

(1) Clustering robust standard errors in parentheses; (2) ****p* < 0.01, ***p* < 0.05, and **p* < 0.1.

Broad Economic Categories (BEC) and Harmonized System (HS) customs code conversion table is selected, which is obtained from the United Nations website. In the section of robustness tests, different macro policies and economic factors are excluded. The relevant policies are from government documents, and the economic indicators are from *China Statistical Yearbook* (2000–2006).

EMPIRICAL RESULTS AND ANALYSIS

Impact of Tax Sharing on DVAR of Firms

This study mainly investigates the impact of the tax sharing reform implemented by the central government in 2002 on the DVAR of firms, which can be estimated by model (1). The specific results are shown in columns (1) and (2) in **Table 2**.

In column (1), only the impact of tax sharing on the DVAR of firms is investigated. The results show that the tax sharing reform has a negative effect on the DVAR, and preliminarily indicate that tax sharing is not conducive to improving the DVAR of firms. After controlling firm fixed effect, time fixed effect, and other related factors, the results are shown in column (2). The results show that after the control of other factors, tax sharing reduces the DVAR of firms, and that the effect is significant at the level of 1%. In addition, considering the particularity of Shanghai, it has been implementing tax sharing between the central and local governments for the non-central state-owned or non-foreign-funded firms. Therefore, the firms in Shanghai are not be influenced by the tax sharing reform in 2002, which causes the bias of the evaluation in this study. Considering this particularity, we exclude all the firms in Shanghai and re-estimate

the model (1). The results are shown in columns (3) and (4) in **Table 2**. It can be seen that the exclusion of firms in Shanghai does not influence the impact of tax sharing reform on the DVAR of firms. Additionally, compared with columns (1) and (2) in **Table 2**, the effect of tax sharing reform has enhanced, which indicates that the inclusion of firms in Shanghai leads to the underestimation of the effect of tax sharing reform on the DVAR of firms.

In order to further explain the impact of tax sharing degree on the DVAR of firms, this study constructs the variable *Share Ratio*, based on the process of tax sharing reform. Specifically, in 2002, the proportion to share revenue from income taxes was 50% for the central government and 50% for the local government. However, since 2003, it has been 60% for the central government and 40% for the local government. We use the regression of continuous DID method to estimate the effect of tax sharing degree on the DVAR of firms. The results are shown in columns (5) and (6) in **Table 2**. It can be seen that the increase of tax share proportion significantly reduces the DVAR of firms.

According to the results of columns (1)–(6) in **Table 2**, the tax sharing reform not only significantly reduces the DVAR of firms but also has a stronger hindering effect on the DVAR of firms with the deepening of the reform. With the increase of tax sharing ratio, the reform has a greater obstacle to the export value-added rate of firms. In addition, the tax sharing reform may have a long-term effect on the DVAR of firms, while the model (1) only evaluates the average effect of tax sharing on the DVAR of firms. To examine its long-term effect, we perform the regression in the model (2). The results are shown in columns (7) and (8) in **Table 2**. It can be seen that the effect of tax sharing reform on DVAR is not significant in the current period. However, as the reform goes on, the hindering effect of tax sharing reform on the DVAR of firms enhances. For the control variables, firm productivity is an important factor to promote DVAR. Higher productivity can enable firms to maintain a strong competitive advantage in the market and help firms increase DVAR. However, firm size has a negative effect on DVAR, and it is significant at the level of 1%, indicating that small-scale firms tend to have a higher DVAR. The possible reason is that large-scale firms rely too much on the input of imported intermediate goods.

Robustness Tests

The results in **Table 2** show that tax sharing not only reduces the DVAR of firms, but that the hindering effect also enhances with the deepening of reform. Additionally, with the increase of the tax sharing ratio, the hindering effect on DVAR also enhances. To guarantee the validity and robustness of the regression results, a set of robustness tests is carried out from the perspectives of policy shock interference, firm innovation, variable replacement, and counterfactual test. The specific tests are as follows:

(1) Controlling the interference of other policies:

This study mainly investigates the impact of tax sharing on the DVAR of firms during the period of 2000–2006. However, the implementation of other macro policies in this period may affect

the DVAR of firms, which influences the effect that we evaluate. To exclude the interference of relevant policies, this study focuses on the following policies:

- (i) The accession of China to the WTO in 2001. Considering that the accession of China to the WTO at the end of 2001 has a great impact on the trade development of China, this historical event not only accelerates trade liberalization and opening up but also promotes the active participation of China in the global trade division and sharing of trade gains. Therefore, the accession of China to the WTO has a potential impact on the change of the DVAR of firms. To exclude its influence, this study has done the following two treatments: first, according to the time of the accession of China to the WTO, a dummy variable (*wto*) is generated. When the value of the variable is 1, it means that China has joined the WTO after 2001. Otherwise, it means that China has not joined the WTO. Second, since the accession of China to the WTO has more impact on “general trade,” it is necessary to exclude “general trade” from samples to reduce the impact of joining WTO on the results of this study. The specific regression results are shown in columns (1) and (2) in **Table 3**. It can be seen that the tax sharing reform still has a significant hindering effect on DVAR after removing the interference of WTO, and the results have not changed significantly. Additionally, from column (1), it can be seen that the accession to the WTO also promotes the DVAR of firms, and that the effect is significant at the level of 1%.
- (ii) The reform of the exchange rate system of China in 2005. China carried out the reform of RMB exchange rate system in 2005, which made the RMB exchange rate to revalue. Considering the influence of exchange rate appreciation, this study excludes the samples of 2005 and subsequent years from the regression, and only the samples of 2000–2004 are regressed. In this way, the influence of exchange rate system reform will be effectively eliminated. The specific results are shown in column (3) of **Table 3**. It can be seen that the elimination of the influence of RMB exchange rate reform does not change the hindering effect of tax sharing on the DVAR of firms, which further indicates the robustness of the above results.
- (iii) Value added tax reform in Northeast China in 2004. In addition, China has also carried out VAT reform in Northeast China. The specific process of the reform is as follows: from July 1, 2004, VAT transformation was first carried out in the equipment manufacturing industry, petrochemical industry, and eight other industries in three northeastern provinces; from July 1, 2007, the pilot scope was expanded to eight major industries, such as power industry and extractive industry in 26 old industrial base cities in six provinces in central China; since January 1, 2009, VAT reform has been carried out in all regions and industries in China. In order to avoid the bias caused by the VAT reform on the results of this study, we exclude the samples from the three northeast provinces in the regression. The specific results are shown in the column (4)

TABLE 3 | Robustness tests.

	DVAR (1)	DVAR (2)	DVAR (3)	DVAR (4)	DVAR (5)	DVAR (6)	DVAR (7)	DVAR10 (8)	DVAR (9)	DVAR (10)	DVAR (11)	DVAR (12)
<i>Share</i> × <i>Post</i>	-0.0187*** (0.0023)	-0.0182*** (0.0029)	-0.0178*** (0.0027)	-0.0181*** (0.0023)	-0.0187*** (0.0023)	-0.0187*** (0.0023)	-0.0168*** (0.0031)	-0.0179*** (0.0022)	-0.0187*** (0.0023)	-0.0195*** (0.0024)		
<i>wto</i>	0.0822*** (0.0038)											
<i>Tax</i>					-0.0023 (0.0020)							
<i>Tax ratio</i>						-0.0246* (0.0146)						
<i>Innovation</i>									-0.0005 (0.0042)			
<i>random1</i>											-0.0008 (0.0012)	
<i>random2</i>												-0.0012 (0.0011)
Control variables	YES	YES	YES									
Time fixed effects	YES	YES	YES									
Firm fixed effects	YES	YES	YES									
<i>N</i>	55,405	41,492	31,379	53,087	55,405	55,405	34,298	55,403	55,405	49,913	55,405	55,405
<i>F</i>	131.2926	132.2873	65.0496	127.3256	123.2498	123.3331	76.1551	147.9288	123.0955	121.5373	129.4160	129.4396
<i>R</i> ² -adj	0.1132	0.1436	0.0783	0.1151	0.1133	0.1133	0.1121	0.1227	0.1132	0.1149	0.1111	0.1111

(1) Clustering robust standard errors in parentheses; (2) ****p* < 0.01 and **p* < 0.1.

of **Table 3**. With the elimination of the influence of VAT reform, tax sharing reform still significantly reduces the DVAR of firms.

(2) Export tax rebate:

In addition to the interference of macro policies, the implementation of the export tax rebate policy is also an important influencing factor that cannot be ignored. We eliminate this influencing factor by reviewing the policy documents in the period 2000–2006 about the export tax rebate, sorting out the tax rebate proportion regulated by different industries in different years, and using the change of the proportion to assign a value. Specifically, based on the above documents, this study processes the export tax rebate in the following three ways: First, generate a dummy variable *Tax* according to whether the industry carries out the export tax rebate reform. The value of this variable is 1, indicating that the industry has implemented export tax rebate, otherwise, it has not implemented export tax rebate; second, we assign a value to the industry according to the change in the proportion of export tax rebate, and generate variable *Tax ratio*, which represents the impact of export tax rebate on different industries. Third, all industries involved in the implementation of export tax rebate are excluded from the regression analysis to eliminate the interference of export tax rebate. The specific results are shown in columns (5)–(7) of **Table 3**. It can be seen that the regression coefficient has a little change compared with the results in column (2) of **Table 2**, which fully indicates

that export tax rebate does not influence the effect of tax sharing on DVAR.

(3) Taking an alternative of indicator:

It is assumed that the share of foreign materials in domestic raw materials is 5% when we calculate the DVAR of firms. However, according to the research of Koopman et al. (2012), processing trade firms in China make the largest share of domestic raw materials and foreign products reach about 10%. The different proportions of foreign products will affect the calculation of the export value-added rate of firms, which will further influence the results of this study. In view of this, if we recalculate the DVAR of firms with the share of foreign materials in domestic raw materials accounting for 10%, we can obtain *DVAR10*. Then, the model (1) is regressed with *DVAR10* as the dependent variable. The results are shown in column (8) of **Table 3**. The results show that the tax sharing reform reduces the DVAR of firms, and that the effect is significant at the 1% level, indicating that the change of the share of foreign materials in domestic raw materials in the process of calculating DVAR does not influence the results of this article.

(4) Firm innovation:

Considering that the innovative activities of firms potentially affect the DVAR of firms, the above analysis does not effectively control them, which may affect the results of the above analysis. Therefore, we attempt to quantify the innovation activities of firms and directly put them into the model (1) to effectively

control the influence of firm innovation. Based on the availability of data, this study uses the proportion of new product sales in total sales of firms (*Innovation*) to measure the innovation activities of firms. The specific results are shown in column (9) of **Table 3**. It can be seen from the results that after controlling the innovation activities of firms, the sign and significance of the regression coefficient of tax sharing on DVAR have not changed obviously, which indicates the robustness of the regression results.

(5) Excluding firms with age <6 years:

Moreover, the effect of tax sharing may have an impact on the establishment year and the strategic choice of tax avoidance, which may underestimate the effect of tax sharing on the DVAR of firms. To eliminate this influence, this study further excludes new firms established since the new century and firms with age <6 years. The results are shown in column (10) of **Table 3**. It is found that the tax sharing still significantly reduces DVAR after excluding the firms with age <6 years. The increase of the estimation coefficient indicates that the existence of new firms leads to the overestimation of the coefficient. However, in general, the exclusion of samples does not change the above conclusions, which show the validity of the results.

(6) Counterfactual tests:

Are the effects of tax sharing on the DVAR of firms affected by other random factors? To answer the question, this study performs regional counterfactual tests to exclude other influences. We examine the whole sample and the sample from the eastern region. We randomly select half of the firms in each group as the hypothetical intervention group for the tax sharing reform, and the other samples belong to the control group. We use the DID method to evaluate the effect of the hypothesis. If the effect is the same significant real effect, it indicates that there are still interferences from other factors. Otherwise, the effect is entirely from the tax sharing reform. The specific results are shown in columns (11) and (12) of **Table 3**. Column (11) reports the regression results of the intervention group randomly selected from the eastern region sample, and column (12) reports the regression results of the intervention group randomly selected in the overall sample. It can be seen that the same significant effect is not obtained, which indicates that there is no other random factor affecting the results. It further proves that the hindering effect on DVAR is not caused by other factors, but by the tax sharing reform.

(7) Sample selection bias due to ownership:

In the DID analysis, the sample of the intervention group is basically composed of local private firms, while the sample of the control group is mostly central firms and foreign-funded firms. Therefore, in addition to the above-mentioned factors that may cause evaluation bias, the differences in firm ownership and confounding factors caused by the differences, such as the higher level of technology owned by foreign-funded firms and the unequal status of state-owned firms and private firms in the domestic factor market, may also affect DVAR and the evaluation results. In view of this, this study tries to eliminate

these factors, and the following three treatments have been done: first, we generate dummy variables for foreign-funded (*foreign*) and state-owned firms (*state*) according to the nature of the firm, and test whether the nature will affect DVAR. The results are shown in columns (1) and (2) of **Table 4**. The results show that the DVAR of foreign-funded firms is significantly higher than that of other types of firms; second, to further control it, we add dummy variables representing foreign-funded and state-owned firms in the model. The results are shown in columns (3) and (4) of **Table 4**, and we can see that the effective control of the nature of the firm has not changed the hindering effect of tax sharing on DVAR, and that the effect is still significant at the level of 1%; Third, we exclude state-owned firms and non-Hong Kong, Macao, and Taiwan foreign-invested firms to reduce the impact of firm nature on the control group. The results are shown in columns (5) and (6) of **Table 4**. It is found that the coefficients do not change significantly, which indicates that the nature of the firm does not change the results above. Finally, considering that the implementation of the Western Development Policy makes the tax borne by firms in the western region different from that in the eastern region, to eliminate the interference caused by tax incentives, we exclude the sample of firms in the western region. The results are shown in column (7). It can be seen that the elimination of the western samples does not change the conclusion that tax sharing significantly inhibits the DVAR of firms, which shows the robustness of the results in this study.

Investigation of Macro Factors

In addition to the above factors influencing the DVAR of firms, the change of macro factors in the region and industry where the firms belong may also have an impact on the DVAR. The investigation of this issue is the main task of this part. We will start from the following two aspects to conduct a detailed investigation of macro factors:

First, for the general quantifiable macroeconomic factors, they are measured with indicators in this study. The specific approach is to match the macroeconomic factors at the provincial level with the firm data, directly incorporate these factors into the model, and then effectively control them so as to eliminate the impact of macroeconomic factors on the export value-added rate of firms. Combined with the contents of this study, we measure the level of economic growth with the logarithm of regional GDP, the degree of regional openness with the proportion of total foreign direct investment to GDP, the scale of regional government with the proportion of fiscal expenditure to GDP, the degree of regional financial development with the proportion of total regional loans to GDP, and the level of urbanization with the proportion of urban population to total population, and the regional cost is represented by the logarithm of regional total wages. The specific regression results are shown in columns (1)–(6) of **Table 5**. It can be seen that there is still a hindering effect of tax sharing on the DVAR of firms after the effective control of macroeconomic factors. Additionally, the increase of regional cost will not be conducive to the increase of DVAR. The local economic growth can improve the DVAR of firms, but the effect is not significant.

Second, for the unobservable factors in the region where the firm is located and the industry it belongs to, this study controls

TABLE 4 | Firm ownership and sample selection bias.

	DVAR (1)	DVAR (2)	DVAR (3)	DVAR (4)	DVAR (5)	DVAR (6)	DVAR (7)
<i>Share</i> × <i>Post</i>			−0.0195*** (0.0030)	−0.0200*** (0.0025)	−0.0204*** (0.0025)	−0.0218*** (0.0028)	−0.0187*** (0.0024)
<i>foreign</i>	0.0109*** (0.0019)		−0.0011 (0.0025)				
<i>state</i>		0.0025 (0.0033)		−0.0084** (0.0036)			
Control variables	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES
<i>N</i>	55,405	55,405	55,405	55,405	53,298	39,864	53,977
<i>F</i>	129.9967	129.4526	123.1953	123.1693	129.5028	78.3598	130.5882
<i>R</i> ² -adj	0.1120	0.1111	0.1132	0.1133	0.1172	0.1048	0.1154

(1) Clustering robust standard errors in parentheses; (2) ****p* < 0.01 and ***p* < 0.05.

TABLE 5 | Investigation of macro factors.

	DVAR (1)	DVAR (2)	DVAR (3)	DVAR (4)	DVAR (5)	DVAR (6)	DVAR (7)	DVAR (8)	DVAR (9)	DVAR (10)
<i>Share</i> × <i>Post</i>	−0.0185*** −0.0023	−0.0150*** −0.0024	−0.0186*** −0.0023	−0.0186*** −0.0023	−0.0197*** −0.0024	−0.0176*** −0.0023	−0.0188*** −0.0023	−0.0173*** −0.0023	−0.0104*** −0.003	−0.0101*** −0.003
<i>gdp</i>	0.0341 (0.0213)									
<i>open</i>		−0.0003*** (0.0000)								
<i>government</i>			−0.4727*** (0.0893)							
<i>financial</i>				−0.0124 (0.0112)						
<i>urban</i>					0.0224 (0.0299)					
<i>wage</i>						−0.1337*** (0.0183)				
Industry fixed effects	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO
$\gamma \times t$	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO
$\gamma \times t^2$	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO
City fixed effects	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES
$\varphi \times t$	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
$\varphi \times t^2$	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
<i>N</i>	55,405	53,728	55,405	55,358	47,851	55,358	55,405	55,405	41,806	41,806
<i>F</i>	123.1556	118.4254	124.6107	123.0763	94.5	123.9925				
<i>R</i> ² -adj	0.1133	0.1155	0.1148	0.1133	0.1081	0.116	0.1139	0.1273	0.1378	0.1393

(1) Clustering robust standard errors in parentheses; (2) ****p* < 0.01; (3) control variables, time fixed effects, and firm fixed effects are added to the above regressions. Due to space limitations, they are not presented in the table here; (4) since there may be mobility among firms, we have joined the firm, industry and city FEs here at the same time.

these factors by incorporating regional fixed effects and industry fixed effects into the model, and considers the regional non-linear trends and industry non-linear trends. Another purpose of this approach is to test the parallel trend hypothesis required by the DID. This study takes the tax sharing reform that began in 2002 as the quasi-natural experiment, and the investigation period is limited to 2000–2006. Therefore, there is only the two-period data before the implementation of the tax sharing reform. The few years before the implementation of this policy makes it unable to a perform regression test on the parallel trend hypothesis. Therefore, following Moser and Voena (2012), the fixed effects of regions and industries and their non-linear trends are added to the model. The specific regression results are shown in columns (7)–(10) of **Table 5**. Columns (7) and (8) are mainly for the analysis of industry fixed effects and non-linear trends, while columns (9) and (10) are for the investigation of regional fixed effects and non-linear trends. The results show that after controlling the regional and industry effects and their non-linear trends the tax sharing reform reduces the DVAR of firms, and that the effect is still significant at the level of 1%. From the perspective of regression coefficients, there is no large fluctuation in the coefficients after controlling the industry. However, the control of regional fixed effects makes the evaluation coefficient fluctuate greatly. In general, the control of macro factors that are difficult to quantify in the regions and industries has not changed the hindering effect of tax sharing on the DVAR of firms. It also shows that the parallel trend assumption required by the DID method is satisfied in this study, which further proves the robustness of the conclusions of this paper.

INFLUENCING MECHANISM

In this section, we will focus on how fiscal centralization influences the DVAR of firms. Through the theoretical elaboration in the second section, it can be seen that there may be two types of potential paths for tax sharing to have an impact on the DVAR of firms. One is the role of the cost markup rate; the other is the change of the price of intermediate goods input. Therefore, we will try to analyze these two mechanisms and estimate their impact on DVAR.

Calculation of Cost Markup Rate

As the core of the mechanism analysis in this study, the calculation of the cost markup rate is another major task. According to the definition of the cost markup rate of the firm, it is necessary to know the price and marginal cost of the products of the firm in order to measure it. However, from the data used in this study, the China Industry Business Performance Database does not directly give product prices and marginal costs. In view of this, De Loecker and Warzynski (2012) use the cost minimization method and express the cost markup rate of the firm as the ratio of the output elasticity of the intermediate to the expenditure share of the element. The new method of calculating cost markup rate is specifically expressed as follows:

$$\mu_{it} = \theta_{it}^x (\alpha_{it}^x)^{-1} \quad (7)$$

where μ_{it} represents the cost markup rate, θ_{it}^x represents the output elasticity of intermediate input x , and α_{it}^x represents the ratio of intermediate input x to the expenditure.

For the calculation of the above formula, this study adopts the structural model by Xu and Li (2018) to deal with the unobservable productivity shocks and price factors, which will not require to consider the factors of demand structure. It can be seen from the China Industry Business Performance Database that the proportion of intermediate input expenditure can be obtained directly from the firm-level data. Therefore, the key to calculate the cost markup rate is the unbiased estimation of the output elasticity of the intermediate input, which needs the unobservable productivity shocks to be controlled. Therefore, this study uses the two-step method to make a robust estimation of the cost markup rate of the firm, and this method can deal with the endogenous problem of productivity. For the form of the production function, the translog production function is used here. The specific form is as follows:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_x x_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{xx} x_{it}^2 + \beta_{lk} l_{it} k_{it} + \beta_{kx} k_{it} x_{it} + \beta_{lx} l_{it} x_{it} + \beta_{lxx} l_{it} k_{it} x_{it} + \omega_{it} + \varepsilon_{it} \quad (8)$$

where y represents the total industrial output. k , l , and x represent the capital input, labor input, and intermediate input, respectively. All indicators are converted to constant price and logarithmic value. ω represents the heterogeneous productivity of the firm. ε is a random error term. The first step in the two-step method is to estimate the output y_{it} of the firm and obtain its unbiased estimation $\hat{\phi}_{it}$, and use a non-parametric method to obtain the random productivity shock $\hat{v}_{it}(\beta)$. According to the initial decision of firm capital k , and if the nature of labor l and intermediate input x are not related to the productivity of the lagging one-stage period, the following moment condition are obtained:

$$E \left[\hat{v}_{it}(\beta) (l_{i,t-1}, k_{it}, x_{i,t-1}, l_{i,t-1}^2, k_{it}^2, x_{i,t-1}^2, l_{i,t-1} k_{it}, k_{it} x_{i,t-1}, l_{i,t-1} x_{i,t-1}, l_{i,t-1} k_{it} x_{it})' \right] = 0 \quad (9)$$

For the above equation, this study uses the generalized moment estimation method to estimate all the parameters in the production function, and then obtain the output elasticity of the intermediate input of the firm $\hat{\beta}_x + 2\hat{\beta}_{xx} x_{it} + \hat{\beta}_{lx} l_{it} + \hat{\beta}_{kx} k_{it} + \hat{\beta}_{lxx} l_{it} k_{it}$. Finally, the estimation of cost markup rate $\hat{\mu}$ can be calculated.

Analysis of Influence Mechanism

If firms are faced with local partiality and tax competition under tax sharing, they will reduce production and operation costs to a large extent driven by tax evasion incentives. Therefore, under the circumstances of prominent export advantages, the export industry with excess profit attracts more firms to participate in, which will be reflected in the linear rise of cost markup rate (Berman et al., 2012; Yu and Cui, 2018). For individual firms, the cost markup rate reflects the ratio of total output to total investment. Under the condition that the output value remains unchanged in a short time, the reduction of input cost

will inevitably promote the increase of profit rate (Mao and Xu, 2018). With the increase of local tax sharing under fiscal centralization, the increase of the cost markup rate of private firms will lead to the corresponding increase of DVAR. However, the tax competition of local governments aims to attract firms to enter, improve business performance, and make up for the tax reduction deficit. Therefore, the export firms whose main business is the export of products and services will have to bear more export pressure and responsibility after local tax sharing. In this case, in order to achieve the economic performance set by the local government, the downstream producer will increase their export efforts, so as to increase the demand for intermediate goods in the market in a short time, and it will further raise the price of domestic intermediate goods. Compared with the constant price of imported intermediate goods, the increase of the price of domestic intermediate goods will reduce the relative price of imported intermediate goods. Furthermore, it has a crowding-out effect on the market input of domestic intermediate goods, which will inhibit the DVAR of firms.

To test whether the above two mechanisms hold or not, we choose the firm cost markup rate and the relative price of imported intermediate goods as intermediary variables and conduct an empirical test. The specific intermediary effect models are as follows:

$$\begin{aligned} Middle_{it} &= \theta_1 + \theta_2 Share_i \times Post_t + \sum Control_{it} + \mu_i + \delta_t \\ &+ \varepsilon_{it} \end{aligned} \quad (10)$$

$$\begin{aligned} Mkp_{it} &= \varphi_1 + \varphi_2 Share_i \times Post_t + \sum Control_{it} + \mu_i + \delta_t \\ &+ \varepsilon_{it} \end{aligned} \quad (11)$$

$$\begin{aligned} DVAR_{it} &= \phi_1 + \phi_2 Share_i \times Post_t + \eta Mkp_{it} + \sum Control_{it} \\ &+ \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \quad (12)$$

$$\begin{aligned} DVAR_{it} &= \gamma_1 + \gamma_2 share_i \times Post_t + \rho Middle_{it} + \sum Control_{it} \\ &+ \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \quad (13)$$

where $Middle_{it}$ represents the intermediate goods input in firm i in year t . Mkp_{it} represents the cost markup rate of firm i in year t . Models (10) and (11) mainly investigate the effect of tax sharing on the input of intermediate goods and cost markup rate of firms. While models (12) and (13) mainly analyze the effect of tax sharing on DVAR when the cost markup rate and relative price of imported intermediate goods are considered as intermediary variables.

Based on the above regression, the test results are shown in **Table 6**. Columns (1) and (2), respectively, regress the firm cost markup rate and the import intermediate goods input to the DVAR. The results show that they both have a significant effect on DVAR at the level of 1%, but that the effect is opposite. Then, we test the effect of tax sharing on foreign intermediate good input and firm cost markup rate in columns (3) and (5). It can be found that, as the theoretical analysis shows, on the one hand, the tax sharing reform improves the profit of firms,

thus promoting the cost markup rate. On the other hand, it also improves the market price of domestic intermediate goods and further increases the total amount of imported intermediate goods. Therefore, are these two mechanisms established? In column (4), the intermediary variable of imported intermediate good input is added. The result shows that this variable has a significant negative effect on the DVAR of firms in the regression model, indicating that the centralized tax reduces the relative price of imported intermediate goods, and that it has a significant crowding-out effect on domestic intermediate goods. Under the situation of domestic intermediate market declining, the DVAR of firms is also restrained, and this mechanism can be established. In terms of cost markup rate, it is added as an intermediary variable in column (6). The effect of cost markup rate on the DVAR is no longer significant, and the coefficient has a great change (from 0.0528 to -0.0312), indicating the mechanism that cost markup rate effect in tax sharing has a significant effect on the DVAR is not established. Therefore, this mechanism cannot be used as the real logic of the centralized tax system to improve DVAR.

The above mechanism analysis provides further evidence for the results of this study. In the theoretical analysis, on the one hand, we think that the cost markup effect can improve DVAR. On the other hand, we think that the crowding-out effect of intermediate goods can inhibit the increase of VAR. Through the mechanism tests, we find that the promotion effect is not significant, but that the hindering effect is significant, which further provides an empirical basis for the negative impact of fiscal centralization on DVAR.

CONCLUSIONS

Taking the implementation of income tax sharing reform in China in 2002 as a quasi-natural experiment, this study examines the effect of fiscal centralization on DVAR by the DID method. It is found that with the further tightening of the fiscal power of the central government, the grab for local income tax may significantly reduce DVAR. For local governments, the strategy to transfer the tax burden to local firms often works in the short term, but this strategy is not sustainable in a long-term development. This short-sighted behavior of replacing “quality improvement” with “quantity increase” is not conducive to the improvement of the export competitiveness and enhancement of sustainable export innovation behavior of firms, thus hindering the climbing of firms in the global value chain.

The above conclusions have very important policy implications for deepening the reform of the tax system and promoting the rise of the global value chain of export firms. Specifically: (1) reasonable sharing system arrangements and the standard behaviors of local governments are of great importance to cultivating a good export environment for firms. Therefore, it is necessary to continue to deepen the reform of income tax sharing and maximize the neutral principle and incentive effect of taxation, so as to provide necessary institutional advantages for promoting the DVAR of the export of Chinese firms and the construction of their own export

TABLE 6 | Influence mechanism tests.

	DVAR (1)	DVAR (2)	Middle (3)	DVAR (4)	Mkp (5)	DVAR (6)
Share×Post			0.0615*** (0.0132)	-0.0109*** (0.0017)	0.0081*** (0.0013)	-0.0103*** (0.0030)
Mkp	0.1751*** (0.0198)	0.0528*** (0.0193)				-0.0312 (0.0193)
Middle	-0.1150*** (0.0016)	-0.1385*** (0.0017)		-0.1270*** (0.0014)		
Control variables	No	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES
N	42,449	41,804	55,405	55,405	41,804	41,804
F	818.656	526.0692	294.9704	580.0916	643.7168	122.8412
R ² -adj	0.4383	0.5312	0.2291	0.5065	0.4609	0.137

(1) Clustering robust standard errors in parentheses; (2) ***p < 0.01.

competitiveness. (2) Since the competitive crowding-out effects of processing trade firms with different output elasticity of intermediate products are different, appropriate tax incentives or government subsidies can be given to firms according to the characteristics of different types of firms. This helps firms improve their ability to promote DVAR, strive for more trade benefits in export competition, and form an export competitive advantage, so as to achieve a high-end position in the global value chain.

DATA AVAILABILITY STATEMENT

The data used to support the findings of this study have not been made available due to the third party restrictions. Requests to access these datasets should be directed to <http://www.stats.gov.cn>.

AUTHOR CONTRIBUTIONS

CF, BS, and CB: conceptualization. CF and BS: methodology. CF, BS, and SY: data. CF, BS, and HY: writing and original draft

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preparation. CF, SY, and CB: writing, review, and editing. HY and SY: investigation. BS and SY: funding acquisition. All authors contributed to the article and approved the submitted version.

FUNDING

This study was supported by the Humanities and Social Science Fund of the Ministry of Education in China (Grant No: 20YJC790165), the National Social Science Foundation of China (Grant No: 20CGL005), China-Central Eastern European Countries Higher Joint Education Project (Grant No: 202028), and Shaanxi Provincial Natural Science Basic research program (Grant No: 2021JQ-457).

ACKNOWLEDGMENTS

We are grateful to Ziyang Fan, a professor at the Shanghai University of Finance and Economics, for his help with valuable suggestions. This study has benefited from comments from Yan Zhang, a scholar of the Northwest University.

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Is Cross-Shareholding Conducive to Corporate Sustainability? Evidence From the Environmental Investment of Chinese Listed Firms

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OPEN ACCESS

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Reviewed by:

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 05 October 2021

Accepted: 18 October 2021

Published: 05 November 2021

Citation:

Tian J, Cao W and Ji X (2021) Is
Cross-Shareholding Conducive
to Corporate Sustainability? Evidence
From the Environmental Investment
of Chinese Listed Firms.
Front. Psychol. 12:789811.
doi: 10.3389/fpsyg.2021.789811

This article examines the impact of cross-shareholding on corporate environmental investment (Env) using Chinese listed firms from 2014 to 2019 as the research setting. The results show that there is a positive impact of cross-shareholding on corporate environmental investment. The finding remains robust to a battery of robustness checks. In addition, the heterogeneity analysis illustrates that the positive impact of cross-shareholding on corporate environmental investment is more pronounced in state-owned firms and high-polluting industries when compared to non-state-owned firms and low-polluting industries, respectively. This study extends the research on cross-shareholding and provides practical implications for corporate sustainable development.

Keywords: cross-shareholding, environmental investment, corporate sustainable development, emerging market, China

INTRODUCTION

Inter-firm cross-shareholding is when two or more firms hold shares in each other's firms, entailing a binding of financial interests. Its main purposes are to reduce transaction risks (Williamson, 1979), resist hostile takeovers (Nyberg, 1995), and increase profits (Amundsen and Beergman, 2002). Cross-shareholding between firms can bring a range of synergistic benefits such as improving information advantages, facilitating inter-firm collaborations, and fulfilling financing demands (Uzzi, 1999; Rauch and Casella, 2003; Cohen et al., 2008).

Due to the increasing complexity and volatility of stock market, cross-shareholding has become a popular mode for listed companies in China to maintain their market competitiveness (Peng et al., 2019; Guo H. et al., 2021). The popularity of inter-firm cross-shareholding in China's capital market is further fueled by the country's vigorous shareholding reform, continuous stock market expansion, rising demand for capital operation, and the arbitrage motives of short-term capital flows (Peng et al., 2019).

Corporate environmental investment (Env) refers to companies' practices and initiatives to help protect the environment (Nakamura, 2011). Companies are the primary resource consumer and polluter (Tian et al., 2020), and as such, they are obliged to assume responsibilities for environmental governance (Wan et al., 2021). Environmental regulations, as a major part of China's green development efforts, have also compelled businesses to reduce the damage to the environment during their production process. Firms have an essential role in environmental protection, and corporate environmental investment is crucial to facilitating the green development of society (Li et al., 2021). Existing studies are concentrated around the impacts of policies and within-firm factors on corporate environmental investment (Saltari and Travaglini, 2011;

Wei and Zhou, 2020; Huang and Lei, 2021), the impacts of inter-firm factors are seldom investigated. Therefore, this article aims to examine the impact of cross-shareholding on corporate environmental investment.

Corporate strategy is one of the main internal factors affecting firms' environmental investment decisions (Wei and Zhou, 2020). Cross-shareholding strategy has the potential to make contributions to corporate healthy development (Liu et al., 2018); its relationship with corporate environmental investment is thus worth studying. This article selects Chinese listed firms as the research setting for the following reasons. First, China's carbon emissions per unit of GDP surpass the global average, and its carbon emissions in 2019 reached nearly 10 billion tons, ranking first in the world (The World Bank, 2016; BP, 2019). Second, since businesses are the main resource consumer and polluter, they are obliged to take environmental responsibility (Fan et al., 2021). Third, the strong emphasis on social relationships and networking in Chinese culture (Yan and Sun, 2021), as well as the weak regulation of cross-shareholding in Chinese corporate law, both contribute to the rising popularity of cross-shareholding among Chinese firms. However, there has been little research on the impact of cross-shareholding on corporate environmental investment.

Therefore, this article examines the impact of cross-shareholding on corporate environmental investment using Chinese listed companies as the research setting. The results indicate that cross-shareholding has a positive impact on corporate environmental investment. Further analysis shows a heterogeneous effect of corporate ownership structure and industry effect in the relationship between cross-shareholding and corporate environmental investment. The positive effect of cross-shareholding on corporate environmental investment is more pronounced in state-owned companies or firms in the heavily polluting industry. The results remain robust when using alternative measure of the cross-shareholding variable and using random sampling approach.

The remainder of the article is structured as follows. In section "Literature Review and Hypothesis Development," we review the prior research on cross-shareholding and environmental investment, and propose the hypotheses. Section "Research Design" describes the data and variables. In section "Results," regression analysis is conducted to examine the hypotheses, followed by heterogeneity analysis and robustness checks. Section "Conclusion" concludes the article.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Cross-Shareholding

Inter-firm cross-shareholding is the practice of two or more firms holding shares in each other's firms. Companies create business alliances through cross-shareholding, which helps them share resources, reduce production costs and expand production scale (Ranjan, 1998; Boyatzis et al., 2015), and improve financial performance and corporate governance (Farrell and Shapiro, 1988; Ranjan, 1998). Cross-shareholding is classified

into two types: one-way cross-shareholding and two-way cross-shareholding. The cross-shareholding models in China are predominantly one-way cross-shareholding (Guo H. et al., 2021); therefore, this article defines the concept of cross-shareholding using one-way cross-shareholding, i.e., firm A holds shares of firm B, but firm B is not required to hold shares of firm A at the same time (Flath, 1992).

Cross-shareholding is mainly used to reduce operation risks (Williamson, 1979), resist hostile takeovers (Nyberg, 1995), and increase financial returns (Amundsen and Beergman, 2002). The special inter-firm relationship of cross-shareholding can help overcome certain flaws of external mechanisms, which is critical to China's economic transformation (Peng et al., 2019; Bourgeois-Bougrine, 2020). Inter-firm cross-shareholding has become very popular in Chinese capital market due to China's active shareholding reform, continuous stock market expansion, rising demand for capital operations, and the arbitrage motivations of short-term capital flow (Peng et al., 2019). Another possible explanation for the rise of cross-shareholding in China is that the society places a high value on social relationships and networking (Xue et al., 2021), and so corporate finance happens to be highly dependent on social ties (Talavera et al., 2012; Su et al., 2020). Inter-firm cross-shareholding has a relatively strong synergistic effect among Chinese firms in terms of enhancing information advantages (Cohen et al., 2008), corporate cooperation (Uzzi, 1999), and financing capacity (Rauch and Casella, 2003).

Through cross-shareholding, listed firms can form a stable strategic alliance with equity ties (Gibb and Li, 2003), which allows them to share resources, reduce production costs and expand production scale, achieve economies of scale (Ranjan, 1998; Park and Luo, 2010) and improve corporate governance (Farrell and Shapiro, 1988; Ranjan, 1998), ultimately improving financial performance (Singh and Delios, 2017). At the same time, cross-shareholding can protect firms from hostile takeovers, reduce risks, and increase profits. Firms that cross-hold shares can not only earn dividends from equity, but also achieve higher financial performance as a result of industry chain integration and complementary advantages (Brooks et al., 2018).

Corporate Environmental Investment

Environmental investment refers to the total expenses related to environmental practices such as pollution control and environment improvement, which belong to a special type of corporate investment (Ehresman and Okereke, 2015). Environmental investment pursues economic, environmental, and social returns, but the latter two tend to outweigh the economic returns (Ehresman and Okereke, 2015). Environmental investments do not generate direct capital inflows, and they often require significant extra expenditure on environmental facilities and technologies, leaving firms with little incentives to practice (Orsato, 2006). Based on factor endowment hypothesis, corporate environmental investment decisions are the tradeoff between costs and returns (Leiter et al., 2011). Firms thus tend to lack motivations to make voluntary environmental investments. However, firms can benefit from investing in pro-environmental activities. On the one hand, higher environmental investment implies a reduction in the

cost of environmental compliance (Maxwell and Decker, 2006). On the other hand, firms enjoy better reputation by delivering a positive and environmentally friendly image to the public (Wei and Zhou, 2020).

Corporate environmental investment is susceptible to both external and internal factors. The external factors primarily include the degree of government intervention and institutional constraint, and regional economic development (Saltari and Travaglini, 2011; Ducassy and Montandrou, 2015; Huang and Lei, 2021). Internal factors are mainly corporate financial performance (Blanco et al., 2009) and internal governance (Wei and Zhou, 2020); for example, a healthy financial position makes it easy for businesses to make environmental investments (Blanco et al., 2009).

Hypothesis Development

Cross-shareholding is critical for improving corporate performance. Through cross-shareholding, a strategic alliance with equity ties can be formed between firms, which helps firms to reduce production costs and expand production scale through information sharing and technology complementation, thus achieving economies of scale (Ranjan, 1998) and higher financial performance (Nyberg, 1995). Moreover, cross-shareholding shields firms from hostile takeovers while simultaneously lower risks and increase profits. Firms can benefit not just from dividends generated from cross-holding stocks, but also from improved financial performance as a result of industry chain integration or complementary advantages (Brooks et al., 2018). Corporate environmental investment is commercial investment; thus, firms' financial performance will have a direct impact on the scale of their environmental investment, and a healthy financial position is helpful in promoting environmental investment (Blanco et al., 2009).

Furthermore, cross-shareholding is conducive to reducing managerial myopia and speculative behaviors (Gilson and Roe, 1993; Guo L. X. et al., 2021) and so encouraging firms to pay more attention to long-term benefits. Managers are more inclined to make environmental investments when the purpose is to maintain corporate reputation, social image, and sustainable development. And the reduction of management speculative behavior can lead to more compliant business operations (Rocha and Salomão, 2019). When firms are under stringent government environmental regulations, they are incentivized to reduce environmental compliance costs by increasing environmental investment (Maxwell and Decker, 2006; Bierbaum et al., 2020).

Taken together, cross-shareholding may increase corporate environmental investment by enhancing financial performance and reducing managerial myopia and speculative behaviors. Based on this, this article proposes the following hypothesis:

Hypothesis 1: Cross-shareholding has a positive impact on corporate environmental investment.

Although firms play an important role in social and environmental development, their incentives to fulfill environmental responsibility might change as their ownership structure shifts. In China, state-owned enterprises (SOEs) are closely tied to the government and they control the bulk of

economic resources (Li and Wang, 2021). However, besides economic responsibility, SOEs are expected to take on social responsibility as well, and thus they are more susceptible to government policies, particularly strategic and social policies (Lin and Tan, 1999; Xue et al., 2019). Moreover, since government support such as financial and policy support is heavily tilted in favor of SOEs, SOEs suffer considerably less financial pressure than non-SOEs (Lin, 2021). When the state has more protection and supervision over SOEs, they become more susceptible to state intervention (Kornai, 1986). As a result, in the context of China's active national campaign for low-carbon transition and carbon neutrality, SOEs are more likely to make green investment. Therefore, we propose the following hypothesis:

Hypothesis 2: Cross-shareholding has a greater influence on environmental investment in SOEs than it does in non-SOEs.

Firms' responses to market changes differ by industry, as do government macro control policies (Halme and Huse, 1997). As a major resource consumer and polluter, firms are obliged to take environmental responsibility, which is also reflected in one of China's environmental policies of "assigning responsibility to those who created pollution to clearing it up"¹. Since heavy polluting industries cause more environmental problems, they are subject to more government oversight, which means higher environmental compliance costs and, as a result, a larger scale of environmental investment (Chang et al., 2021). Chinese government has been aggressively promoting sustainable development by stepping up efforts to preserve the ecological environment and control carbon emissions. The Chinese environmental protection authorities have issued regulations, such as the *Notice on Further Regulating the Environmental Evaluation of Companies Applying for Listing or Refinancing in the Heavy Pollution Industry*² and the *Regulation on Management of Inventory of Pollutant Discharging Units subject to Key Management*³, further strengthening the supervision and punishment mechanism for heavy polluting industries. As a result, the heavily polluting industries face much stronger external regulation than low polluting industries (Wang et al., 2021). Therefore, in order to reduce the cost of environmental compliance, heavy polluters are more likely to invest in environmental measures or projects. Based on this, this article proposes the following hypothesis:

Hypothesis 3: The impact of cross-shareholding on the environmental investment in heavily polluting industries is stronger compared to low polluting industries.

RESEARCH DESIGN

Data

This article uses Chinese listed firms in the A-share stock market from 2014 to 2019 as the research setting, of which the cross-shareholding data are sourced from the Wind financial

¹http://www.gov.cn/xinwen/2017-01/19/content_5161226.htm

²https://www.mee.gov.cn/gkml/zj/bgt/200910/t20091022_174035.htm

³https://www.mee.gov.cn/gkml/hbb/bgt/201712/t20171201_427287.htm

database⁴ and the environmental investment data are retrieved from the accrued expenses related to environmental practices in the notes appended to corporate financial statements. The control variables used in this article are sourced from the China Stock Market & Accounting Research Database (CSMAR)⁵, and the raw data were pre-processed based on the following screening principles: (1) excluding ST, ST*, and delisted firms; (2) excluding samples with missing data from 2014 to 2019. Finally, we reached 1,122 firm-year observations.

Variables

This section introduces the dependent variable, explanatory variable, and control variables, and presents descriptive statistics and the correlation matrix for all variables as shown in **Table 1**.

Dependent Variable

Corporate *Env* is the dependent variable. Most of the existing studies on China's corporate environmental investment use the amount of environmental investment disclosed in the corporate social responsibility (CSR) or sustainability report to represent firms' environmental investment, but this measurement has certain shortcomings. This is because the Chinese government does not explicitly require listed firms to disclose their environmental investments in their CSR or sustainability reports. When firms choose not to disclose this information, it may result in missing data for the sample firm. Therefore, this article chooses the accrued expenses of wastewater treatment, energy-saving devices, technological upgrading, and related engineering projects as the measurement of corporate environmental investment based on firm's financial statement notes (Zhang et al., 2019). The financial information of these listed firms are subject to independent third-party audits, which ensures data reliability and precision.

Explanatory Variable

Cross-shareholding (*Inv*) is the explanatory variable. This variable denotes the size of firms' cross-holding investment, which is measured by the natural logarithm of total investment that firms cross-hold in other firms.

Control Variables

Firm age (*age*)

The longer the firm has been operating, the more likely it is to pay attention to corporate sustainability and invest in environmental projects. This article uses firm age as a control variable, and it is measured by the number of years since the establishment multiplied by 10.

Firm size (*size*)

Firms of different sizes has varied abilities to deploy human capital, material, and financial resources, which ultimately affects the scale of environmental investment. This article uses the natural logarithm of total assets to measure the firm size.

Profitability (*roe*)

Managers may face varying financial pressure based on their company's profitability. Although environmental investment enhances corporate sustainability, it can put the company under financial constraints in the short term. Therefore, when corporate profitability is low, managers may reduce environmental investment. In this article, we choose return on assets to measure corporate profitability.

Financial leverage (*lev*)

The larger a firm's financial leverage, the higher the debt risk it faces; and in the face of high debt risk, managers may reduce unnecessary expenses or investments. Therefore, we use total debts divided by total assets to measure the financial leverage.

Growth (*growth*)

Corporate growth ability reflects the growth rate of firm size; as firms expand, so does their ability to deploy social resources such as human capital, material, and financial resources; and managers will then deploy commensurate strategies in the continuous expansion, impacting the scale of environmental investment. This article uses the growth rate of operating income to indicate corporate growth ability.

Equity concentration (*first*)

Equity concentration can reflect firms' governance structure effectively which to a certain extent affects corporate strategic decisions. In this article, we use the shares percentage of the largest shareholder to measure equity concentration.

⁴<https://www.wind.com.cn/>

⁵<http://cndata1.csmar.com/>

TABLE 1 | Summary statistics and correlation matrix.

Variable	Mean	SD	1	2	3	4	5	6	7	8
1. <i>Env</i>	16.75	2.24								
2. <i>Inv</i>	17.21	2.67	0.25							
3. <i>Age</i>	207.12	48.88	-0.07	0.01						
4. <i>Size</i>	23.48	1.52	0.54	0.38	-0.07					
5. <i>Roe</i>	0.06	0.25	0.07	0.07	0.04	0.09				
6. <i>Lev</i>	1.31	7.22	-0.01	-0.03	-0.01	0.06	0.01			
7. <i>Growth</i>	0.15	0.71	-0.01	-0.04	0.01	0.03	0.07	-0.02		
8. <i>First</i>	0.37	0.16	0.26	0.07	-0.22	0.38	0.00	0.04	0.04	
9. <i>Cash</i>	0.13	0.09	-0.14	-0.06	0.02	-0.11	0.10	-0.02	-0.06	-0.08

Financial constraint (cash)

This variable reflects the level of cash flow of sample firms, which directly determines firms' upper limit for environmental investment. This article uses net cash flow scaled by total assets to measure financial constraint.

RESULTS

Baseline Results

This article examines the impact of cross-shareholding on corporate environmental investment using Chinese listed companies from 2014 to 2019 as the research setting, and estimates the following regression. The regression results for the impact of cross-shareholding (*Env*) on corporate environmental investment (*Inv*) are shown in **Table 2**.

$$Env = \beta_0 + \beta_1 Inv + \beta_2 Age + \beta_3 Size + \beta_4 Roe + \beta_5 Lev + \beta_6 Growth + \beta_7 First + \beta_8 Cash + FirmFE + YearFE + \varepsilon \quad (1)$$

Model (1) controls for firm fixed effect (*Firm FE*) with no control variable added. Model (2) adds year fixed effect (*Year FE*) to Model (1). Model (3) adds the control variables of basic firm characteristics, financial indicators and insider control issues, including firm age (*Age*) and firm size (*Size*), profitability (*Roe*), financial leverage (*Lev*), growth ability (*Growth*), financial constraint (*Cash*), and the shares percentage of the largest shareholder (*First*), and controls for firm and year fixed effects.

The results demonstrate that there is a positive and significant impact of cross-shareholding on corporate environmental investment across all regressions. Therefore, cross-shareholding has a positive impact on environmental investment, supporting *Hypothesis 1*.

Heterogeneity Analysis

State Ownership

Environmental investment is a social responsibility and is characterized by long cycle and so low short-term returns,

TABLE 3 | Heterogeneity results for state ownership.

Variable	(1) SOEs	(2) Non-SOEs
<i>Inv</i>	0.0979*** (2.64)	0.0685 (1.05)
<i>Age</i>	-0.0052*** (-4.51)	-0.0070 (-0.87)
<i>Size</i>	0.5227* (2.34)	0.9126** (2.38)
<i>Roe</i>	-0.1634 (-0.71)	1.600318 (1.28)
<i>Lev</i>	-0.0194*** (-2.91)	0.0021 (0.19)
<i>Growth</i>	-0.1267 (-1.22)	-0.0953 (-1.00)
<i>First</i>	-1.9540 (-1.60)	-4.1394 (-1.50)
<i>Cash</i>	-2.0724* (-1.79)	0.6532 (0.43)
<i>Year FE</i>	Yes	Yes
<i>Firm FE</i>	Yes	Yes
<i>R-squared</i>	0.2814	0.0910
<i>N</i>	782	339

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.
(2) t-values are provided in parentheses.

which discourages firms from investing. However, compared to non-SOEs, SOEs are more susceptible to government macro control policies, making them more incentivized to invest in environmental projects (Lin and Tan, 1999). As such, the impact of cross-shareholding on corporate environmental investment may change when firms' ownership structure changes. To examine the heterogeneity effect of corporate ownership structure in the nexus between cross-shareholding and environmental investment, we introduce the dummy variable *SOE*, which equals to 1 if a firm is state-owned and 0 otherwise. The results are shown in **Table 3**.

The results show that the coefficient of cross-shareholding on corporate environmental investment is significantly positive at the 1% level in SOEs, but not significant in non-SOEs. Therefore, the impact of cross-shareholding on corporate environmental investment is more pronounced in SOEs than in non-SOEs, which supports *Hypothesis 2*.

Polluting Industry

To examine the different effects of cross-shareholding on environmental investment in industries with varying level of pollution, we introduce the dummy variable *pollute*, which equals to 1 if a firm falls in the category of heavily polluting industry and 0 otherwise. In terms of the classification criteria, we categorize firms into heavily polluting and low polluting industries based on the *Regulation on Management of Inventory of Pollutant Discharging Units subject to Key Management* (see text footnote 3) issued by the Ministry of Ecology and Environment of the People's Republic of China, where heavily polluting industries are defined as industries that are subject to priority administration of discharge permits or are generating soluble and highly toxic waste residues, such as thermal power generation, steel manufacturing, non-ferrous metal smelting, mining, textile. **Table 4** reports the results.

The results show that cross-shareholding has a positive effect on corporate environmental investment in high polluting

TABLE 2 | Baseline regression results.

Variable	Model (1)	Model (2)	Model (3)
<i>Inv</i>	0.1034*** (3.22)	0.1053*** (3.27)	0.0879*** (2.77)
<i>Age</i>			0.0272*** (4.39)
<i>Size</i>			0.7308*** (4.02)
<i>Roe</i>			-0.0998 (-0.43)
<i>Lev</i>			-0.0131** (-2.28)
<i>Growth</i>			-0.072 (-1.12)
<i>First</i>			-1.7694* (-1.67)
<i>Cash</i>			-1.0001 (-1.14)
<i>Year FE</i>	No	Yes	Yes
<i>Firm FE</i>	Yes	Yes	Yes
<i>R-squared</i>	0.0544	0.0564	0.1181
<i>N</i>	1121	1121	1121

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.
(2) t-values are provided in parentheses.

TABLE 4 | Heterogeneity results for high versus low polluting industry.

Variable	(1) High polluting	(2) Low polluting
<i>Inv</i>	0.0732** (2.13)	0.0569 (1.32)
<i>Age</i>	-0.0050 (-0.95)	-0.0054*** (-4.62)
<i>Size</i>	0.6822** (2.23)	0.7795*** (3.28)
<i>Roe</i>	0.0142 (0.02)	-0.1459 (-0.59)
<i>Lev</i>	-0.0188** (-2.41)	-0.0071 (-0.80)
<i>Growth</i>	-0.1650** (-2.01)	0.0979 (0.67)
<i>First</i>	0.8667 (0.56)	-4.2974*** (-2.68)
<i>Cash</i>	-1.9095 (-1.54)	0.4997 (0.39)
<i>Year FE</i>	Yes	Yes
<i>Firm FE</i>	Yes	Yes
<i>R-squared</i>	0.3933	0.1871
<i>N</i>	569	553

(1) ** and *** represent significant at the 5 and 1% significance level, respectively.
 (2) t-values are provided in parentheses.

industry; however, the impact of cross-shareholding on corporate environmental investment is not observed in low polluting industry. Therefore, the positive impact of cross-shareholding on corporate environmental investment is more pronounced in the heavily polluting industry than in the low polluting industry, supporting *Hypothesis 3*.

Robustness Checks

Alternative Measure of Explanatory Variable

To test the robustness of the baseline results, we use the crossholding scaled by total assets as the alternative measure of cross-shareholding, and re-estimate the main baseline regressions. The results in **Table 5** show that the impact of cross-shareholding on environmental investment remains significantly positive when only controlling for annual dummy variable without additional control variable. As such, the results are consistent with the baseline results and the findings remain robust.

TABLE 5 | Robustness checks for alternative measure.

Variable	(1)	(2)
<i>Inv</i>	0.0810*** (2.57)	0.0879*** (2.77)
<i>Age</i>		-0.0053*** (-4.39)
<i>Size</i>		0.8228*** (4.46)
<i>Roe</i>		-0.1021 (-0.44)
<i>Lev</i>		-0.0130** (-2.28)
<i>Growth</i>		-0.0675 (-1.04)
<i>First</i>		-1.7676* (-1.66)
<i>Cash</i>		-1.0021 (-1.14)
<i>Year FE</i>	Yes	Yes
<i>Firm FE</i>	Yes	Yes
<i>R-squared</i>	0.0160	0.2574
<i>N</i>	1121	1121

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.
 (2) t-values are provided in parentheses.

Random Sampling

To further test the robustness of the baseline results, we randomly select 1/2 of the total sample and re-estimate the main regressions. As shown in **Table 6**, the results are again consistent with the baseline results. Therefore, our baseline findings are robust and reliable.

CONCLUSION

This article uses Chinese A-share listed firms from 2014 to 2019 as the research setting to investigate the impact of cross-shareholding on corporate environmental investment, and the results are summarized as follows. First, corporate participation in cross-shareholding will have a positive impact on firms' environmental investment. Second, the positive impact of cross-shareholding on environment investment is more pronounced in state-owned firms or firms in high polluting industry. Third, the empirical results remain robust after using alternative measure of cross-shareholding and robust to random sampling.

Our findings have important implications for companies and policymakers. First, this article verifies that cross-shareholding contributes to corporate sustainable development by promoting environmental investment, providing insights for corporate sustainability. Second, State-owned firms and firms in high polluting industry can moderately increase their cross-shareholding to promote environmental investment. Third, although cross-shareholding benefits firms in terms of source allocation, strategic alliance, and profitability, the government should still be vigilant about this conduct, as the abuse of cross-shareholding between upstream and downstream firms can lead to industry monopoly, resulting in market disruptions that are detrimental to public welfare. Therefore, the government should strengthen the supervision and regulation to avoid malicious cross-shareholding practices.

TABLE 6 | Robustness checks for random sampling.

Variable	(1)	(2)
<i>Inv</i>	0.1050*** (2.37)	0.0943** (2.19)
<i>Age</i>		0.0276*** (4.37)
<i>Size</i>		0.8600*** (3.47)
<i>Roe</i>		-1.4228** (-2.02)
<i>Lev</i>		-0.0567** (-2.50)
<i>Growth</i>		-0.0556 (-0.80)
<i>First</i>		-0.0362 (-1.01)
<i>Cash</i>		-0.00344 (-0.86)
<i>Year FE</i>	Yes	Yes
<i>Firm FE</i>	Yes	Yes
<i>R-squared</i>	0.0529	0.1842
<i>N</i>	560	560

(1) ** and *** represent significant at the 5 and 1% significance level, respectively.
 (2) t-values are provided in parentheses.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

JT: conceptualization, funding acquisition, project administration, and supervision. WC: investigation,

validation, and writing–review and editing. XJ: formal analysis, methodology, and writing–original draft. All authors contributed to the article and approved the submitted version.

FUNDING

This research was supported by the National Social Science Foundation of China (Grant Number: 20BTJ030).

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- Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
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Corporate Competing Culture and Environmental Investment

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Using Chinese listed companies as research setting, this paper constructs a measure of corporate competing culture through textual analysis on firms' management discussion and analysis (MD&A) disclosures, and examines the impact of corporate competing culture on environmental investment. The results show that competing culture has a significant and positive impact on firms' environmental investment, and the results remain robust to a battery of robustness tests. Moreover, the mediating analysis indicates that competing culture promotes corporate environmental investment through enhancing firms' internal control quality. Furthermore, the heterogeneity results show that the positive impact of corporate competing culture on environmental investment is more pronounced in firms with larger size, stronger corporate governance, in high-polluting industry, and located in less developed regions. Our findings shed light on the importance of corporate competing culture and provide practical implications for corporate sustainable development.

Keywords: competing culture, environmental investment, internal control quality, corporate sustainable development, MD&A

OPEN ACCESS

Edited by:

Hong Chen,
Jiangnan University, China

Reviewed by:

Yile Wang,
Sichuan University, China
Xiaoyan Zhu,
Sichuan Normal University, China

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authorship

Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 11 September 2021

Accepted: 31 December 2021

Published: 20 January 2022

Citation:

Tian J, Cao W, Cheng Q, Huang Y
and Hu S (2022) Corporate
Competing Culture and Environmental
Investment.
Front. Psychol. 12:774173.
doi: 10.3389/fpsyg.2021.774173

INTRODUCTION

Corporate culture is a set of norms and values that are widely shared and strongly held within an organization (Guiso et al., 2015). Positive corporate culture can foster a healthy working environment by enhancing internal communication (Jacobs et al., 2013), which in turn shapes employee mindsets, enhances corporate strategic decision-making, and ultimately increases firm value (Yusuf, 2002). As such, a sound corporate culture is conducive to corporate management and operation (Han, 2004).

Competing culture is an important type of corporate culture (Fiordelisi and Ricci, 2014). It refers to a culture that upholds competing components and seeks to make the company more competitive as a whole (Fiordelisi et al., 2019). Employees may feel a sense of pressure in a competing culture, which may increase internal competition and, as a result, has an influence on the company's market share and profitability (Fiordelisi et al., 2019). Competing culture, if properly guided by managers, will motivate employees' productivity and enhance firms' core competencies (Fiordelisi et al., 2019); otherwise, it may cause cut-throat internal competition and conflicts, resulting in a loss in firms' core competencies (Hu et al., 2021).

Corporate environmental investment plays a non-negligible role in promoting sustainable development (Tian et al., 2020). Companies can improve environmental performance and reduce environmental liabilities by investing in environmentally friendly technologies that reduce emissions and improve resource utilization (Bierbaum et al., 2019). Corporate environmental investment is a major part of corporate social responsibility (Bierbaum et al., 2019). By investing in pro-environmental activities, companies can improve their social reputation

(Aksak et al., 2016), gain the trust of stakeholders, and therefore enhance their financial performance (Pekovic et al., 2018). As such, corporate environmental investment is conducive to corporate sustainable development (Tian et al., 2020).

A number of factors, including external and internal factors, can influence corporate environmental investment. External factors include environmental regulations (Huang and Lei, 2021), government subsidies (Jung and Feng, 2020), and market competition (Ducassy and Montandrou, 2015). First, in terms of environmental regulations, considering that companies are the main carbon emitters and energy consumers (Alam et al., 2019), governments of various countries have introduced environmental laws and regulations to regulate companies' operation and production (Du et al., 2020), forcing companies to improve their environmental performance. Second, in terms of government subsidies, the governments may provide incentives, such as green subsidies, for companies to adopt environmentally friendly strategies (Huang et al., 2020), leading to an increase in corporate environmental investment. Third, in terms of market competition, companies in the same industry can also incentivize peer companies' environmental investment by investing in clean technologies to increase core competencies and gain competitive advantages in the market (Sengupta, 2015). Internal factors include board structure (Du et al., 2017; Sun et al., 2020), manager characteristics (Wei and Zhou, 2020), and corporate culture (Fiordelisi et al., 2019). First, in terms of board structure, the more diverse the board members' background and educational attainment, the more feasible the environmental investment decisions made by the firm (Du et al., 2017; Sun et al., 2020). Second, in terms of manager characteristics, managers' insight and personality have a substantial impact on firms' decisions of long-term investment such as environmental investment (Wei and Zhou, 2020). Third, in terms of corporate culture, Fiordelisi et al. (2019) find that corporate culture plays a guiding role in the strategic decision making of environmental investment.

Albeit rarely studied, corporate culture, as an internal factor, could play an important role in firms' strategic decision-making process of environmental investment (Lu and Wang, 2021). Thus, corporate competing culture, as an important corporate culture, might have a significant relation with corporate environmental investment that merits investigation. We select Chinese firms as the research setting to examine impact of competing culture on corporate environmental investment because China is the largest carbon emitter and listed firms contribute most to a nation's carbon emissions (Chen et al., 2021; Fan et al., 2021; Frank et al., 2021; Yan et al., 2021). Accordingly, we select Chinese listed firms from 2010–2019 to investigate the relationship between corporate competing culture and environmental investment. Based on the management discussion and analysis (MD&A) disclosures of Chinese listed companies, this paper uses text mining technique to construct a quantitative measure of corporate competing culture and examines the impact of competing culture on corporate environmental investment. The results show that corporate competing culture has a significant and positive impact on environmental investment. This positive impact is more pronounced in companies with larger size, stronger corporate governance, in high-polluting industry, and located in less

developed regions. Through the mediating analysis, we find that internal control quality transmits the positive impact of corporate competing culture onto environmental investment. The results remain robust to multiple robustness tests. Therefore, this study provides practical implications for promoting sustainable development of businesses and the society.

The remainder of the paper is structured as follows. Section "Literature Review" reviews related literature on corporate competing culture and environmental investment, followed by data and variable descriptions in section "Research Design." Section "Results" shows the results and section "Conclusion" concludes the paper.

LITERATURE REVIEW

Corporate Competing Culture

Corporate culture is *a set of norms and values that are widely shared and strongly held within an organization* (Guiso et al., 2015). Through shared values and norms, corporate culture can enhance the effectiveness of internal communication (Jacobs et al., 2013) and motivate employees to work toward common goals (Deal and Kennedy, 1983). More importantly, corporate culture influences the value of a company by influencing employees' mindsets and work productivity (Fiordelisi et al., 2019). Typical corporate cultures include innovation culture (Fiordelisi et al., 2019), integrity culture (Peng et al., 2020), and many more.

A culture of innovation inspires and promotes creative thinking and action among members of an organization, allowing them to produce remarkable results (Michaelis et al., 2018). A cautionary example is the company *Kodak*, where rigid bureaucracy and fixed mindsets of top management, and lack of creative thinking have greatly hampered the company's development of image capturing and sharing technologies. *Kodak's* inability to adapt to innovative digital thinking significantly reduced its market share, stock prices, and market value, eventually resulting in its bankruptcy (Lucas and Goh, 2009).

An integrity-oriented culture encourages companies to take social responsibility and gain public trust so as to increase their social and economic value (Peng et al., 2020). The energy company *Enron*, however, abandoned the culture of integrity and resorted to deceive the investors by manipulating financial reports, resulting in a plunge in its stock price and, and eventually, a bankruptcy (Linthicum et al., 2010).

Few existing studies investigate corporate competing culture. A competing culture is a culture that incorporates high social comparison (Hofstede, 1986). Social comparison refers to individuals comparing their own beliefs, attitudes and achievements with those of others (Buunk and Gibbons, 2007). Such social comparisons occur between individuals, and between companies (Hofstede, 1986). When such social comparisons take place within companies and create differences, a competing "motivation field" is created (Dissanaike et al., 2019), resulting in a competing culture. Corporate competing culture refers to a consensus and atmosphere within a firm that upholds

competition components in order to make the firm competitive as a whole (Fiordelisi et al., 2019). Companies pursuing a competing culture are often distinguished by a focus on competitiveness enhancement, customer centricity, and effective internal and external controls (Fiordelisi et al., 2019). Moreover, competing culture increases mutual supervision and competition among employees and teams, creating a sense of urgency and pressure (Fiordelisi et al., 2019). If properly guided by the managers, it can motivate employees to create and work actively (Huang and Mas-Tur, 2015), improve the quality and efficiency of production, and make the firm more competitive in the market (Fiordelisi et al., 2019). However, if the managers have a poor guidance of competing culture, for example, by prioritizing short-term interests over long-term growth, it can result in cut-throat competition, low trust, high interpersonal sensitivity within the firm. This may cause further conflicts, making it difficult for strategic decision making and heightening the company's operation cost (Hu et al., 2021).

Corporate Environmental Investment

Corporate social responsibility (CSR) refers to a range of initiatives and practices that firms voluntarily adopt to meet social and environmental requirements and contribute to environmental sustainability (Barbosa and Oliveira, 2020). CSR is the aggregation of the obligations that society as a whole expects companies to fulfill, i.e., the responsibilities that companies have toward other stakeholders in society (Carroll, 1979). CSR encompasses four categories, including economic responsibility, legal responsibility, ethical responsibility, and philanthropic responsibility (Carroll, 1979). By practicing CSR, companies can improve their reputation, gain the trust of stakeholders, generate more social value, and thereby increase firm value (Barbosa and Oliveira, 2020; Su et al., 2020). The most common forms of CSR activities include environmental protection, ethical labor practices, and community services (Barbosa and Oliveira, 2020). Among them, environmental investment is an important way for companies to practice CSR and contribute to environmental protection.

Environmental investment is a type of investment that aims to solve real or potential environmental problems and to balance the relationship between humans and the environment (Linhard, 2005). Typical environmental investment includes expenditure on research and development, renovation of environmental technologies, renovation of environmental facilities, pollution control, ecological protection, and cleaner production (Askildsen et al., 2006; Kumari et al., 2021). Environmental investment helps to balance the human-environment connection and promotes sustainable development (Tian et al., 2020). Corporate environmental investment promotes the adoption of green technologies, which lead to efficient resource use and lower environmental compliance cost (Bierbaum et al., 2019), thereby improving corporate environmental performance (Tian et al., 2020). In addition, companies can fulfill their social responsibility through environmental investment (Bierbaum et al., 2019), which improves firm reputation (Aksak et al., 2016), brand value (Guenther and Guenther, 2019), and overall corporate performance (Pekovic et al., 2018). On the other

hand, the main objective of companies is to generate profits and maximize shareholder interests (Murthy et al., 2021); however, environmental investment—as a form of public utility investment (Michelfelder et al., 2019)—has lower returns and higher costs in the short term (Wei and Zhou, 2020). As such, firms' budgets may be constrained and production and operation may be affected by environmental investments (Azadegan et al., 2018). Therefore, the motivations of environmental investment from the private sector deserve to be further explored.

We classify driving factors of corporate environmental investment into external and internal factors. External factors include environmental regulations (Huang and Lei, 2021), government subsidies (Jung and Feng, 2020), and market competition (Ducassy and Montandrou, 2015). First, nowadays, global environmental problems are increasingly severe, and firms are the main carbon emitters and energy consumers (Alam et al., 2019). Given that industrial production depends heavily on environmental resources (Yin et al., 2021), governments worldwide have introduced various environmental regulations and policies to regulate industrial production (Du et al., 2020), forcing companies to increase investment in environmental protection. Second, green subsidies can incentivize corporate environmental investment (Jung and Feng, 2020). Green subsidy refers to the government's provision of loans, tax subsidies, and/or other incentives for firms to adopt environmentally-friendly measures (Huang et al., 2020) and increase environmental investment. Third, when companies make profits from investing in new environmental technologies such as clean technologies, it will create an appealing incentive for other companies in the market to increase environmental investment to compete (Sengupta, 2015).

Internal driving factors of corporate environmental investment include board structure (Du et al., 2017; Sun et al., 2020), manager characteristics (Wei and Zhou, 2020), and corporate culture (Fiordelisi et al., 2019). First, Sun et al. (2020) finds that board member diversity, such as gender and age, increases the diversification of firms' investment portfolio (Du et al., 2017; Sun et al., 2020) and promotes environmental investment. Second, managers with short-sightedness characteristics tend to prioritize short-term investment for immediate benefits over long-term and sustainable investment such as environmental investment (Wei and Zhou, 2020). Third, corporate culture plays a guiding role in firms' strategic decision making (Fiordelisi et al., 2019). However, research on corporate culture remains scarce, especially on the influence of corporate competing culture on environmental investment.

Corporate Competing Culture and Environmental Investment

Existing research shows mixed results on the impact of competing culture on corporate environmental investment. On the one hand, competing culture may have a negative effect on corporate environmental investment. A competing culture may lead to increased internal competition (Hitka et al., 2015) or even cut-throat competition and conflicts if managers cannot provide the right guidance (Andersen and Johansen, 2021). As a result,

employee trust decreases and interpersonal relationships become tense, leading to splits within the company (Andersen and Johansen, 2021). Companies with such a working environment are highly associated with managers' short-sightedness (Hu et al., 2021). According to upper echelons theory, managerial short-sightedness affects a firm's investment decisions (Hu et al., 2021). Short-sighted managers are more inclined to invest in projects with short duration and high risks (Hu et al., 2021) than in long-term investment such as environmental investment (Wei and Zhou, 2020). Therefore, corporate competing culture may hinder environmental investment.

However, on the other hand, competing culture may also promote corporate environmental investment. First, as mentioned above, corporate competing culture increases internal competition, which, if properly guided by the managers, may increase employee motivation, productivity, and corporate market competitiveness (Fiordelisi et al., 2019). Corporate competitiveness is highly associated with firms' social reputation (Barbosa and Oliveira, 2020; Bruna and Nicolò, 2020; Nguyen et al., 2021). Social reputation is one of the important social resources available to companies. Resource dependency theory suggests that to survive and gain an advantage over competition, companies shall rely on their external environment such as the social environment to get support (Pugliese et al., 2014). To a certain extent, the theory reveals the close relationship between firms and their external environment. Therefore, to improve social reputation and further acquire external resources and support, companies will actively practice social responsibility (Singh and Misra, 2020) and so invest more in pro-environmental activities, which enhances corporate image and increases their social value (Singh and Misra, 2020). Accordingly, a healthy competing culture may promote corporate environmental investment.

Second, to control speculative behaviors that may result from a competing culture (Hitka et al., 2015), managers will improve operation management and increase corporate compliance (Rocha and Salomão, 2019). Theory of compliance states that companies should comply with laws and regulations and establish sustainable development goals (Rocha and Salomão, 2019). Currently, companies are subject to increasingly stringent environmental laws and regulations, prompting them to

increase environmental investment in order to improve resource use efficiency and reduce pollutant emissions (Tian et al., 2020). Firms increase environmental investment to make their production and operation more compliant and therefore lower the environmental compliance cost (Bierbaum et al., 2019). As such, corporate competing culture may promote environmental investment by increasing corporate compliance.

In summary, theory on managerial short-sightedness suggests that corporate competing culture gives rise to speculation that is detrimental to environmental investment; however, on the other hand, resource dependence theory and theory of compliance suggest that if a competing culture is well managed, firms will pay greater attention to social reputation and operational compliance, and therefore increase environmental investment. The mixed effects of corporate competing culture on environmental investment make the relationship between the two more valuable to investigate.

RESEARCH DESIGN

Data

We use all Chinese A-share listed companies on the Shanghai and Shenzhen Stock Exchanges from 2010 to 2019 as the research setting. As financial firms follow different reporting schemes, we have eliminated financial firms from our sample. With missing data eliminated, we reach a final sample of 5,915 firm-year observations.

The environmental investment data and control variables used in this study are derived from the *China Stock Market Accounting Research* (CSMAR); the management discussion and analysis (MD&A) disclosure data are derived from the MD&A database of the *Chinese Research Data Services Platform* (CNRDS); and the competing culture keywords are derived from the *WinGo Textual Analytics Database*.

Measuring Corporate Competing Culture

Following Loughran and McDonald (2011), this paper adopts the keyword frequency method to measure corporate competing culture. There are two ways to determine word frequency—one is by the count of relevant words, and the other is by the percentage

TABLE 1 | Summary statistics deviations and correlation matrix.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. <i>Envir_inv</i>	15.21	2.29											
2. <i>Compete</i>	0.03	0.01	0.076										
3. <i>Roa</i>	1.48	0.78	0.022	-0.058									
4. <i>Size</i>	3.10	0.06	0.468	0.099	-0.121								
5. <i>Age</i>	2.76	0.38	0.069	-0.032	-0.074	0.193							
6. <i>TQ</i>	1.77	1.92	-0.269	-0.106	0.301	-0.541	-0.088						
7. <i>Envir_regu</i>	3.06	0.53	0.036	-0.095	0.084	0.069	0.163	-0.176					
8. <i>Independent</i>	38.30	10.16	-0.061	0.069	-0.036	-0.066	-0.130	0.100	-0.293				
9. <i>Ownership</i>	21.60	1.17	0.442	0.076	0.030	0.928	0.152	-0.439	0.095	-0.072			
10. <i>Leverage</i>	0.37	0.15	0.235	0.101	-0.402	0.488	0.150	-0.440	-0.040	-0.002	0.161		
11. <i>SOE</i>	0.52	0.50	0.140	0.203	-0.192	0.307	0.239	-0.176	-0.043	-0.018	0.216	0.321	
12. <i>Isduality</i>	0.22	0.41	-0.044	-0.105	0.058	-0.140	-0.058	0.095	0.027	0.026	-0.114	-0.113	-0.252

of the count of relevant words to the total word counts in the text (frequency ratio). To avoid the scale difference of absolute values (Loughran and McDonald, 2011), we follow Ferris et al. (2013) and Austin et al. (2021) and uses keyword frequency ratio to measure corporate competing culture. We construct the measure in following three steps.

Step 1: Competing culture seed word selection. Based on the dictionary constructed by Fiordelisi et al. (2019), we translated words with etyma related to the semantic meaning of “compete” via widely-used translation software into Chinese, and conducted a preliminary word screening on the translated Chinese words. Considering the different understanding of the semantic meaning of “compete” in Chinese and English, words unrelated to the semantic meaning of “compete” in Chinese were removed. For example, “agreem” in English has a connotation of “compete,” but it is translated as “agree, endorse, reach agreement” in Chinese. Therefore, the Chinese words translated from “agreem” were removed. In terms of etyma with multiple semantic meanings, for example, “mov” is translated as “motive” and “move” in Chinese, and “move” is associated with the semantic meaning of “compete” in Chinese, therefore, the translated Chinese word with the semantic meaning of “move” was retained.

We further supplemented the seed word set with synonyms using the Chinese Synonym Dictionary. For objectivity purpose, the revised seed word set was triangulated and examined by three experts in the field of corporate culture.

Step 2: Near-synonym expansion. In textual analysis, it is more effective to expand the seed word set with near-synonyms (Aghion et al., 2014). In this study, we used the deep learning technique provided by the *WinGo Textual Analytics Database* to expand the competing culture seed word set with near-synonyms. The deep learning technique uses the word2vec word embedding algorithm to convert cleaned texts into a set of vectors, and calculates the similarity between words. The greater the similarity, the smaller the difference of the semantic meaning between the two words. Therefore, we used the deep learning tool to derive an extended set of words with a similarity of 0.6 or more to the seed word set and removed the duplicate words¹.

Step 3: Calculating corporate competing culture. Based on the extended seed word set, we calculated and used the competing culture seed word frequency ratio in the management discussion and analysis (MD&A) section of sample companies’ annual report to quantitatively measure corporate competing culture. The greater the competing culture seed word frequency ratio, the stronger the competing culture of a company.

Variables

This section introduces the dependent variable, explanatory variable, and control variables. **Table 1** presents the descriptive statistics and the correlation coefficient matrix of all variables.

¹To test the robustness of our results, we built three competing culture word sets: (1) the extended word set (Compete1) with a similarity of 0.5 or greater to the seed word set, (2) the extended word set (Compete) with a similarity of 0.6 or greater to the seed word set, and (3) the extended word set (Compete2) with a similarity of 0.7 or greater to the seed word set. We use Compete1 in the baseline regressions, and conducted robustness checks using the remaining two word sets as alternative measures of corporate competing culture.

Dependent variable. The dependent variable is corporate environmental investment (*Envir_invest*). Following prior studies (e.g., Hu et al., 2017), we define the expenditure related to environmental protection in ongoing projects to measure corporate environmental investment.

Explanatory variable. The explanatory variable is corporate competing culture (*Compete*). We use the competing culture seed word frequency ratio in the MD&A texts of sample firms’ annual report as a measure of corporate competing culture.

Control variables. Following existing studies (e.g., Sloan, 1996; Shen et al., 2019; Su et al., 2020; Gu et al., 2021), we choose a set of firm characteristics as control variables, including firm age (*Age*), firm size (*Size*), total liabilities (*Leverage*), return on assets (*Roa*), owner’s equity (*Ownership*), Tobin’s Q (*TQ*), state ownership (*SOE*), proportion of independent board members (*Independent*), and duality of the CEO (*Isduality*). Moreover, because of the increasingly important influence of environmental regulation on

TABLE 2 | The impact of corporate competing culture on environmental investment.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
<i>Compete</i>	25.5979*** (3.6307)	10.9211*** (4.0123)	15.4105*** (4.6896)			18.4600** (7.883)
<i>Compete1</i>				11.0520*** (3.0362)		
<i>Compete2</i>					15.0237** (7.3872)	
<i>Roa</i>		0.2284*** (0.0445)	0.2453*** (0.0513)	0.2531*** (0.0513)	0.2412*** (0.0515)	0.2410*** (0.0506)
<i>Size</i>		0.2323 (0.2096)	0.4557* (0.2331)	0.4479* (0.2330)	0.4641** (0.2335)	0.3840** (0.1730)
<i>Age</i>		-0.2856*** (0.1023)	-0.1960* (0.1166)	-0.2154* (0.1165)	-0.2013* (0.1167)	-0.2280* (0.1220)
<i>TQ</i>		-0.0356 (0.0250)	-0.0307 (0.0294)	-0.0272 (0.0294)	-0.0344 (0.0294)	-0.0337 (0.0337)
<i>Envir_regu</i>		-0.1193 (0.1272)	0.0689 (0.1465)	0.0559 (0.1465)	0.0725 (0.1467)	-0.2190 (0.1460)
<i>Qwnership</i>		0.5916*** (0.1612)	0.4223** (0.1788)	0.4355** (0.1787)	0.4132** (0.1792)	0.3870** (0.1680)
<i>Independent</i>		-0.0052 (0.0032)	-0.0075* (0.0039)	-0.0079** (0.0039)	-0.0075* (0.0039)	-0.00940** (0.0037)
<i>Leverage</i>		2.2481*** (0.5559)	1.6413*** (0.6315)	1.6851*** (0.6311)	1.6564*** (0.6322)	1.6600*** (0.6020)
<i>SOE</i>		-0.0287 (0.0729)	-0.1311 (0.0853)	-0.1453* (0.0857)	-0.1200 (0.0856)	-0.0819 (0.0844)
<i>Isduality</i>		0.1285* (0.0764)	0.0131 (0.0905)	0.0211 (0.0906)	0.0061 (0.0906)	0.1530* (0.0879)
<i>Constant</i>	14.4137*** (0.3964)	3.0156 (3.7293)	5.9578 (4.1509)	5.5974 (4.1525)	6.4372 (4.1545)	-1.012 (1.1610)
<i>Year FE</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>No. of obs.</i>	5,912	4,035	2,722	2,722	2,722	2,770
<i>R²</i>	0.1979	0.3529	0.3910	0.3916	0.3895	0.3910

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively; (2) standard deviations are provided in parentheses.

companies' green investment (Huang and Lei, 2021), the number of environmental regulations (*Envir_regu*) is also added as a control variable. Furthermore, we also control for industry fixed effects (*Industry FE*) and year fixed effects (*Year FE*).

RESULTS

Corporate Competing Culture and Environmental Investment

To investigate the impact of competing culture on corporate environmental investment, we use the following regression model:

$$Envir_invest = \alpha_0 + \alpha_1 Compete + \beta Z + YearFE + IndustryFE + \varepsilon \tag{1}$$

where *Envir_invest* represents corporate environmental investment, *Compete* is corporate competing culture, and *Z* denotes the control variables, including firm age (*Age*), firm

size (*Size*), total liabilities (*Leverage*), return on assets (*Roa*), owners' equity (*Ownership*), Tobin's Q (*TQ*), percentage of independent board members (*Independent*), whether the CEO is also the chairman of the board (*Isduality*), whether the firm is state-owned (*SOE*), and the number of environmental regulations (*Envir_regu*). In addition, we control for year fixed effects (*Year FE*) and industry fixed effects (*Industry FE*). The results are presented in **Table 2**.

Model 1 controls for industry fixed effects and year fixed effects without adding any control variables. The results show that the impact of corporate competing culture on environmental investment is positive and statistically significant at the 1% significance level, indicating that corporate competing culture significantly promotes environmental investment. In Model 2, after controlling for firm age (*Age*), firm size (*Size*), total liabilities (*Leverage*), return on assets (*Roa*), owners' equity (*Ownership*), Tobin's Q (*TQ*), percentage of independent board members (*Independent*), duality of the CEO (*Isduality*), state ownership (*SOE*), and the number of environmental regulations (*Envir_regu*), the coefficient of *Compete* is still significantly

TABLE 3 | Heterogeneity results.

Variables	Scale		East		Board		Pollu	
	SME	Large	Central & Western	Eastern	Small	Large	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Compete</i>	8.7425 (5.7640)	11.3265** (5.6673)	25.7425*** (5.6511)	-0.6012 (5.6401)	8.7607 (5.4379)	15.5482** (6.0806)	2.5915 (6.2773)	16.6036*** (5.2226)
<i>Roa</i>	0.1394** (0.0620)	0.2872*** (0.0676)	0.1401** (0.0620)	0.2833*** (0.0642)	0.2733*** (0.0610)	0.1639** (0.0669)	0.3110*** (0.0739)	0.1961*** (0.0557)
<i>Size</i>	19.3683*** (5.2267)	-7.2482 (5.9661)	-0.7252 (4.8622)	8.6798 (5.8206)	2.7366 (5.8091)	7.6158 (5.1448)	-8.4408 (6.5606)	10.6864** (4.5801)
<i>Age</i>	-0.4109*** (0.1287)	-0.0552 (0.1709)	0.0824 (0.1584)	-0.4952*** (0.1403)	-0.3109** (0.1300)	-0.2596 (0.1716)	-0.3541** (0.1584)	-0.2256* (0.1345)
<i>TQ</i>	-0.0670** (0.0298)	0.0016 (0.0681)	-0.0026 (0.0331)	-0.0605 (0.0377)	-0.0428 (0.0330)	-0.0251 (0.0398)	-0.0049 (0.0418)	-0.0519* (0.0313)
<i>Envir_regu</i>	-0.2585 (0.1729)	0.0280 (0.1850)	-0.5340** (0.2442)	-0.1277 (0.1655)	-0.1565 (0.1681)	0.0129 (0.1974)	-0.1629 (0.1995)	-0.0941 (0.1644)
<i>Ownership</i>	-0.0328 (0.2193)	1.1187*** (0.2488)	0.8328*** (0.2081)	0.3241 (0.2529)	0.5939** (0.2556)	0.5144** (0.2150)	1.1243*** (0.2886)	0.3185 (0.1944)
<i>Independent</i>	0.0010 (0.0042)	-0.0137*** (0.0048)	0.0006 (0.0047)	-0.0110** (0.0043)	-0.0032 (0.0041)	-0.0084 (0.0056)	0.0011 (0.0048)	-0.0095** (0.0042)
<i>leverage</i>	0.3957 (0.7000)	4.1887*** (0.9447)	3.1841*** (0.7687)	1.5898* (0.8138)	2.5488*** (0.7985)	1.4339* (0.8332)	4.3409*** (0.9651)	0.9933 (0.6802)
<i>SOE</i>	-0.0029 (0.1010)	-0.0353 (0.1064)	0.0933 (0.1094)	0.0486 (0.1052)	0.0640 (0.0971)	-0.1672 (0.1142)	-0.1040 (0.1203)	0.0140 (0.0915)
<i>Isduality</i>	0.1368 (0.0959)	0.0841 (0.1261)	0.2444** (0.1207)	0.0385 (0.0994)	0.0811 (0.0979)	0.1761 (0.1261)	-0.1783 (0.1254)	0.3407*** (0.0967)
<i>Constant</i>	-44.0780*** (11.7187)	14.0946 (13.0829)	-0.6425 (10.5398)	-19.3291 (12.5498)	-5.9307 (12.4046)	-18.2564 (11.3041)	17.3302 (14.0164)	-24.6280** (9.9526)
<i>Year FE</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>No. of obs.</i>	1,900	2,135	1,787	2,248	2,315	1,720	1,606	2,429
<i>R-squared</i>	0.2810	0.3169	0.4260	0.3524	0.3363	0.3956	0.3896	0.3230

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively; (2) standard deviations are provided in parentheses.

positive at the 1% significance level, which further confirms that competing culture has a significant and positive impact on corporate environmental investment. This is consistent with resource dependency theory that firms will gain more support from external environment by increasing environmental investment promoted by fostering a competing culture. The finding is also consistent with theory of compliance that a stronger competing culture will strengthen monitoring and regulation to circumvent speculative behavior and motivate companies to increase their environmental investment in order to reduce the cost of environmental regulation risks.

In addition, given the long-term nature of environmental investment, we follow Hu et al. (2017) and use the one-year-ahead corporate environmental investment as the dependent variable to re-estimate the model. The results, as shown in Model 3, illustrate that the impact of corporate competing culture on environmental investment is still significantly positive.

We further use two alternative measures of corporate competing culture—*Compete1* (the extended word set with a similarity of 0.5 or greater to the seed word set) and *Compete2* (the extended word set with a similarity of 0.7 or greater to the seed word set)—to re-estimate the regression models. The results, as shown in Models 4 and 5, are consistent with the baseline results. Therefore, our findings on the positive relationship between corporate competing culture and environmental investment are valid and robust.

Considering the reverse causality between corporate competing culture and environmental investment, we employ the system Generalized Moment Methods (Sys-GMM) to mitigate endogeneity concerns (Ferrell et al., 2016; Shi et al., 2016; Sutton et al., 2021). The results are displayed in Model 6 of **Table 2**. It results confirm the positive causal relationship between corporate competing culture and environmental investment. Besides, the results for underidentification test and weak instrument test both show the effectiveness of the instrument variable. Therefore, our key findings of the positive impact of competing culture on corporate environmental investment is reliable².

Heterogeneity Analysis

To explore the heterogeneous impact of size effect, region effect, governance effect, and industry effect, we examine the relationship between corporate competing culture and environmental investment in terms of different firm size (*scale*), geographical location (*east*), board size (*board*), and a binary variable of high-polluting industry (*pollu*). *scale* is taken as 1 if the firm size is smaller than the median value of firm size, and 0 otherwise. *east* is taken as 1 if the firm is located in the eastern China, and 0 otherwise. *board* is taken as 1 if the board size is larger than the median value of board size, and 0 otherwise. *pollu* is taken as 1 if the firm is in a heavy polluting industry, and 0 otherwise.

Size effect. As shown in the first two columns of **Table 3**, the coefficient of *Compete* is insignificant when a firm's size is less than the median size of the sample firms ($size < size_median$), but significantly positive at the 5% significance level when the

firm's size is greater than the median size ($size \geq size_median$). The results indicate that the positive impact of corporate competing culture on environmental investment is more pronounced in larger firms.

Region effect. As shown in Columns 3 and 4 of **Table 3**, the coefficient of *Compete* is significantly positive at the 1% significance level in firms in central and western China, but not significant in firms in eastern China. The finding indicates that in less developed regions, firms with a competing culture are more likely to invest in environmental protection.

Governance effect. As shown in Columns 5 and 6 of **Table 3**, the coefficient of *Compete* is insignificant when the board size is less than the median board size, but significantly positive at the 5% significance level when the board size is greater than the median value. The results illustrate that the stronger the corporate governance, the more pronounced the positive impact of competing culture on its environmental investment.

Industry effect. As shown in the last two columns of **Table 3**, the coefficient of *Compete* is significantly positive at the 1%

TABLE 4 | Mediating analysis of internal control quality.

Variables	<i>ici</i>	<i>envir_invest</i>
<i>Compete</i>	1,039.4768*** (282.2982)	10.9472*** (4.0952)
<i>ici</i>		0.0004* (0.0002)
<i>Roa</i>	30.2879*** (3.1021)	0.2136*** (0.0455)
<i>Size</i>	-101.4917*** (14.6230)	0.2852 (0.2131)
<i>Age</i>	1.8930 (7.4645)	-0.2686** (0.1081)
<i>TQ</i>	-4.6751*** (1.7733)	-0.0319 (0.0257)
<i>Envir_regu</i>	-0.5086 (8.9694)	-0.1300 (0.1299)
<i>Ownership</i>	107.8710*** (11.2367)	0.5410*** (0.1647)
<i>Independent</i>	-0.0485 (0.2243)	-0.0059* (0.0032)
<i>Leverage</i>	245.5929*** (39.1321)	2.1172*** (0.5696)
<i>SOE</i>	-16.1487*** (5.1194)	-0.0223 (0.0743)
<i>Isduality</i>	-14.4266*** (5.4186)	0.1339* (0.0786)
<i>Constant</i>	-1,766.5930*** (260.3035)	3.9113 (3.7928)
<i>Year FE</i>	Yes	Yes
<i>Industry FE</i>	Yes	Yes
<i>No. of obs.</i>	3,914	3,912
<i>R²</i>	0.1847	0.3511

(1) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively; (2) standard deviations are provided in parentheses.

²The results are available upon request.

significance level in high-polluting firms, but not significant in low-polluting firms. Corporate investment decisions, including investment in environmental protection and pollution control, are affected by environmental laws and regulations (Gray and Deily, 1996). When a firm has a strong competing culture, managers are more likely to strengthen corporate governance and compliance to avoid the speculative conduct that the competing culture may cause (Hitka et al., 2015). This is more common in heavy polluting companies as heavy polluters face stricter restrictions on environmental laws and regulations and so higher penalty costs. Therefore, the impact of corporate competing culture on environmental investment is more pronounced in heavy polluting companies.

Mediating Analysis

Management team with short-sightedness may reduce environmental investment for personal gains as environmental investment cannot guarantee a short-term payoff (Wei and Zhou, 2020). However, high-quality internal control might effectively reduce short-sighted decisions (Cheng et al., 2013) and promote better social responsibility (Bierbaum et al., 2019), thereby increasing the scale of corporate environmental investment. Meanwhile, corporate culture is closely related to the quality of internal control (Yu et al., 2021). Therefore, the quality of a firm's internal control might transmit the positive impact of corporate competing culture onto its environmental investment.

To explore the channel in the relationship between corporate competing culture and environmental investment, we use the internal control index obtained from the internal control database created by the *DIB Database* as a measure of internal control quality to examine its mediating effect in the competing culture-environmental investment nexus.

As displayed in **Table 4**, the coefficient of *Compete* in the first column is positive and statistically significant, and the coefficient of *ici* (internal control index) in the second column is also positive and significant, indicating that corporate competing culture promotes environmental investment through the enhancement of internal control quality. Therefore, firms' internal control quality transmits the positive impact of corporate competing culture onto environmental investment.

CONCLUSION

Using Chinese listed firms from 2010 to 2019 as the research setting, this paper develops a quantitative measure of corporate competing culture through textual analysis and examines the

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impact of corporate competing culture on environmental investment. The results show that (1) corporate competing culture has a significant and positive impact on environmental investment; (2) the results remain robust to alternative measures of corporate competing culture and environmental investment; (3) the positive impact of corporate competing culture on environmental investment is more pronounced in companies with larger size, stronger corporate governance, in high-polluting industry, and located in less developed regions; (4) internal control quality plays a mediating role in transmitting the impact of corporate competing culture onto environmental investment.

This study has important practical implications. First, it broadens the research in the area of corporate sustainability by providing empirical evidence that corporate competing culture contributes to corporate sustainability by promoting environmental investment. Second, internal control quality serves as an important channel for the positive impact of corporate competing culture on environmental investment; firms can thus promote the positive effect of competing culture on environmental investment by improving the quality of internal control. Third, we use deep learning technique to measure corporate competing culture and contribute to the quantitative measurement of corporate competing culture.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JT, WC, QC, YH, and SH contributed to conception and design of the study. JT and WC organized the database and performed the statistical analysis. All authors wrote the first draft of the manuscript, contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This research is supported by the National Social Science Foundation of China (Grant Number: 20BTJ030). SH acknowledges financial support from the National Natural Science Foundation of China (Grant No. 71802029).

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Influencing Mechanism of Justice Sensitivity on Knowledge Hiding in the Chinese Context

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Good knowledge management is important for enterprises to maintain competitive advantage; however, the knowledge hiding behavior may hinder this process. Based on the conservation of resources and psychological ownership theories, using a chain intermediary model, this study investigates the effect of justice sensitivity on knowledge hiding through perceived time pressure and territoriality, and further tests the moderating role of territoriality. For the study, we collected 436 questionnaires from China through the Wenjuanxing Sample Service, of which 391 were valid. We then conducted multiple regression analysis and employed the bootstrap method for our tests. The results show that victim sensitivity has a significant effect on perceived time pressure, territoriality, and knowledge hiding, and that a chain mediating effect of perceived time pressure and territoriality is established between justice sensitivity and knowledge hiding. Further, territoriality has a positive moderating effect on perceived time pressure and knowledge hiding, while the mediating effect of perceived time pressure on justice sensitivity and knowledge hiding is also moderated by territoriality. Further, the study offers important practical implications in that enterprises should not blindly pursue results by making employees work excessively overtime. And there should have rationalized regulations in organization to ensure justice. The management should pay close attention to the psychological problems of victim and perpetrator. Instead, enterprises should have a certain degree of control, offer rationales for overtime work, and give high wages to the employees to compensate for their time, thus making the employees feel the worthiness of their overtime work and reducing the probability of engaging in knowledge hiding behaviors.

Keywords: perpetrator sensitivity, victim sensitivity, territoriality, perceived time pressure, knowledge hiding

INTRODUCTION

With the rapid development of the Internet economy in recent years, knowledge management methods have become increasingly important for enterprises, governments, and non-governmental organizations to remain competitive. In particular, efficient knowledge transfer and sharing among members of an organization can improve performance level and innovation capabilities (Ke et al., 2007; Wang and Yan, 2020). One way for enterprises to achieve sustainable development is to create knowledge through extensive knowledge sharing and exchange among employees, thus organizing knowledge to add greater value. However, knowledge hiding hinders the effectiveness of organizational knowledge management. Therefore, enterprises not only need to promote

OPEN ACCESS

Edited by:

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Reviewed by:

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 26 October 2021

Accepted: 23 December 2021

Published: 03 February 2022

Citation:

Jin-song Z, Hua H, Dan-yang R
and Ya-nan J (2022) Influencing
Mechanism of Justice Sensitivity on
Knowledge Hiding in the Chinese
Context. *Front. Psychol.* 12:802171.
doi: 10.3389/fpsyg.2021.802171

knowledge sharing, but also need to reduce and control employees' knowledge-hiding behavior (Fu et al., 2020) which can affect the sustainable knowledge sharing within a research team by reducing the supply of knowledge, creating a poor knowledge-sharing atmosphere and forming an interpersonal distrust relationship (Liu et al., 2020).

On the one hand, scholars began to explore the reasons for employees to hide their knowledge and the construction of this concept. Connelly et al. (2012) defined the concept of knowledge hiding as an individual's deliberate hiding or hiding of the knowledge asked by others, and developed a scale of knowledge hiding. The factors influencing knowledge hiding can be divided into the following aspects: factors related to knowledge, interpersonal relationship factors, situational factors, and personality characteristics. Current research mostly focuses on interpersonal and situational factors; however, the structure of factors influencing knowledge hiding behavior has not been fully studied despite its significance, as such behavior is ubiquitous in organizations and may affect results at the individual and organizational levels (Kumar Jha and Varkkey, 2018). An example of a counterproductive behavior of knowledge workers is the unwillingness to share knowledge with others or give false information, which overlaps with the concept of knowledge hiding (Peng, 2011). However, knowledge hiding is not always negative, as the motives may include prosocial ones (Peng, 2013), thus they can be both positive and negative. In the study of counterproductive behaviors, they are often combined with organizational justice (Liu et al., 2011). Organizational Justice has a direct negative impact on Knowledge Hiding (Oubrich et al., 2021). Justice sensitivity, which is defined as people's sensitivity to unfair events, is related to both prosocial and antisocial behaviors, with previous studies showing that fairness is a stable personal trait. Nevertheless, despite the importance of evaluating the influence of justice sensitivity on knowledge hiding, it has not been sufficiently explored in the existing literature.

On the other hand, the theory of resource conservation covers a wide range of fields. Hobfoll (1989) proposed the theory of resource conservation to explain pressure and how individuals respond accordingly when facing it. According to Hobfoll (1989), employees perceive pressure in the following four situations: ① when individuals perceive the threat of resource loss; ② when resources are lost; ③ when individuals perceive that they need to invest more resources in the work; ④ when an individual's perceived input is inconsistent with output. In addition, justice sensitivity occurs when people experience reaction intensity due to unfair events, which can be defined as people gain or lose resources, with many studies verifying the role of knowledge hiding as indicated by the conservation of resources theory (Škerlavaj et al., 2018; He and Gao, 2019).

In addition, De Clercq et al. (2019) investigated the relationship between time-related work stress and counterproductive work behavior. Time pressure has been widely used in workplace research, and some studies have directly shown that perceived time pressure has a positive effect on knowledge hiding (Zhang et al., 2021). This has laid a good foundation for the research of this paper. In China, the new generation of employees have been placed on the stage with the

changes of times. They work in the stressful environment. More and more employees work from nine in the morning to nine in the evening on Monday to Saturday. This study pay attention to this time pressure. The pressure seems to be a reason for negative behavior.

Further, territoriality, a concept developed on the basis of psychological ownership (Ma and Gao, 2010), has rarely been studied in the Chinese context. Territoriality originated from zoology. At a primary stage, it investigates the behavior of animals occupying territory to study the evolutionary traits of organisms. Additionally, it studies human territoriality and territorial behavior. Unlike animal territoriality, humans not only have biological evolutionary characteristics (Edney, 1974) but also understand territoriality as an individual's sense of possession of his/her own things and a sense of preventing others from encroachment (Chu and Yang, 2011). In particular, previous studies have shown that territoriality is closely linked to knowledge hiding (Peng, 2013). Therefore, this study includes territoriality in its analysis.

This paper focuses on the factors influencing knowledge hiding behavior in the Chinese context. The sample was from companies in China. This studied also can be used in other areas of China and other countries. They are outstanding problems in China. The study on this context is representative. It has been verified that employees around the world all have knowledge hiding behavior. American Management Association's studies in 2008 indicated that employees are generally reluctant to share their knowledge (Haas and Park, 2010). IDC's studies shows that the global 500 companies lost 31.5 billion without effective knowledge sharing every year (Li and Huang, 2018). The same is true in China. 46% employees in China had hidden their knowledge (He and Jiang, 2014). Time pressure has been widely used in workplace research, and some studies have directly shown that perceived time pressure has a positive effect on knowledge hiding (Zhang et al., 2021). Time pressure also exists in other countries (De Clercq et al., 2019). The relation between knowledge hiding and territoriality had been verified abroad (Singh, 2019). So we believe that the analysis and discussion in this paper could cover these stressful phenomena. They can represent a part of same problem about knowledge hiding in other countries. Thus, this study investigates the influence mechanism of justice sensitivity on knowledge hiding by focusing on knowledge hiding in the process of knowledge communication of enterprise employees and introducing multiple variables such as perceived time pressure and territoriality.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Justice Sensitivity and Knowledge Hiding

Based on (Schmitt et al., 2005) classification of unfair events, justice sensitivity can be divided into victim sensitivity, perpetrator sensitivity, and observer sensitivity. Further, perpetrator sensitivity can be divided into two categories perpetrator sensitivity and beneficiary sensitivity (Schmitt

et al., 2010). This study only selects victim sensitivity and perpetrator sensitivity for two reasons. First, studies have shown that observer sensitivity and beneficiary sensitivity have a high correlation, with non-ideal discriminant validity (Xie et al., 2013). Second, since the sensitivities of victims and beneficiaries to unfair events under the circumstance of active participation can be regarded as two opposite types, it aims to compare and study the knowledge hiding of these two justice sensitivity types.

Victim sensitivity predicts peoples' behaviors in a social dilemma. As people with high sensitivity might perceive themselves as victims of unfair situations such as destiny and are less likely to trust others, they usually show noncooperation, hostility, and even vindictiveness (Gollwitzer and Rothmund, 2011; Stavrova et al., 2014) because of the psychology of self-protection (Gerlach et al., 2012). According to the research on knowledge hiding, distrust is positively related to knowledge hiding (Kumar Jha and Varkkey, 2018) while a significant cause of knowledge hiding is self-protection (Peng, 2013). When knowledge is unique to individuals, it could provide a competitive advantage for people in organizations. Therefore, we propose the following hypothesis:

H1a: Victim sensitivity is positively related to knowledge hiding.

When being unfairly treated, perpetrators usually think they have violated the social or organizational justice rules (Stavrova et al., 2014) and thus have a sense of guilt and tend to make up for their own mistakes. Therefore, personal guilt has a negative impact on knowledge hiding (Fang, 2017). Moreover, the perpetrators' sensitivity is positively correlated with humility and gentleness, and positively predicts prosocial tendencies, such as solidarity with vulnerable others (Baumert et al., 2014). Thus, perpetrators with high sensitivity tend to share more to gain more benefits, rather than asking others to share as losers (Stavrova and Schlösser, 2015). Hence, we postulate the following hypothesis:

H1b: Perpetrator sensitivity is negatively related to knowledge hiding.

Justice Sensitivity and Perceived Time Pressure

Although victim sensitivity and perpetrator sensitivity elicit different inner activities and emotional tendencies, people with high sensitivity of both types are reflected in their sensitivity to injustice. In general, people with high justice sensitivity can perceive more information about injustice (Chi et al., 1981; Schneider and Bjorklund, 1992). In corporate work, when employees perceive time pressure, they think that individual time resources have been deprived, which is an unfair event, with people with high justice sensitivity being more likely to detect such unfair events (Baumert et al., 2011). According to the conservation of resources theory, individuals regard potential or actual resource loss as a threat (Hobfoll, 1989). Therefore, individuals with high victim sensitivity have a high degree of perception of their own adverse situations and psychological prevention construction. Although perpetrators with high sensitivity are the ones who gain benefits, studies show

that perpetrators with high sensitivity also perceive more pressure and loss of resources (Chi et al., 1981). Hence, we put forward the following hypotheses:

H2a: Victim sensitivity is positively related to perceived time pressure.

H2b: Perpetrator sensitivity is positively related to perceived time pressure.

Justice Sensitivity and Territoriality

Studies on the influence of perceived organizational justice on organizational citizenship behavior and psychological ownership have found that perceived organizational justice could increase organizational citizenship behavior and psychological ownership (Mohammad et al., 2019). Further, individual and organizational psychological ownerships are often in opposition. Whereas individual psychological ownership pays more attention to the individual, organizational ownership focuses on the organization. In addition, some studies have shown that employee psychological ownership has a positive impact on territoriality (Peng, 2013). Moreover, organizational justice refers to the employees' perceptions of fairness in an organization, which increases organizational psychological ownership. This further indicates that organizational justice has a negative effect on employee psychological ownership, and consequently, territoriality because employee psychological ownership has a positive impact on territoriality.

From the victim's viewpoint, the victim, as the aggrieved party, will be filled with feelings of injustice. In particular, organization injustice can increase the staff's personal psychological ownership, while personal psychological ownership increases territoriality. Therefore, victim sensitivity has a positive effect on territoriality.

From the perspective of perpetrators, who obtain the benefits, their sense of the organization fairness will increase, and think that the organization itself allow them to obtain more benefits. Therefore, people with high perpetrator sensitivity will have higher organizational psychological ownership, that is, a reduction in personal psychological ownership, and consequently, a reduction in territoriality. Since the perpetrators tend to share more to gain more benefits (Chi et al., 1981), perpetrator sensitivity should have a negative impact on territoriality. Hence, we postulate the following hypotheses:

H3a: Victim sensitivity is positively related to territoriality.

H3b: Perpetrator sensitivity is negatively related to territoriality.

Perceived Time Pressure and Territoriality

When individual resources are deprived, individuals tend to take priority actions to protect their own resources to avoid the continuous loss of resources (Cheek and Buss, 1981). According to the conservation of resources theory, time can be regarded as an individual resource. When animals feel time pressure, they will feel deprived of individual resources, thus evoking

the will and actions to protect their personal resources, which will increase their territoriality. For example, in response to the increased intruder pressure at the time of dawn, a critical period for vocal displays, songbirds can increase the singing rates (Hill et al., 2017). Other studies from the field of zoology show that time pressure has an impact on territoriality (Wronski and Plath, 2006). The above conclusion is in turn extended to anthropological research, which shows that in the retail environment, the impending closing time will lead to the employees' feeling of territoriality invasion, and consequently, the employees' territorial behavior (Ashley and Noble, 2014). Thus, we put forward the following hypothesis:

H4: Perceived time pressure is positively related to territoriality.

The Mediating Effect Between Perceived Time Pressure and Territoriality

In today's competitive environment, enterprises and organizations of different sizes have their own performance evaluation systems and adopt different approaches to improve their performance including the use of their own unique advantages or personal tacit knowledge. Since knowledge is inherently exclusive and monopolistic, in a competitive environment, individuals need to ensure that their knowledge resources are not stolen by others in pursuit of higher performance, thus maintaining their advantage and showing a territoriality behavior. Simultaneously, in a competitive environment, people with high justice sensitivity will pursue fairer competition, as justice sensitivity affects their territoriality, and consequently, knowledge hiding (Peng, 2013). Therefore, territoriality may mediate the relationship between justice sensitivity and knowledge hiding.

However, with the prevalence of overtime work in today's society, time deprivation is becoming a serious phenomenon, making people with high justice sensitivity more concerned about whether they will get adequate compensation for their deprived time. Therefore, they will be more sensitive to time deprivation, that is, they will perceive a greater time pressure, thus increasing knowledge hiding (Škerlavaj et al., 2018). Therefore, perceived time pressure may mediate the relationship between justice sensitivity and knowledge hiding.

According to the theory of conservation of resources, when employees feel pressure, they need to obtain new resources from the outside world to compensate for the lost resources, or they will take more strict actions to protect the resources they own (Wu et al., 2012). Victim sensitivity can improve people's perceived pressure, with existing studies showing that perceived time pressure has an impact on knowledge hiding (Škerlavaj et al., 2018). Facing time pressure, people will discover more possibilities of territoriality invasion and engage in territorial behavior to influence other people. Moreover, existing studies show that territoriality can affect knowledge hiding (Peng, 2013). Based on hypotheses H1, H2, H3, and H4, we further propose that perpetrator sensitivity has an indirect effect on knowledge hiding. Although the indirect paths of perpetrator sensitivity and victim sensitivity are similar, the mechanisms differ under

the influence of perceived time pressure and territoriality. The specific hypotheses are as follows:

H5a: Perceived time pressure mediates the relationship between victim sensitivity and knowledge hiding.

H5b: Perceived time pressure mediates the relationship between perpetrator sensitivity and knowledge hiding.

H6a: Territoriality mediates the relationship between victim sensitivity and knowledge hiding.

H6b: Territoriality mediates the relationship between perpetrator sensitivity and knowledge hiding.

H7a: Perceived time pressure and territoriality play a chain-mediating role between victim sensitivity and knowledge hiding.

H7b: Perceived time pressure and territoriality play a chain-mediating role between perpetrator sensitivity and knowledge hiding.

The Moderating Effect of Territoriality

According to the theory of conservation of resources, time is a personal resource of people. Thus, when people feel time pressure, the resources are occupied. For people with high territoriality, they care more about their territory being violated, thus evoking a more reactive defensive behavior, namely, the more the resources of a person that are encroached, the higher the probability of a knowledge-hiding behavior. In addition, territoriality plays a moderating role between perceived time pressure and knowledge hiding, that is, the higher the degree of aggression against other people's territory, the higher the sense of injustice, the greater the anger, and the more aggressive the reactive defensive behavior (Brown and Robinson, 2011). Therefore, people's self-defense will increase when their resources are violated, and an increase in self-defense may lead to an increase in knowledge hiding. Through the influence of justice sensitivity on perceived time pressure, knowledge hiding is influenced by territoriality performance. Therefore, it can be inferred that territoriality has a moderating effect on the two mediating pathways of justice sensitivity and knowledge hiding. Thus, it is assumed in this study that the higher the territoriality, the more likely people are to engage in knowledge hiding behaviors under time pressure. Therefore, we propose the following hypotheses:

H9: Territoriality positively moderates the relationship between perceived time pressure and knowledge hiding.

H10a: Territoriality positivity moderates the relationship between victim sensitivity and knowledge hiding through perceived time pressure.

H10b: Territoriality positivity moderates the link between perpetrator sensitivity and knowledge hiding through perceived time pressure.

We take territoriality as both mediator variable and moderator variable. Firstly, it is feasible for a variable to act as both

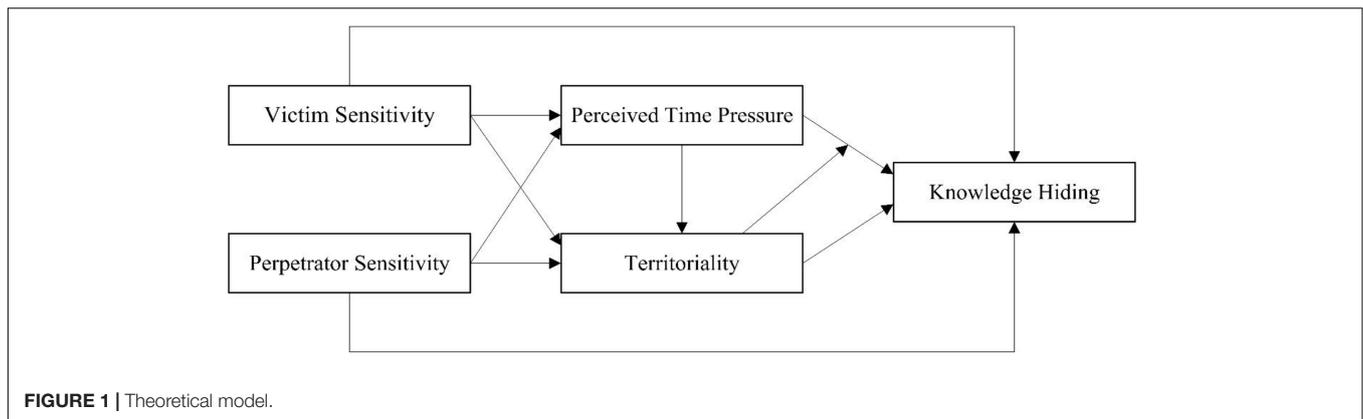


FIGURE 1 | Theoretical model.

a mediator variable and a moderator variable (Ma, 2012). According to the meanings of territoriality, we take it as both mediator variable and moderator variable. First, the level of each individual territoriality is different (Brown et al., 2005). People react differently to feeling injustice and stress between high level and low level of territoriality. It also makes a difference in the part of knowledge hiding behavior. People's territoriality is also disturbed by other factors. For example, territoriality may be a normal range in the general state. It changes if people are subjected to a particular stimulus such as justice sensitivity and perceived time pressure (Peng, 2011). Territoriality could be as the moderator variable. It is affected by justice sensitivity and perceived time pressure. Then, knowledge hiding behavior is affected by territoriality. Based on the above hypotheses, we construct the following theoretical model in **Figure 1**.

MATERIALS AND METHODS

Measuring Tools

In this study, we used a total of five variables (i.e., victim sensitivity, perpetrator sensitivity, perceived time pressure, territoriality, and knowledge hiding). All the scales used in this study are mature and have been repeatedly studied and verified. After the pre-survey, the formal items were determined and scored on a 7-point Likert scale; the higher the score, the stronger the corresponding trend.

We adopted the scale developed by Schmitt (Schmitt et al., 2010), the author of the justice sensitivity theory, to measure victim sensitivity. The scale includes nine items, such as "I am very upset when others receive something that should belong to me." For perpetrator sensitivity, we adopted another scale developed by Schmitt et al. (Schmitt et al., 2010), which includes 10 questions, such as "I feel depressed when I take something from others that I should not have." The scale developed by Putrevu et al. was used to measure perceived time pressure. Following Škerlavaj et al. (2018), we verified that the scale includes three items, such as "When I need to complete a task, I find myself short of time." For territoriality, we used a scale developed by Avey et al. (2009) and validated by Peng (2013) which includes 3 questions such as "I protect my ideas

from being used by others in the organization." For knowledge hiding, we used the scale developed by Connelly et al. (2012), the author of the concept, which includes 12 items, such as "Pretend I don't know relevant information when colleagues ask me about knowledge".

Moreover, according to the results of previous studies, some demographic variables were selected as control variables, such as including gender, age, working years, education, enterprise nature, industry, and position level.

The paper design the scale questions are from foreign mature scale. It applies to this article research object. The article's research object includes perpetrator sensitivity, victim sensitivity, territoriality, perceived time pressure and knowledge hiding. Their meaning is similar under different backgrounds of culture. These scales have been used in Chinese literature. They had been verified that they are validated in the Chinese context (Peng, 2011; Liu et al., 2019; Zhang et al., 2021). Hence, we choose these fully fledged scales.

Sample Characteristics

The questionnaires for this study were collected from China through the Wenjuanxing Sample Service. A total of 436 questionnaires were collected, of which 391 were valid, with a recovery rate of 90.0%. The descriptive statistical results are shown in **Table 1**. (It is the content about descriptive statistics in **Appendix A**).

Data Verification

The reliability and validity of the test results are presented in **Table 2**. The Cronbach's alpha values of the variables in this study were all greater than 0.7, indicating good reliability, the composite reliability (CR) values of all variables were greater than 0.7, and the average variance extracted (AVE) values were greater than 0.5. The shaded part in the table is the square root of AVE, which was greater than the correlation coefficient between the corresponding variable and other variables, indicating good discriminative validity. The degree of variation of the cumulative explanatory variance of the five common factors was 62.36%, among which the variation degree of the explanatory variance of the first factor was 26.60%, but did not exceed 40%, indicating that there was no common method deviation

TABLE 1 | Distribution of demographic characteristics of samples.

Characteristic	Category	Proportion(%)	Characteristic	Category	Proportion(%)
Gender	Male	44.8	Enterprise nature	state-owned enterprise	23.5
	Female	55.2		private enterprise	55.0
Age	< 18	0		jointly operated enterprise	15.6
	18–25	24.8		Others	5.9
	26–39	73.9	Industry	manufacturing	31.2
	> 40	1.3		Construction	9.7
Work experience	< 1	2.0		Finance	13.0
	1–3	24.6	information technology service industry	28.4	
	3–5	24.6	wholesale and retail	5.9	
	5–10	39.1	Others	11.8	
	> 10	9.7	Position level	ordinary frontline staff	31.5
Education	senior high school and below	2.3		frontline managers	38.9
	junior college	11.0		middle managers	26.9
	Undergraduate	74.2		top management	2.8
	Master's degree and higher	12.5			

TABLE 2 | Reliability, validity, and correlation coefficients of latent variables.

	Cronbach's Alpha	CR	AVE	Knowledge Hiding	Victim Sensitivity	Perpetrator Sensitivity	Perceived Time Pressure	Territoriality
Knowledge Hiding	0.949	0.951	0.623	0.789				
Victim Sensitivity	0.900	0.902	0.506	0.251**	0.711			
Perpetrator Sensitivity	0.899	0.912	0.510	0.088	0.303**	0.714		
Perceived Time Pressure	0.829	0.835	0.628	0.295**	0.379**	0.312**	0.792	
Territoriality	0.840	0.788	0.553	0.279**	0.368**	0.173**	0.348**	0.743

** $p < 0.01$. The square roots of the AVEs are the bottom shadow numbers on the diagonal line.

(Zhao and Xu, 2020). The data analysis was performed using the SPSS software.

RESULTS

Multiple Regression Analysis

Hierarchical regression was conducted, and the results are presented in **Table 3**. They show that victim sensitivity has a significant positive predictive effect on knowledge hiding (a standardization coefficient of 0.218, $P < 0.001$), thus verifying H1a. However, perpetrator sensitivity has no significant negative predictive effect on knowledge hiding (a standardization coefficient of 0.015, $P > 0.05$) thus rejecting H1b. After including victim sensitivity, perpetrator sensitivity, territoriality, and perceived time pressure in the regression equation, the predictive effects of territoriality and perceived time pressure on knowledge hiding were found to be significant at the 0.01 level, whereas perpetrator sensitivity was still not significant. In addition, victim sensitivity has a significant positive effect on perceived time pressure (a standardization coefficient of 0.315, $P < 0.001$) and perpetrator sensitivity has a significant effect on perceived time pressure (a standardization coefficient of 0.215, $P < 0.001$) thus supporting H2A and H2B. The effects of victim sensitivity and perceived time pressure on territoriality were found to be both significant at the 0.001 level, whereas perpetrator

sensitivity was not significant, thus supporting H3A and H4 and rejecting H3B.

Mediating Effect Analysis

① The Mediating Effect of Victim Sensitivity on Knowledge Hiding

In this study, the bootstrap method (5000 samples) was used to investigate the chain mediating effect of perceived time pressure and territoriality between victim sensitivity and knowledge hiding using Process3.3 plugin. Gender, age, working years, educational level, industry, enterprise nature, position level, and perpetrator sensitivity were used as control variables. The results of the mediating effect analysis are presented in **Table 4**. The results show that the direct effect of victim sensitivity on knowledge hiding is not significant. The bootstrap 95% confidence interval included zero; thus, the perceived time pressure and territoriality play a complete mediating role between victim sensitivity and knowledge hiding. The total effect was 0.218, and the confidence interval did not contain zero, indicating significance. The confidence intervals of the three mediating effects did not contain zero, indicating that all are significant. The total mediating effect value was 0.115, accounting for 52.8% of the total effect. The path of indirect effect 1 was victim sensitivity → perceived time pressure → knowledge hiding, with an effect value of 0.057, accounting for 26.3% of the total effect ratio. The path of indirect effect 2 was victim sensitivity → territoriality

TABLE 3 | Regression analysis results.

Variable	Knowledge Hiding		Territoriality	Perceived Time Pressure
Gender	-0.028	-0.040	0.020	0.041
Age	-0.118	-0.123*	0.020	0.006
Work experience	-0.102	-0.089	-0.050	-0.021
Education	-0.072	-0.049	-0.104*	-0.021
Enterprise nature 1	0.085	0.063	0.106	0.021
Enterprise nature 2	0.021	0.024	0.057	-0.054
Enterprise nature 3	0.042	0.041	0.078	-0.054
Industry 1	-0.050	-0.037	-0.041	-0.025
Industry 2	0.016	0.019	-0.003	-0.011
Industry 3	0.131	0.125	-0.054	0.069
Industry 4	-0.016	0.009	-0.050	-0.075
Industry 5	-0.002	0.001	-0.055	0.025
Position level	0.156**	0.150**	-0.044	0.062
Victim Sensitivity	0.218***	0.103	0.266***	0.315***
Perpetrator Sensitivity	0.015	-0.037	0.028	0.215***
Perceived Time Pressure		0.182**	0.240***	
Territoriality		0.167**		
R ²	0.130	0.191	0.210	0.210
F	3.737***	5.180***	6.207***	6.637***

p* < 0.05; *p* < 0.01; ****p* < 0.001.

TABLE 4 | The mediating effect of victim sensitivity on knowledge hiding.

	Effect	BootSE	BootLLCI	BootULCI	Percentage to total effect
Total effect	0.218	0.053	0.114	0.322	100%
Direct effect	0.103	0.055	-0.006	0.212	-
Total indirect effect	0.115	0.028	0.065	0.173	52.8%
Indirect effect 1	0.057	0.020	0.023	0.102	26.1%
Indirect effect 2	0.045	0.018	0.014	0.085	20.6%
Indirect effect 3	0.013	0.005	0.004	0.024	6.0%
1 minus 2	0.013	0.029	-0.042	0.070	-
1 minus 3	0.045	0.020	0.010	0.087	20.6%
2 minus-3	0.032	0.017	0.004	0.071	14.7%

→ knowledge hiding, with an effect value of 0.045, accounting for 20.4% of the total effect ratio. The path of indirect effect 3 was victim sensitivity → perceived time pressure → territoriality → knowledge hiding. The results show that the chain mediating effect was significant, accounting for 6.20% of the total effect. Further, 1-3 is the difference between indirect effect 1 and indirect effect 3, and the result was significant, as is 2-3, thus supporting H5A, H6A, and H7A.

② The Mediating Effect of Perpetrator Sensitivity on Knowledge Hiding

The mediating effect of perceived time pressure and territoriality on perpetrator sensitivity and knowledge hiding are shown in **Table 5**. The results show that the direct effect of perpetrator sensitivity on knowledge hiding was not significant. The bootstrap 95% confidence interval contained zero; thus, the perceived time pressure and territoriality play a complete

TABLE 5 | The mediating effect of perpetrator sensitivity on knowledge hiding.

	Effect	BootSE	BootLLCI	BootULCI	Percentage to total effect
Total effect	0.015	0.052	-0.088	0.118	-
Direct effect	-0.037	0.052	-0.139	0.065	-
Total indirect effect	0.052	0.018	0.019	0.090	58.4%
Indirect effect 1	0.039	0.014	0.015	0.068	43.8%
Indirect effect 2	0.005	0.011	-0.017	0.027	-
Indirect effect 3	0.009	0.004	0.002	0.019	10.1%
1 minus 2	0.034	0.018	0.001	0.072	38.2%
1 minus 3	0.030	0.013	0.007	0.059	33.7%
2 minus-3	-0.004	0.012	-0.032	0.019	-

TABLE 6 | Regression coefficients and significance.

	Knowledge Hiding			
	Effect	BootSE	BootLLCI	BootULCI
Perceived Time Pressure	0.184	0.054	0.079	0.290
Territoriality	0.190	0.053	0.085	0.295
Int_1	0.083	0.041	0.003	0.163

mediating role between perpetrator sensitivity and knowledge hiding, with a total effect of 0.089 (the absolute value of indirect effect + direct effect). The total indirect effect value was 0.052, accounting for 58.4% of the total effect. The path of indirect effect 1 was perpetrator sensitivity → perceived time pressure → knowledge hiding, with an effect value of 0.039, accounting for 43.8% of the total effect ratio. The confidence interval did not contain zero, indicating significance. The path of indirect effect 2 was perpetrator sensitivity → territoriality → knowledge hiding, with an effect value of 0.005, and a confidence interval that contained 0; thus, not significant. The path of indirect effect 3 was perpetrator sensitivity → perceived time pressure → territoriality → knowledge hiding. This chain mediation effect was found to be significant, accounting for 10.1% of the total effect. 1-2 is the difference between indirect effect 1 and indirect effect 2, and the result was significant, as is 1-3, thus supporting, H5B and H7B and rejecting H6B.

Moderating Effect Analysis

① The Moderating Role of Territoriality Between Perceived Time Pressure and Knowledge Hiding

Using Process3.3, victim sensitivity and perpetrator sensitivity and demographic variables were used as control variables. The results are listed in **Table 6**. Int_1 is the perceived time pressure × territoriality, with significant interaction term, indicating that the moderating effect is significant.

Figure 2 shows a moderating effect diagram. The results show that, regardless of the level of perceived time pressure, territoriality plays a positive moderating role between perceived time pressure and knowledge hiding, and the effect of perceived time pressure on knowledge hiding is always positive, thus supporting H9.

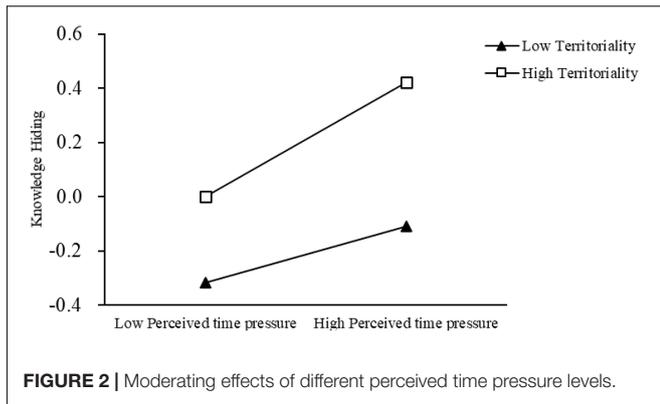


FIGURE 2 | Moderating effects of different perceived time pressure levels.

TABLE 7 | Moderated mediating regression coefficients and significance of victim sensitivity.

	Knowledge Hiding			
	Effect	BootSE	BootLLCI	BootULCI
Victim Sensitivity	0.108	0.055	-0.009	0.216
Perceived Time Pressure	0.184	0.054	0.079	0.290
Territoriality	0.190	0.053	0.085	0.295
Int_1	0.083	0.041	0.003	0.163

TABLE 8 | Moderated mediating effect of victim sensitivity.

	Moderated mediating effect			
	Effect	BootSE	BootLLCI	BootULCI
M-1SD	0.032	0.020	-0.001	0.076
M	0.058	0.019	0.025	0.100
M+1SD	0.084	0.027	0.037	0.143
Index	0.026	0.013	0.001	0.053
2 minus 1	0.026	0.013	0.001	0.053
3 minus 1	0.053	0.027	0.002	0.106
3 minus 2	0.026	0.013	0.001	0.053

② The Moderating Role of Territoriality Between Victim Sensitivity and Knowledge Hiding

We tested the moderating effect of the territoriality in the mediating path from victim sensitivity to knowledge hiding. The results are shown in Table 7, where Int_1 is the perceived time pressure × territoriality. In this mediation model, the moderating effect of territoriality was significant.

Table 8 shows the results of the mediating effect analysis. The results show that the mediating effect was 0.032 and the confidence interval contained 0 when subtracting one standard deviation from the moderator variable territoriality, indicating an insignificant mediating effect. When one standard deviation was added, the mediating effect increased to 0.084 with a confidence interval that did not contain zero, indicating a significant mediating effect. It can be seen that the mediating effect has significant changes under the regulation of territoriality. Further, the confidence interval of Index did not contain zero (Hayes, 2015), thus further indicating that the mediation model is valid.

In the table, 2-1 represents the difference between the mediating effect under M and M-1SD, 3-1 represents the difference between M+1SD and M-1SD, and 3-2 represents the difference between M+1SD and M. The results were all significant, thus supporting H10a and confirming the validity of the mediation model.

As shown in Figure 3, for the mediating effect of slope variation, as this can regulate the mediating effect during the second half only, and the direct effect of victim sensitivity on knowledge hiding was not significant, the direct effect is represented as a straight line parallel to the x-axis. With the augmentation of the regulating effect, the indirect effect becomes increasingly large, and simultaneously the total effect also increases. When $M_0 = 2.32$, the direct and indirect effects are equal, then the indirect effect becomes greater than the direct effect.

According to the results in Table 8, in the case of a negative one standard deviation, the indirect effect of victim sensitivity on knowledge hiding was not significant. In this study, we use continuous control variables. Additionally, the collocation method (Preacher et al., 2007) is used to estimate the mediation effect of the simple slope and to investigate the mediation effect significant points. Specific results are shown in Figure 4. When the territoriality is greater than -0.98, the mediating effect is significant, and with the increase of the moderating effect, the mediating effect becomes stronger, that is, the territoriality has a positive moderating

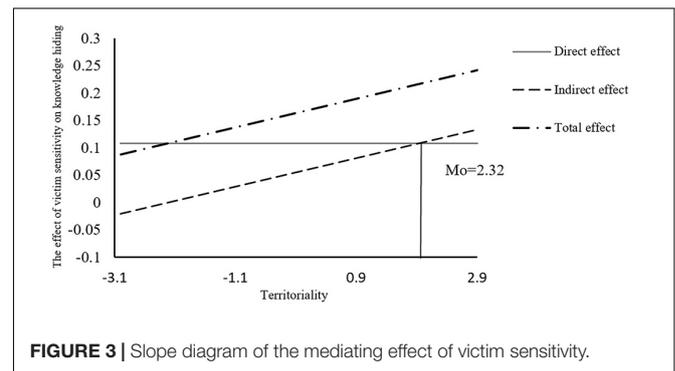


FIGURE 3 | Slope diagram of the mediating effect of victim sensitivity.

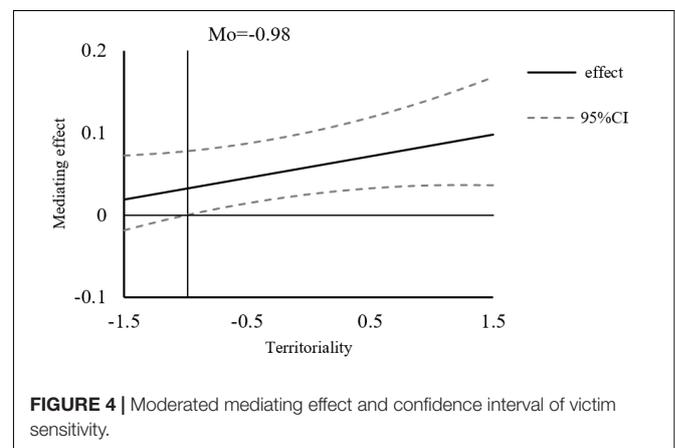


FIGURE 4 | Moderated mediating effect and confidence interval of victim sensitivity.

TABLE 9 | Moderated mediating regression coefficients and significance of perpetrator sensitivity.

	Knowledge Hiding			
	Effect	BootSE	BootLLCI	BootULCI
Perpetrator Sensitivity	-0.028	0.052	-0.129	0.074
Perceived Time Pressure	0.184	0.054	0.079	0.290
Territoriality	0.190	0.053	0.085	0.295
Int_1	0.083	0.041	0.003	0.163

TABLE 10 | Moderated mediating effect of perpetrator sensitivity.

	Moderated mediating effect			
	Effect	BootSE	BootLLCI	BootULCI
M-1SD	0.022	0.013	-0.001	0.050
M	0.040	0.014	0.016	0.070
M+1SD	0.057	0.020	0.023	0.102
Index	0.018	0.010	0.001	0.040
2 minus 1	0.018	0.010	0.001	0.040
3 minus 1	0.036	0.020	0.002	0.081
3 minus 2	0.018	0.010	0.001	0.040

influence on the relationship between victim sensitivity and knowledge hiding.

③ The Moderating Role of Territoriality Between Perpetrator Sensitivity and Knowledge Hiding

The moderating effect of territoriality in the mediating path from perpetrator sensitivity to knowledge hiding was tested. The results are shown in **Table 9**, where Int_1 is the perceived time pressure × territoriality. In this mediating model, the moderating effect of territoriality was significant.

The moderated mediating effect analysis is presented in **Table 10**. The results show that the mediating effect was 0.022 and the confidence interval contained zero when subtracting one standard deviation from the moderator variable of territoriality, and the mediating effect was not significant. When a standard deviation was added, the mediating effect increased to 0.057, the confidence interval did not contain zero, and the mediating

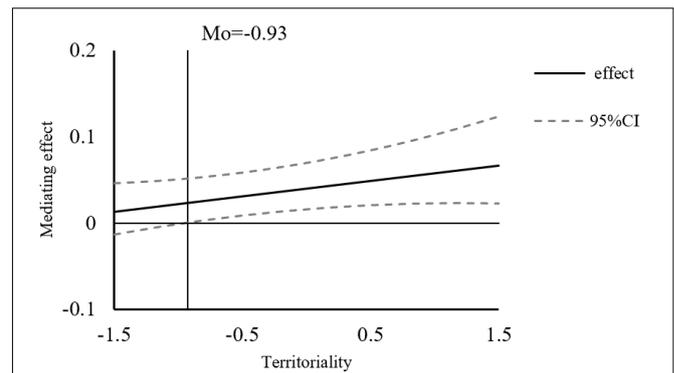


FIGURE 6 | Moderated mediating effect and confidence interval of perpetrator sensitivity.

effect was significant. It can be seen that the mediating effect changes significantly under the mediation of territoriality. Further, the confidence interval of Index did not contain zero, further indicating that the mediation model is valid. Comparisons between the mediating effects were also significant, thus supporting H10b and confirming the validity of the mediation model.

As shown in **Figure 5**, for the intermediary effect of slope variation, as this can regulate the mediation effect only during the second half, and the direct effect of perpetrator sensitivity on knowledge hiding was not significant, the direct effect is represented as a straight line parallel to the x-axis. With the augmentation of the regulating effect, the indirect effect becomes increasingly large, and simultaneously the total effect also increases due to the direct effect being negative. Therefore, when the total effect is equal to zero, the direct and indirect effects are equal. When $Mo = 0.67$, the direct and indirect effects are equal, then the indirect effect becomes greater than the direct effect.

According to the results in **Table 10**, in the case of a negative one standard deviation, the indirect effect of perpetrator sensitivity on knowledge hiding was not significant. In this study, we use continuous control variables. Additionally, the collocation method is used to estimate the mediation effect of

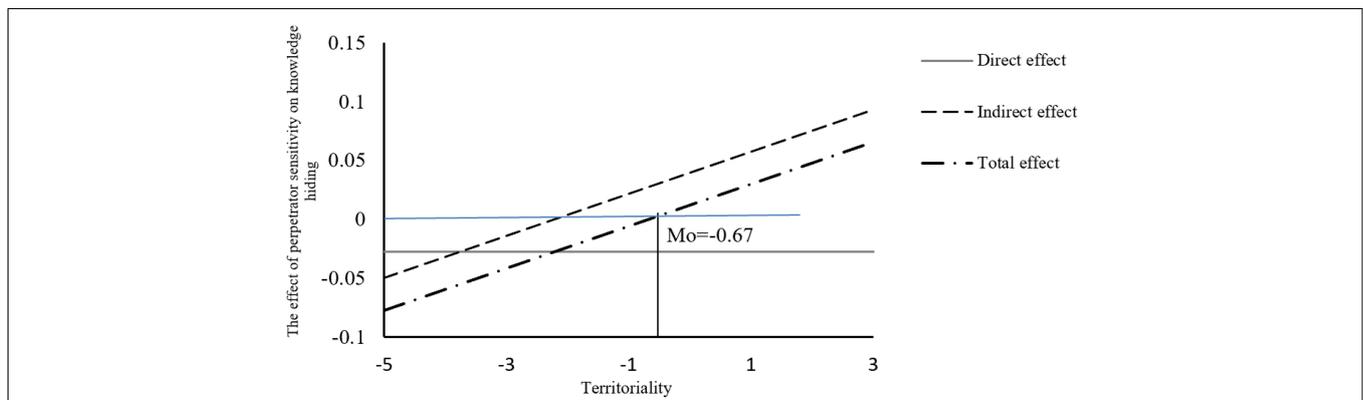


FIGURE 5 | Slope diagram of the mediating effect of perpetrator sensitivity.

the simple slope and investigate the mediation effect significant points. Specific results are shown in **Figure 6**. When the territoriality is greater than -0.93 , the mediating effect is significant, and with the increase of the moderating effect, the mediating effect becomes stronger, that is, the territoriality has a positive moderating effect on the relationship between perpetrator sensitivity and knowledge hiding.

DISCUSSION AND CONCLUSION

Main Conclusion

Based on the obtained results, we draw the following conclusions:

① Victim sensitivity has a positive direct effect on knowledge hiding, whereas perpetrator sensitivity has insignificant negative effect. In addition, the two justice sensitivities have significant impact on the perceived time pressure. It can be concluded that, regardless of the type, for people with high justice sensitivity, their sense of injustice around them will be enhanced, thus having a positive impact on perceived time pressure. Moreover, victim sensitivity has a positive effect on territoriality, indicating that victims tend to protect their own interests, thus increasing people's territoriality, whereas the influence of perpetrator sensitivity on territoriality is not supported. The effect of perceived time pressure on territoriality is verified, which indicates that employees under time pressure will improve their territoriality behavior to protect their interests. On the one hand, perpetrator feel guilty. It will lead to reduce the knowledge hiding behavior (Fang, 2017). On the other hand, people with high perpetrator sensitivity are also highly sensitive to the injustice, which may reduce harmful behaviors. But it does not mean that will harm their own interests (Stavrova and Schlösser, 2015). The effect of perpetrator sensitivity on knowledge hiding is not significant because of the superposition of two kinds of psychological.

② Perceived time pressure can act as an independent mediating variable and play a mediating role. In particular, victim sensitivity can improve the perception of time pressure. Under time pressure, employees think that time resources have been occupied; thus, they will seek to make up for their loss of resources by engaging in knowledge hiding behaviors. The indirect path of territoriality as an independent mediating variable is also significant, indicating that people with high victim sensitivity will enhance their territoriality behavior to protect their interests from being damaged, while people with high territoriality will value their resource advantages, which will further promote the knowledge hiding behaviors. Since perception of time pressure improves people's territoriality, victim sensitivity can cause knowledge hiding by increasing people's perception of time pressure. In addition, although the total effect of perpetrator sensitivity on knowledge hiding is not significant, it is actually the result of the direct relationship between perpetrator sensitivity and knowledge hiding as well as the mediating effect of perceived time pressure and territoriality. Moreover, perpetrator sensitivity increases perceived time pressure, which in turn increases knowledge hiding behaviors. Therefore, the superposition of the positive indirect and negative direct effects (although not significant) leads to an

insignificant relationship between perpetrator sensitivity and knowledge hiding.

③ The moderating effect of territoriality in both mediating paths is supported. The two types of justice sensitivities have a positive influence on the employees' perception of time pressure, resulting in knowledge hiding behaviors through two indirect paths. People with high territoriality under time pressure will increasingly adopt a knowledge hiding behavior, whereas those with low territoriality, even under time pressure, are unlikely to hide knowledge. By adjusting the relationship between perceived time pressure and knowledge hiding, territoriality can further regulate the sensitivity of victims and perpetrators to knowledge hiding generated by perceived time pressure. The higher the territoriality, the higher the degree of justice sensitivity indirectly affecting knowledge hiding; whereas the lower the territoriality, the lower the degree of the indirect influence of justice sensitivity on knowledge hiding or the more insignificant the relationship.

Theoretical Contributions

① Identifying the Influencing Factors of Knowledge Hiding

Currently, there are few studies on the influence of individual factors on knowledge hiding despite its great significance to the literature on knowledge hiding at the individual level. In the past, many studies have shown that justice sensitivity has a significant effect on the psychology and behavior of employees; however, research in exploring the knowledge management field has been relatively insufficient. From the perspective of organizational justice, this paper investigates the mechanisms of employees' knowledge hiding behavior to facilitate research and theory development.

② Investigating the Influence of Justice Sensitivity on Outcome Variables

Since knowledge hiding is a type of self-protection behavior, and the theory of justice sensitivity can explain people's self-protection behavior, this study focuses on justice sensitivity, studies its influence on knowledge hiding, and discusses the mechanisms of victim sensitivity and perpetrator sensitivity. Although some previous studies have combined the theories of resource protection and psychological ownership to explore the phenomenon of knowledge hiding, the relationship between justice sensitivity and knowledge hiding has not been sufficiently explored. Therefore, this study not only enriches the justice sensitivity theory and its relationship with knowledge hiding, but also explores its relationship with perceived time pressure and territoriality.

③ Further Study on the Effect of Perceived Time Pressure and Territoriality on Knowledge Hiding

Time is an important resource, and under time pressure, people will think that their rights have been violated. Thus, it is meaningful to introduce the variable of perceived time pressure to explore the mechanism of people's knowledge hiding. Moreover, according to the theory of psychological ownership of ideas, information, knowledge, and professional knowledge, the gain that people obtain when they invest considerable amounts of time and energy promotes all organizations to engage in

territorial behaviors. Under this psychological effect, the impact of justice sensitivity on knowledge hiding behavior is mediated by the perceived time pressure and territoriality behavior. This implication is of great significance to the application of psychological ownership theory and the study of knowledge hiding and justice sensitivity. This study further explores the moderating effect of territoriality on the path of perceived time pressure as a single mediating variable.

Practical Significance

This study has important practical implications and can provide new insights for the knowledge management of enterprises and organizations. In the case of injustice, the employee is either the victim or the perpetrator as the first participant. Victims are on the losing side of the injustice, and if they are not consoled at the organizational level, that will only increase their anger and lead to a more negative behavior. However, if the organization recognizes the existence of injustice, it should make timely compensations to the victims for their losses and provide favorable psychological conditions to protect the victims' interests. Nevertheless, compensating the victims does not mean punishing the perpetrators. Although the perpetrators may cause knowledge hiding behaviors through various other factors, they are also in an unfair event. Even if the perpetrator is not the party whose interests are damaged, he/she feels that there is injustice in the organization and will continue to maintain his own interests in different ways. Therefore, organizations should provide perpetrators with a certain degree of psychological counseling to alleviate their inner feelings of guilt and alter their negative behavior. In order to mollify the sense of injustice and quench the anger and guilt, the management should take the effective organizational remedy (Zhu and Kou, 2014). The organization should lay down rationalized regulations to ensure justice. It could effectively protect the interests of employees and reduce knowledge hiding behavior.

In terms of working hours, although Chinese enterprises have a perfect overtime system and offer high salaries, if the time pressure reaches a certain level, employees may think that their loss of resources cannot be compensated by the salaries paid by the company, which will lead to the outbreak of a series of negative events. A number Therefore, enterprises should not blindly pursue results by making employees work excessively overtime. Instead, enterprises should have a certain degree of control, offer rationales for overtime work, and give high wages to the employees to compensate for their time, thus making the employees feel the worthiness of their overtime work and reducing the probability of engaging in knowledge hiding behaviors.

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Research Limitations and Future Prospects

First, this study discusses the regulating effect of territoriality, which acts as both a mediating and a moderating variable. However, in reality, there may be more external variables that regulate the model relationships. Second, limited to the theoretical model, the study fails to further explore the specific relationship between perpetrator sensitivity and territoriality. Thus, from the perspective of organizational justice, future studies can investigate the influence of other factors in the field of organizational justice and knowledge concealment, such as fairness sensitivity and other types of organizational justice. Thirdly, this paper did not extensively investigate the organizational knowledge systems. Therefore, future research can focus on knowledge in the organizational context with respect to the aspects of creation, innovation, and performance, and investigate the pre-variables and determinants that affect the knowledge hiding phenomenon. At last, justice sensitivity may be influenced by cultural characteristics. Thus, whether the relationship between justice sensitivity and other variables in this study is applicable to foreign cultural backgrounds needs further verification.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

ZJ-S and JY-N designed the study. HH and RD-Y collected data and performed the data analysis. ZJ-S and JY-N checked the result. HH created figures. RD-Y made tables. ZJ-S and JY-N wrote, reviewed, and edited the manuscript. All authors wrote the manuscript and read and agreed to the published version of the manuscript.

FUNDING

This work was supported by the academic team “Data Science and Management Decision” of South-Central University for Nationalities.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX A

Here Are Descriptive Statistics

TABLE A1

	Skewness		Kurtosis	
	Statistic	Standard Error	Statistic	Standard Error
Knowledge hiding1	0.846	0.123	-0.133	0.246
Perpetrator Sensitivity1	-1.071	0.123	1.553	0.246
Victim Sensitivity1	-1.251	0.123	1.828	0.246
Victim Sensitivity2	-0.841	0.123	0.351	0.246
Victim Sensitivity3	-0.654	0.123	-0.188	0.246
Victim Sensitivity4				

TABLE A2

	<i>N</i>	Minimum	Maximum	Mean	Standard Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Knowledge hiding1	391	1.00	6.50	3.0488	1.34554	1.810
Perpetrator Sensitivity1	391	1.40	7.00	5.0972	1.00818	1.016
Victim Sensitivity1	391	1.22	6.78	4.9255	1.04523	1.093
Territoriality1	391	1.00	7.00	4.9838	1.29695	1.682
Perceived Time Pressure1	391	1.00	7.00	4.8261	1.23915	1.535
Valid <i>N</i> (List Status)	391					



Policy Announcement, Investor Attention, and Stock Volatility: Evidence From the New Energy Vehicle Industry

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New energy vehicle (NEV) policies have greatly promoted the growth of the NEV industry in China, while also attracting a lot of investor attention. Using Chinese NEV concept stocks and related industrial policies, including purchase tax incentives (PTI) and promotion and application (P&A) policies, issued from 2011 to 2020 as the research setting, this paper adopts a panel data model to examine the impact of policy announcement on the volatility of NEV concept stocks, as well as the mediating role of investor attention in transmitting the impact. We find that NEV P&A policies have a significant and positive impact on NEV concept stock volatility, while PTI policies do not have a significant impact. Moreover, investor attention plays a partial mediating role in transmitting the impact of P&A policies on NEV stock market by increasing the stock volatility risk. Furthermore, there is heterogeneous effect of equity ownership in the relationship between policy announcement and investor attention on the volatility of NEV concept stocks; non-state-owned firms are more sensitive to the NEV P&A policies than state-owned firms. By analyzing the relationship between policy announcement and concept stock volatility, this paper enriches the research on NEV concept stocks and provides policy implications for the NEV industry.

Keywords: new energy vehicle, policy announcement, stock volatility, investor attention, Chinese

OPEN ACCESS

Edited by:

Haiyue Liu,
Sichuan University, China

Reviewed by:

Yi Zhimin,
Sichuan University, China
Yile Wang,
Sichuan University, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 18 December 2021

Accepted: 03 February 2022

Published: 23 February 2022

Citation:

Su M and Wang C (2022) Policy
Announcement, Investor Attention,
and Stock Volatility: Evidence From
the New Energy Vehicle Industry.
Front. Psychol. 13:838588.
doi: 10.3389/fpsyg.2022.838588

INTRODUCTION

As global warming intensifies, countries have introduced a variety of carbon emission reduction policies to promote sustainable development (Yang et al., 2020). With the transportation sector being one of the major sources of carbon emissions (Zhu and Li, 2017), the development of new energy vehicles (NEV) is thus critical to building a low-carbon society (Liu et al., 2021). From 2001 to 2020, the Chinese government implemented a series of policies to encourage the use of NEV (Tian et al., 2021; Wan et al., 2021), including regulations, financial incentives, pilot demonstrations, and charging infrastructure deployment (Tian et al., 2020). These policies, together with energy market reform, have assisted the rapid growth of China's NEV industry; in 2020, the sales of NEVs reached about 1.4 million units, accounting for roughly two fifths of global totals (Wu et al., 2021).

Policy announcement not only has an impact on the real economy, but they may also cause stock market volatility. Government control and regulation are essential for a functioning stock market, and government policies can play a regulatory role in stock markets. Previous studies have shown that macro policies have a significant impact on stock market volatility (Engle and Rangel, 2008). The socialist market economy with Chinese characteristics is a combination of effective government intervention and efficient market, and policy changes have a strong influence on Chinese economy (Xue et al., 2019, 2021). Compared to other countries, the Chinese government implements policies more frequently (Zhang et al., 2021a), and the impact of policy changes on Chinese stock market is more prominent (You et al., 2017). Therefore, it is important to explore the impact of policy changes on the stock market of NEVs in China. Concept stocks are a distinct category of the Chinese stock market; it is a collection of stocks related to a specific sector that have emerged in response to hot events or concepts. China's NEV industry policies have given rise to the "NEV concept stock" segment in the stock market. On 23 April 2020, the day the NEV subsidy extension policy¹ was released, the Baidu search volume for NEV stocks increased by 18% month on month.²

Different policies have different impact on the stock market. For example, monetary policies can cause larger stock market fluctuations compared to fiscal policies. Currently, NEV-related policies mainly focus on NEV purchase tax incentives (PTI) and promotion and application (P&A). Since there is a lack of comparative research on such policies in prior studies, this paper divides NEV policies into two categories, namely, purchase tax incentives (PTI) and P&A policies, and analyzes their impact on the volatility of related concept stocks.

Investor attention is an important cause of liquidity and volatility in stock markets (Fang and Peress, 2009). When faced with a large amount of information, investors may make inaccurate judgments due to their limited information processing ability and herd effects (Hirshleifer and Teoh, 2003; Barber and Odean, 2008), and they tend to be drawn to hot concepts or events and prefer to focus on hot markets rather than a specific stock (Carro et al., 2015; Balcilar et al., 2017). A concept stock is a type of stock that was created as result of a hot event or concept, and it is subject to the board effect, which means that stocks of the same concept rise and fall together. Therefore, this paper will investigate the mediating effect of investment attention in the impact of policy announcement on stock market volatility.

To sum up, China's NEV policy has promoted the development of its NEV industry, which in turn attracts investor attention and causes stock market volatility. Given the sensitivity of the concept stock sector to policy changes and the differences in how different policies affect stock market, this paper conducts

an empirical study on the impact of NEV policies on concept stock price behavior and the mediating effect of investor attention in conveying the impact of NEV policies into concept stocks. This paper takes Chinese NEV concept stocks as the research setting and selects relevant Chinese industrial policies, including PTI and P&A policies, issued from 2011 to 2020 for empirical analysis. We find that NEV P&A policies have a significant and positive impact on the volatility of NEV concept stocks, while the PTI do not have a significant impact. Moreover, increased investor attention will raise the impact of NEV P&A policies on NEV concept stock volatility. Furthermore, there is heterogeneity across natures of equity in the impact of policy announcement and investor attention on the volatility of NEV concept stocks—non-state-owned enterprises are more sensitive to NEV P&A policies than state-owned enterprises. By analyzing the relationship between policy announcement and the volatility of NEV concept stocks, this paper enriches the study of how policies affect NEV concept stocks. It also provides a theoretical reference for formulating effective NEV-related policies.

Using China's concept stock market as the research setting, this paper investigates the impact of new energy policies on new energy-related stock price volatility and explores the potential channels through which policies affect the stock market by analyzing the mediating effect of investor attention. We believe that this will be a promising area for future research that can be extended to other developing-country stock market studies. First, we select concept stocks, a distinct segment of China's stock market, as the research object to examine the impact of the announcement of NEV policies on the volatility of related stocks. Second, we investigate the relationship between investor attention and concept stock trading activity, providing new insights for future research on stock market volatility. More importantly, this paper examines the mediating effect of investor attention in the relationship between policy announcements and the stock market, adding to the body of literature on investor attention and providing references for future research.

The remainder of the paper is structured as follows. In the following section, we review the concept stocks and the literature related to the impact of policy announcement and investor attention on the stock market before proposing the research hypotheses. "Research Design" introduces the data sources and variables for the research design. "Results" conducts the empirical analysis and reports the results. "Conclusion" summarizes the findings and proposes policy recommendations.

LITERATURE REVIEW

Concept Stock

Concept stocks are created in response to certain events and are related to hot concepts of the stock market. Concept stocks have a greater advertising effect, because they not only represent a certain type of stock, but also signify popular market trends. Investors, especially retail investors, are more likely to engage in irrational investment behavior when a hot topic or concept is widely followed by the market, which boosts the popularity

¹The policy is as: "Notice on Improving the Fiscal Subsidy Policy for the Promotion and Application of New Energy Vehicles," from the Chinese government website: <http://www.gov.cn/>

²The information is sourced from the official website of Baidu Index: <https://index.baidu.com/v2/index.html#/>

of concept stocks. In addition, concept stocks have a “board effect,” where stocks under the same concept share an internal consistency. For retail investors, who have limited information processing ability and are often unable to fully grasp the dynamics of each stock, they tend to follow the stock market hot spots and focus on a certain type of stock (Chen and Haga, 2021). As a result, investor attention swings to changing market hot topics, causing the corresponding concept stock price to rise and fall at the same time.

China’s NEV concept stock emerged in 2009, when the central government of China issued a policy on 23 January 2009, committing to vigorously developing the NEV industry, and proposing to implement energy-saving and NEV demonstration and promotion pilots in 13 cities, and providing purchase subsidies to enterprises that responded positively to the national policy. Since then, new energy concept stocks have been gaining popularity. China has been devoted to developing NEVs for the past 10 years (Zhang et al., 2021b), establishing a number of policies in the process, and NEV concept stocks have remained popular. In 2015, China issued the Notice on the Fiscal Support Policy for the Promotion and Application of NEVs from 2016 to 2020, which boosted the popularity of NEV concept stocks and enticed many car manufacturers to participate in the new energy transition. In 2020, the government further emphasized the need to accelerate the promotion of NEVs. Major companies saw this as an indication of a bright future for the NEV market and began to participate in its production, making NEV concept stocks surge in popularity.

The Impact of Policy Announcement on Stock Markets

The development of stock markets is inseparable from government promotion and regulation; government policies can play a certain regulatory role in stock markets, and the state ensures the healthy and smooth operation of stock markets through various policies. Previous studies have found that stock market volatility is closely related to changes in macroeconomic indicators (Poon and Taylor, 1991), and the enactment of macroeconomic policies can lead to a significant increase in stock market volatility (Engle and Rangel, 2008). After the government announces a policy change, stock prices will react accordingly (Pastor and Veronesi, 2012). For example, Ramiah selected stocks listed on the Australian Stock Exchange from 2005 to 2011 as the research setting and assessed the impact of 19 environmental regulation announcements on stock prices using the event study method and found that the Australian stock market is more sensitive to announcements of carbon pollution reduction policies, which exhibit varying effects on abnormal stock returns (Ramiah et al., 2013).

This is especially true for the Chinese stock market, and in order to foster market growth, the government implemented various policies to intervene in the operation of the stock market, resulting in the formation of China’s “policy market.” The impact of policy announcement on Chinese stock market volatility is especially prominent in a bull market (You et al., 2017).

The announcement of new environmental regulations will immediately have a negative impact on the stock returns of heavily polluting firms, and the market reaction will become more pronounced as the regulations are implemented (Guo et al., 2020). A new environmental inspection system has an even greater impact on the stock market than environmental regulations; it can result in a significant decrease in shareholder value for heavily polluting firms, and neither political connections nor large firm size can mitigate this effect (Sam and Zhang, 2020). New energy policies are no exception: Hsiao et al. (2021) find that solar energy policies announced between 2005 and 2020 not only increased the volatility of China’s domestic stock market but also had a significant impact on foreign markets in Japan, Germany, and the United States.

Therefore, the development of the stock market is inextricably linked to national policies. A large number of studies have explored the overall impact of macro policies on the stock market, and only a few scholars have analyzed the impact of a particular sector’s policies on its concept stocks. However, concept stocks, as a unique stock segment in China, are more sensitive to policy announcement due to their own characteristics. Current research in this area focuses on two perspectives: one is qualitative analysis, which quantitatively analyzes the impact of policy announcement on the stock market; the other is event study, which explores the impact of policies on relevant concept stocks before and after their promulgation. Prior research has confirmed a significant correlation between national policy announcement and relevant concept stocks in artificial intelligence, supply chain finance, and science and technology innovation (Tversky and Kahneman, 1973; He et al., 2011). Therefore, we argue that the promulgation of NEV policy will also have a significant impact on the volatility of related concept stocks, and we hypothesize as follows.

Hypothesis 1: There is a significant correlation between the promulgation of new energy vehicle policy and the volatility of new energy vehicle concept stocks.

Although policy announcement can have an impact on the stock market, the diversity of policy types leads to differences in their impact. For example, both monetary and fiscal policies can have an impact on the stock market, but in terms of volatility, the implementation of monetary policies is more likely to cause stock market volatility in most sectors (He et al., 2011). In addition, the impact varies depending on the effective duration of the policy: short-term policies have a greater impact on the stock market than medium- and long-term policies, and although medium- and long-term policies have a positive relationship with market volatility, they have a weaker impact on it (Foresti and Napolitano, 2017). The current NEV policies can be divided into two categories, purchase tax incentives (PTI) and P&A policies. Among them, the PTI policies are promulgated at lengthy intervals, with insufficient and tiny tax adjustments, and in a unitary manner, which cannot clearly reflect the strong support for NEVs in national policy. As the government continues to promote NEVs, the continuity of the P&A policies is constantly strengthened,

and its stability is significantly improved. Thus, it can be adjusted according to market changes in a timely manner.

Therefore, this paper divides NEV policies into two categories by content, purchase tax incentives and P&A policies, examines their respective effects on the volatility of related concept stocks, and further explores the impact of different policy types on concept stocks. Hereby, we propose the following hypotheses.

Hypothesis 1a: Purchase tax incentives have no significant effect on the volatility of new energy vehicle concept stocks.

Hypothesis 1b: New energy vehicle promotion and application policies have a significant and positive effect on the volatility of new energy vehicle concept stocks.

The Mediating Role of Investor Attention

Prior studies have discovered many modern financial anomalies that cannot be explained, such as Monday effect, equity premium puzzle, and media effect. To explain these anomalies, behavioral finance was born. Behavioral finance theory argues from a psychological perspective that investors' behavioral decision making is complex that investors' decisions are not always rational; on the other hand, it suggests that even if investors are rational, they are boundedly rational or of limited rationality (Barberis and Thaler, 2005). In behavioral finance, the easiest way to examine whether investors behave irrationally is to study investor behavior in real market conditions (Cooper and Kovacic, 2012). Previous research argues that people have limited processing ability when making investment decisions (Simon, 1955; Tversky and Kahneman, 1973). This is referred to as the limited attention theory, which is widely used in financial market research. Investor attention was thought to be an important cause of stock market liquidity and volatility and financial market anomalies (Fang and Peress, 2009).

Investor decision-making behavior will change as a result of their limited ability to allocate their attention, and process and interpret information (Hirshleifer and Teoh, 2003). Stocks that rise faster tend to attract the greatest attention and investment (Barber and Odean, 2008; Aboody et al., 2010), leading to higher stock returns and volatility (Seasholes and Wu, 2007). Therefore, when positive news was reported during the period of low investor attention, it helps to attract investor attention and affects the firm's economic performance (Loh, 2010). Meanwhile, there are differences in the impact of investor attention on the stock market in different market dynamics; investors' ability to interpret information is generally better in bull market than in the bear ones (Aouadi et al., 2018).

In addition to stocks with anomalous returns, the occurrence of a certain event will also attract investor attention and thus influences their behaviors (Kim, 2013; Jiang et al., 2021). Chinese capital market is relatively immature with its high proportion of individual investors (Admati and Pfleiderer, 2009). Strong government intervention is also a distinct feature of the Chinese market economy. Unlike other countries, the Chinese government implements policies more frequently, which introduces greater

uncertainty into economic policies (Zhang et al., 2013). As a result, Chinese investors are gradually shifting their attention to policy announcement, which in turn influences their investment decisions (Naseem et al., 2021). Later, it was documented that individual investors begin to pay attention to stock information relating to a financial event after that event occurs and prefer to focus on the market as a whole rather than on a specific stock when faced with a plethora of information (Carro et al., 2015; Balcilar et al., 2017). Concept stocks are the type of stocks that are created as a result of certain events or topics. Investors' attention to concept stocks has a significant impact on concept stock prices, and accordingly, increased attention can inflate stock prices, boost stock returns, and increase trading volumes.

Policy announcement and investor attention can both have a significant impact on stock markets, but what is the relationship between the three? Some studies argue that investor attention plays a partial role in transferring the impact of industrial policy to overall stock pricing (Baron and Kenny, 1986), while others argue that investor attention moderates the effect for policy announcement (Peng and Xiong, 2006). Through a systematic literature review, we find that although there are abundant studies on the impact of policy announcement or investor attention on stock market, there are few papers that quantitatively analyze the relationship between policy announcement, investor attention, and stock market. Therefore, this paper introduces investor attention into the study of the relationship between policy announcement and stock market, and argues that the promulgation of NEV policies can influence NEV concept stock volatility by attracting investor attention to these stocks. Hereby, we propose the following hypothesis.

Hypothesis 2: Investor attention plays a mediating effect in transmitting the impact of new energy vehicle-related policy announcement into new energy vehicle-related concept stock volatility.

RESEARCH DESIGN

Sample Selection and Data Sources

This paper uses Chinese NEV concept stocks from 2011 to 2020 as the research setting. The stock characteristics data such as opening price, closing price, price fluctuations, market capitalization, total equity, and turnover of 31 NEV concept stocks for 2,294 trading days were obtained from Wind database.

The new energy policy data were collected from the websites of the Ministry of Industry and Information Technology of the People's Republic of China, the State Council of the People's Republic of China, the State Taxation Administration of the People's Republic of China, and the Ministry of Science and Technology of the People's Republic of China from 2010 and 2020. Baidu index was chosen as a proxy variable for investor attention, and "stock code" was used as a keyword to extract daily Baidu search data using Python scrapping technique. The rest of the control variables were obtained from the China Stock Market and Accounting Research (CSMAR) Database and NetEase Finance website.

TABLE 1 | List of policies on new energy vehicles from 2010 to 2020.

Date	Policy	Category
30 May 2010	Circular on expanding the demonstration and promotion of energy saving and new energy vehicles in the public service field	P&A
4 June 2010	A circular on pilot subsidies for private buyers of new energy vehicles	P&A
14 October 2011	Circular on further promoting the demonstration and pilot work of energy-saving and new energy vehicles	P&A
6 March 2012	Circular on tax policies for vehicles and vessels using new energy to save energy	PTI
17 September 2013	Notice on continuing the promotion and application of new energy vehicles	P&A
30 September 2013	Notice on the promotion of energy-saving and environment-friendly cars of 1.6 liters or less	P&A
28 January 2014	Notice on further promotion and application of new energy vehicles	P&A
21 July 2014	Guidelines on accelerating the promotion and application of new energy vehicles	P&A
1 August 2014	New energy vehicle purchase tax exemption announcement	PTI
13 March 2015	Implementation opinions of the Ministry of Transport on accelerating the promotion and application of new energy vehicles in the transportation industry	P&A
22 April 2015	Notice on financial Support Policies for the promotion and application of New energy Vehicles from 2016 to 2020	P&A
21 May 2015	Notice on improving the price subsidy policy for refined oil on city buses to speed up the promotion and application of new energy vehicles	P&A
7 May 2015	Circular on preferential tax policies for vehicles and vessels using new energy to save energy	PTI
20 January 2016	Notice on the "13th Five-Year" new energy vehicle charging infrastructure incentive policy and strengthen the promotion and application of new energy vehicles	P&A
29 December 2016	Notice on adjusting fiscal subsidy policies for the promotion and application of new energy vehicles	P&A
26 December 2017	New energy vehicle purchase tax exemption announcement	PTI
12 February 2018	Notice on adjusting and improving fiscal subsidy policies for the promotion and application of new energy vehicles	P&A
10 July 2018	Notice on the preferential policy of vehicle tax for energy-saving and new energy vehicles and vessels	PTI
26 March 2019	Circular on further improving fiscal subsidy policies for the promotion and application of new energy vehicles	P&A
8 May 2019	Notice on supporting the promotion and application of new energy buses	P&A
28 June 2019	Announcement on continued implementation of preferential tax policies for vehicle purchase	PTI
16 April 2020	Announcement on the new energy vehicle purchase tax exemption policy	PTI
23 April 2020	Circular on improving fiscal subsidy policies for the promotion and application of new energy vehicles	P&A

Variables

This section introduces dependent variable, explanatory variable, mediation variable, and control variables, and presents descriptive statistical analysis.

Dependent Variable

The volatility of NEV concept stocks (*Vol*) is the dependent variable. Volatility reflects the asset price fluctuations and is an important indicator of uncertainty in return on assets. In this paper, the standard deviation of the log-return of the 20-day moving average is used to represent concept stock volatility (*Vol*), which is calculated as follows.

$$Vol_{i,t} = \sqrt{\frac{\sum (X_{i,t} - \bar{X})^2}{N - 1}}$$

$$\bar{X} = \frac{\sum X_{i,t}}{N}$$

Where $Vol_{i,t}$ denotes the volatility of stock i in period t , N is the number of observations, and $X_{i,t}$ represents the logarithmic return of stock i in period t , which is the natural logarithm of closing price of the day divided by the closing price of the previous day.

Explanatory Variable

Policy announcement (*Tep*, *Pap*). Following previous research on NEV-related policies, the national NEV policies are divided

into two categories, the PTI, and P&A policies. Following Guo et al. (2020), we construct the dummy variable to quantify the impact of the policy announcement. In the baseline regression, if the policy was announced before the 15th day of the month, the policy is considered to mainly affect the stock market in the current month, and therefore, the dummy variable of the current month is set to 1. If the policy was announced after the 15th day, the policy is considered to mainly affect the stock market in the next month, and therefore, the dummy variable of the next month is set to 1. So, the dummy variable of the remaining months is set to 0. In addition, to test the robustness of the baseline results, this paper reconstructs the dummy variable for policy announcement using the 20th day of the current month as the cut-off point to re-estimate the baseline regression. *Tep* represents the purchase tax incentive policy, and *Pap* represents the P&A policy.

We collected the policies related to NEVs that were issued by government authorities from 2010 to 2020 through the websites of the Ministry of Industry and Information Technology, the State Council, the State Taxation Administration, and the Ministry of Science and Technology of the People's Republic of China. Because policies issued by local governments are frequently extensions of national policies, only policies issued at the national level are considered for their impact in this paper. PTI policies are implemented to exempt specific types of NEVs from vehicle purchase tax in order to increase the use of NEVs. P&A policies are implemented in each city to promote NEVs, with specific application goals and a variety of government subsidies and incentives. **Table 1** summarizes China's national policies for

promoting NEVs from 2010 to 2020, including seven PTI policies and 16 P&A policies.

Mediation Variable

Investor attention (*Nea*). Following existing studies (Zhang et al., 2013; Zhang and Wang, 2015; Wan et al., 2021), we use Baidu index as a proxy variable and obtain the Baidu index data of the NEV concept stock codes from 4 January 2011 to 10 June 2020 using the Python scrapping technique. The Baidu search index data of 2,294 trading days were eventually retained. Due to the large scale of the Baidu search index data, we take the natural logarithm to mitigate potential heteroskedasticity issues. *Nea* stands for investors' attention to NEVs.

Control Variables

We control for the market capitalization of individual stocks (*Size*), turnover rate (*Tur*), volatility of the CSI 300 index (*HVol*), stock market crash dummy variable (*Guz*), and first trading day dummy variable (*Time*; Kaplanski and Levy, 2010; Levy and Yagil, 2011). All variables are detailed in **Table 2**. The descriptive statistics of all variables are displayed in **Table 3**.

RESULTS

Baseline Results

To examine the impact of policy announcement on NEV concept stock volatility, we estimate the following regression:

$$Vol_{i,t} = \alpha_i + \beta_1 Tep + \beta_2 Pap + \beta_3 Size_{i,t} + \beta_4 Tur_{i,t} + \beta_5 HVol_{i,t} + \beta_6 Time + \beta_7 Guz + \gamma_t + \mu_i + \varepsilon_{i,t}$$

where $Vol_{i,t}$ represents the volatility of the i th stock in period t ; *Tep* is purchase tax incentives, and *Pap* is promotion and application policies; and the control variables include market capitalization of individual stocks ($Size_{i,t}$), turnover rate ($Tur_{i,t}$), volatility of the CSI 300 index ($HVol_{i,t}$), first trading day dummy variable (*Time*), and stock market crash variable (*Guz*). We also control for industry fixed effects (*Industry FE*), individual fixed effects (Individual FE), and time fixed effects (Time FE).

For the above panel data model, we conduct the *F*-test, Hausman test, heteroskedasticity test, and cross-sectional dependence test. The results show the presence of individual effects, heteroskedasticity, and cross-sectional dependence. Therefore, this paper adopts the panel corrected standard error (PCSE) method proposed by Beck and Katz (1995) for the empirical analysis, i.e., the standard errors in the fixed-effect model are corrected. To avoid biased results caused by two policies being announced in the same month, we first estimate the baseline model by investigating the impact of purchase tax incentive (*Tep*) and promotion and application policy (*Pap*) on the stock price volatility, respectively; we also add *Tep* and *Pap* together into the baseline model to investigate their

TABLE 2 | Variable descriptions.

	Variables	Index	Definition
Dependent variable	<i>Vol</i>	New energy vehicle concept stock volatility	Daily volatility of new energy vehicle concept stock from 4 January 2011 to 10 June 2020
Explanatory variable	<i>Tep</i>	Purchase tax incentive	National policies related to purchase tax incentives for new energy vehicles from 2011 to 2020
	<i>Pap</i>	Promotion and application policy	National policies related to the promotion of new energy vehicles from 2011 to 2020
	<i>Nea</i>	Investor attention to new energy vehicle concept stock	Natural logarithm of the sum of Baidu search index of new energy vehicle concept stock codes
Control variable	<i>Size</i>	Market capitalization of individual stocks	Natural logarithm of daily market capitalization of individual stocks
	<i>Tur</i>	Turnover rate	Ratio of stock turnover to total equity
	<i>HVol</i>	Volatility of the CSI 300 index	Daily volatility of the CSI 300 Index from 4 January 2011 to 10 June 2020
	<i>Guz</i>	Stock market crash dummy variable	1 for the period from 26 June 2015 to 31 December 2015, and 0 for the rest of the trading days
	<i>Time</i>	First trading day dummy variable	1 for the first day of a continuous trading day and 0 for the rest

TABLE 3 | Summary statistics.

	Number of observation	Mean	Median	SD
<i>Vol</i>	71,114	0.0260	0.0233	0.0120
<i>Pap</i>	71,114	0.1050	0	0.3070
<i>Tep</i>	71,114	0.0667	0	0.2490
<i>Nea</i>	71,114	6.2443	6.1591	0.6448
<i>Size</i>	71,114	22.6900	22.58	1.0510
<i>Tur</i>	71,114	1.7660	1.123	1.9420
<i>Hvol</i>	71,114	0.0130	0.0116	0.0065
<i>Guz</i>	71,114	0.0558	0	0.2300
<i>Time</i>	71,114	0.2090	0	0.4060

respective impact on stock volatility simultaneously. Finally, by comparing the results, the impact of each policy on stock price volatility is clarified. **Table 4** displays the results.

As shown in **Table 4**, Models (1) and (2) estimate the impact of purchase tax incentives (*Tep*) and *Pap* on the volatility of new energy concept stocks, respectively, by both controlling for market capitalization of individual stocks ($Size_{i,t}$), turnover rate ($Tur_{i,t}$), volatility of the CSI 300 index ($HVol_{i,t}$), first trading day dummy variable (*Time*), and stock market crash variable (*Guz*). Both also control for industry, individual, and time fixed effects. The results show that the coefficient of acquisition tax incentives (*Tep*) is positive but not significant, indicating that the acquisition tax incentives does not have

an impact on the volatility of NEV concept stocks; however, the coefficient of *Pap* is significantly positive at the 1% significance level, which indicates that the P&A policy has a significant and positive impact on the volatility of NEV concept stocks. Thus, hypotheses H1a and H1b are validated. Model (3) adds both types of policies and control variables, and the results are consistent with the previous results, which proves *Hypothesis 1*. In summary, purchase tax incentives have no significant impact on the volatility of NEV concept stocks, whereas promotion and application policies have a significant and positive impact on the volatility of NEV concept stocks. The volatility of a concept stock depends on the type of policy related to the industry. The purchase tax incentive policy is usually announced at long intervals, with insufficient and minor tax adjustments, and in a unitary manner, making it difficult to influence the NEV market. The promotion and application policy, on the other hand, is targeted at the NEV industry, each new version is an update and supplement to the previous one, and it functions as a market bellwether by indicating the country's development direction in the field. Therefore, it exerts a significant impact on the NEV concept stock market.

The Mediating Effect of Investor Attention

NEV promotion and application policies have a significant and positive on the volatility of NEV concept stocks, while purchase tax incentive policies have no significant effect, so we further study the promotion and application policy in the followings. Investors have a limited ability to allocate attention and interpret information, and policy announcement will further affect how investors allocate attention to specific events and information. In this case, we hypothesize that promotion and application policies may increase the volatility of NEV concept stocks by increasing investors' attention to NEV concept stocks. In order to test this hypothesis, we use Python scrapping technique to extract the Baidu search index of different NEV concept stocks with their stock code as the keyword. We take the log of the sum of Baidu search index of NEV concept stock codes to calculate investor attention and investigate the mediating effect of investor attention.

As shown in **Table 5**, the coefficient of *Pap* is significantly positive at the 1% significance level in Model (1), and the positive significance holds in Model (2) where the dependent variable is *Nea* (investor attention). Meanwhile, the coefficients of *Pap* and *Nea* are both significantly positive at the 1% significance level in Model (3) which adds both *Pap* and *Nea* into the model. This indicates that NEV promotion and application policies not only raise the volatility of NEV concept stocks directly but also increase the volatility through boosting investor attention. For accuracy purposes, we conduct a Sobel test on the mediation model with $a=0.12971$, $b=0.00155$, $S_a = 0.02037$, and $S_b = 0.00015$, and the results show that the test value of p is much less than 0.01. Therefore, investor attention partially mediates the impact of promotion and application policy announcement on the volatility of NEV concept stocks proving *Hypothesis 2*.

TABLE 4 | Baseline regression results.

Variables	Model (1)	Model (2)	Model (3)
	Vol	Vol	Vol
Tep	0.00006 (0.00030)		-0.00035 (0.00031)
Pap		0.00141*** (0.00024)	0.00147*** (0.00025)
Size	0.00194*** (0.00011)	0.00179*** (0.00011)	0.00179*** (0.00011)
Tur	0.00143*** (0.00002)	0.00141*** (0.00002)	0.00141*** (0.00002)
Hvol	0.96038*** (0.01374)	0.93860*** (0.01413)	0.93721*** (0.01418)
Guz	0.00869*** (0.00039)	0.00926*** (0.00040)	0.00926*** (0.00040)
Time	-0.00003 (0.00018)	-0.00004 (0.00018)	-0.00004 (0.00018)
Industry FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	71,114	71,114	71,114
R-squared	0.59299	0.59422	0.59426

***represents significant at the 1% significance level. Standard deviations are provided in parentheses.

TABLE 5 | The mediating effect of investor attention.

Variables	Model (1)	Model (2)	Model (3)
	Vol	Nea	Vol
Pap	0.00141*** (0.00024)	0.12971*** (0.02037)	0.00121*** (0.00025)
Nea			0.00155*** (0.00015)
Size	0.00179*** (0.00011)	0.03239*** (0.00808)	0.00174*** (0.00011)
Tur	0.00141*** (0.00002)	0.11026*** (0.00146)	0.00123*** (0.00003)
Hvol	0.93860*** (0.01413)	9.74427*** (1.17959)	0.92348*** (0.01450)
Guz	0.00926*** (0.00040)	0.26469*** (0.03335)	0.00884*** (0.00041)
Time	-0.00004 (0.00018)	0.01026 (0.01516)	-0.00006 (0.00019)
Industry FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	71,114	71,114	71,114
R-squared	0.59422	0.60746	0.59693

***represents significant at the 1% significance level. Standard deviations are provided in parentheses.

Heterogeneity Analysis

Given differences in the equity ownership of NEV concept stocks, the relationship between policy announcement, investor attention, and NEV concept stocks may vary depending on the equity ownership. Therefore, based on the equity ownership information provided by the CSMAR database, we categorize the sample data into state-owned enterprises and non-state-owned

enterprises (Su et al., 2020). We introduce the dummy variable *SOE*, which is assigned to 1 if the stock belongs to a state-owned enterprise and 0 if it belongs to a non-state-owned enterprises. The results are shown in **Table 6**, respectively.

As shown in **Table 6**, the coefficients of *Tep* are not significant in Model (1) and (4), indicating no significant impact of the acquisition tax incentive policy on the volatility of NEV concept stocks regardless of whether the firm is state-owned or not. As indicated by the results of Model (2) and (5), although the announcement of the P&A policy has a significant and positive effect on the stock volatility of state-owned and non-state-owned enterprises, the coefficient difference indicates heterogeneity in the state ownership (value of *p* of test statistic <0.01). Compared with state-owned enterprises, non-state-owned enterprises are more sensitive to NEV promotion and application policies, indicating that when a promotion and application policy was implemented, non-state-owned enterprises are more willing to invest in innovation and energy transition, which in turn increases their stock volatility risk. The results of Model (3) and (6) further validate this finding by indicating that the stock price behavior of NEV concept stocks of state-owned enterprises is more stable than that of non-state-owned enterprises and that state-owned enterprises are able to reduce the risk of volatility caused by investor attention through self-regulation.

Robustness Test

To further test the robustness of the baseline results, we adopt two methods—alternative measure and random sample selection—to verify the impact of policy announcement on the volatility of NEV concept stocks.

Alternative Measure

In the baseline regression, we construct two dummy variables, *Tep* and *Pap*, using the 15th day of the month as the cut-off point. In this section, to avoid the randomness of regression results caused by the 15th day cut-off, we reconstruct the dummy variables *Tep1* and *Pap1* for the NEV policy using the 20th day of the month as the cut-off point instead. The regression results in **Table 7** show that the acquisition tax incentive policy has no significant impact on stock volatility, whereas the P&A policy has a significant and positive effect on the volatility of NEV concept stocks, demonstrating the robustness of the empirical results.

Random Sample Selection

To ensure the applicability of the results, we randomly select 10 stocks from the 31 NEV concept stocks to re-estimate the baseline regression. Considering that the total sample contains six types of NEV stocks, such as computer communication and other electronic equipment manufacturing, automobile manufacturing, rubber and plastic product manufacturing, and so on, we stratified random sampling by industry type. In each sampling stratum, direct random sampling of the stock codes was conducted using the “*Sample*” command in the Stata software, and the appropriate number of stocks was selected from each stratum according to the proportion of stocks in different industry types in the total sample. After stratified sampling, 10 stock codes were obtained, and the final randomly selected sample was formed by matching the relevant stock trading data from 2011 to 2020 to the stock codes. The 10 randomly selected stocks include Shenzhen Kaifa Technology Co., Ltd. (000021), Weichai Power Co., Ltd. (000338),

TABLE 6 | Heterogeneity results for state ownership.

Variables	SOEs			Non-SOEs		
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	Vol	Vol	Vol	Vol	Vol	Vol
<i>Tep</i>	-0.00007 (0.00030)		-0.00040 (0.00031)	0.00026 (0.00034)		-0.00013 (0.00035)
<i>Pap</i>		0.00106*** (0.00025)	0.00114*** (0.00026)		0.00131*** (0.00028)	0.00134*** (0.00029)
<i>Size</i>	0.00193*** (0.00014)	0.00182*** (0.00014)	0.00183*** (0.00014)	0.00196*** (0.00011)	0.00185*** (0.00011)	0.00186*** (0.00011)
<i>Tur</i>	0.00135*** (0.00003)	0.00133*** (0.00003)	0.00132*** (0.00003)	0.00149*** (0.00003)	0.00148*** (0.00003)	0.00148*** (0.00003)
<i>Hvol</i>	0.98996*** (0.01384)	0.97974*** (0.01401)	0.97849*** (0.01404)	0.92223*** (0.01552)	0.90718*** (0.01574)	0.90677*** (0.01578)
<i>Guz</i>	0.00847*** (0.00039)	0.00880*** (0.00040)	0.00880*** (0.00040)	0.00902*** (0.00045)	0.00943*** (0.00045)	0.00943*** (0.00045)
<i>Time</i>	-0.00006 (0.00018)	-0.00007 (0.00018)	-0.00007 (0.00018)	0.00002 (0.00021)	0.00000 (0.00021)	0.00000 (0.00021)
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Individual FE</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Time FE</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>No. of obs.</i>	38,998	38,998	38,998	32,116	32,116	32,116
<i>R-squared</i>	0.60771	0.60895	0.60900	0.57065	0.57196	0.57201

***represents significant at the 1% significance level. Standard deviations are provided in parentheses.

TABLE 7 | Robustness checks for the alternative measure.

Variables	Model (1)	Model (2)	Model (3)
	Vol	Vol	Vol
Tep1	0.00003 (0.00030)		-0.00012 (0.00030)
Pap1		0.00107*** (0.00024)	0.00108*** (0.00024)
Size	0.00194*** (0.00011)	0.00186*** (0.00011)	0.00186*** (0.00011)
Tur	0.00143*** (0.00002)	0.00141*** (0.00002)	0.00141*** (0.00002)
Hvol	0.96028*** (0.01374)	0.94944*** (0.01389)	0.94945*** (0.01389)
Guz	0.00868*** (0.00039)	0.00902*** (0.00040)	0.00901*** (0.00040)
Time	-0.00003 (0.00018)	-0.00004 (0.00018)	-0.00004 (0.00018)
Industry FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	71,114	71,114	71,114
R-squared	0.59299	0.59374	0.59374

***represents significant at the 1% significance level.
Standard deviations are provided in parentheses.

TABLE 8 | Robustness checks for random sampling.

Variables	Model (1)	Model (2)	Model (3)
	Vol	Vol	Vol
Tep	-0.00013 (0.00038)		-0.00044 (0.00038)
Pap		0.00104*** (0.00031)	0.00113*** (0.00032)
Size	0.00349*** (0.00020)	0.00334*** (0.00020)	0.00335*** (0.00020)
Tur	0.00154*** (0.00003)	0.00153*** (0.00003)	0.00153*** (0.00003)
Hvol	0.97608*** (0.01726)	0.96002*** (0.01781)	0.95830*** (0.01788)
Guz	0.00792*** (0.00049)	0.00836*** (0.00050)	0.00836*** (0.00050)
Time	0.00002 (0.00023)	0.00001 (0.00023)	0.00001 (0.00023)
Industry FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	22,940	22,940	22,940
R-squared	0.58406	0.58466	0.58473

***represents significant at the 1% significance level.
Standard deviations are provided in parentheses.

Guizhou Tire Co., Ltd. (000589), Zhongtong Bus Co., Ltd. (000957), Guoguang Electric Co., Ltd. (002045), Shenzhen Auto Electric Power Plant Co., Ltd. (002227), Shenzhen INVT Electric Co., Ltd. (002334), Chengdu Xinzhu Road and Bridge Machinery Co., Ltd. (002480), SAIC Motor Co., Ltd. (600104), and Neusoft Corp. (600718). These 10 concept stocks contain all the NEV stock types from the total sample data, which eliminates the estimation

bias arising from the sampling restricted to certain industries and ensures generalizability and applicability of the randomly selected sample, making the results more reliable. We re-estimate the fixed-effect model with robust standard errors on the randomly selected sample. The results, as shown in **Table 8**, are consistent with the full-sample results, again indicating that the baseline results are robust and reliable.

CONCLUSION

The paper takes NEV concept stocks as the research setting and selects NEV-related policies from 2011 to 2020 to examine the relationship between the volatility behavior of NEV concept stocks and relevant policy announcement including NEV acquisition tax incentives and promotion and application policies. We also explore the mediating effect of investor attention in the relationship between policy announcement and NEV concept stocks. We find that different types of policies have different impacts on NEV concept stocks. The PTI policy does not have a significant impact on the volatility of NEV concept stocks due to their long promulgation interval, insignificant content adjustments, and unitary form, whereas the P&A policy has a significant and positive impact on the volatility of the NEV concept stocks, in which investor attention plays a partial mediating effect. The findings indicate that the introduction of NEV P&A policies has brought about effects to the stock market while also attracting a lot of investor attention. In addition, state-owned NEV firms are less affected by new policies than non-state-owned firms, as they can self-regulate to mitigate the volatility risk brought on by investor attention.

In order to achieve green economic recovery in the post-pandemic era, governments should improve the supporting policies for the new energy industry. Based on our findings, we propose the following recommendations. First, the purpose of NEV policies is to promote energy transition in China's auto industry and achieve low-carbon economic recovery. However, because China's NEV industry has been in the early development stage for the past 10 years and has a lot of room for improvement, the reactions of the society and individuals should be considered comprehensively when formulating policies. Moreover, the government should prioritize NEV promotion and application policies over purchase tax incentive policies, and relevant policies should be updated as the market develops to maintain the policy's effectiveness, stability, and continuity.

Second, the impact of investor attention on the stock market should not be overlooked. The government should encourage rational stock investment and provide guidance to individual investors in identifying risks and making sensible investment decisions. Moreover, the government should improve corporate operation regulations, increase stock market transparency, provide symmetric information to investors, and monitor concept stocks.

Third, the government should vigorously support the development of NEV-related industries, including state-owned firms or non-state-owned firms, while closely monitoring the effectiveness of policies for state-owned NEV firms. In addition, policymakers should consider different firm ownerships when

formulating policies and improve the risk control ability of non-state-owned NEV firms when revising policies. At the same time, the government should encourage state-owned NEV firms to participate in energy transition and enhance their competitiveness.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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AUTHOR CONTRIBUTIONS

MS: conceptualization, investigation, validation, and writing—review and editing. CW: formal analysis, methodology, and writing—original draft. All authors contributed to the article and approved the submitted version.

FUNDING

This research is supported by the Social Science Planning Project of Shandong Province (grant number: 19CDN26).

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Platform Leadership and Sustainable Competitive Advantage: The Mediating Role of Ambidextrous Learning

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In the context of the knowledge economy, the role of traditional leadership for enterprises is questioned. Based on contingency theory and the resource-based view, this paper proposes the important role of platform leadership, a new leadership type in line with the context of the times, for a sustainable competitive advantage. We conducted an empirical study to examine and confirm the positive effects of platform leadership on sustainable competitive advantage and ambidextrous learning. We also verified the mediation effect of exploratory and exploitative learning on platform leadership and sustainable competitive advantage. Additionally, relevant discussion and research contributions are put forward.

OPEN ACCESS

Edited by:

Rui Xue,
Macquarie University, Australia

Reviewed by:

Zhongfeng Su,
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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 15 December 2021

Accepted: 02 February 2022

Published: 24 February 2022

Citation:

Yang X, Jin R and Zhao C (2022)
Platform Leadership and Sustainable
Competitive Advantage: The
Mediating Role of Ambidextrous
Learning.
Front. Psychol. 13:836241.
doi: 10.3389/fpsyg.2022.836241

Keywords: sustainable competitive advantage, platform leadership, ambidextrous learning, exploratory learning, exploitative learning

INTRODUCTION

With the accelerating process of economic globalization, advanced technology and productivity are rapidly flowing worldwide, and new market opportunities are emerging. Meanwhile, competition among enterprises is becoming increasingly intense. How to gain a sustainable competitive advantage to meet the increasingly fierce competition in the market has become a common topic of concern for both the academia and industry. Studies have shown that the establishment of a sustainable competitive advantage increases the difficulty and cost for competitors to copy a company's successful model (Barney, 1991). It also provides the material basis and strategic options for the company to develop new resources and markets and ensures that a strong competitive position and a competitive advantage are maintained in a long period (Benner and Tushman, 2003). Therefore, to respond to the competitive demands and achieve strategic goals, companies must pay attention to the construction of sustainable competitive advantage. This perspective is also widely accepted in academic circles (Asimakopoulos et al., 2020; Khourouh et al., 2020; Knudsen et al., 2021; Prabowo et al., 2021; Yang et al., 2021).

Leadership is an important role that influences others to make sustained efforts to achieve goals, and it is widely present at all levels of government, business, schools, hospitals, military, and social groups (Hao, 2016). For centuries, scholars have extensively discussed the topic of leadership, the relationship between leadership types and organizational development, business performance, and so on (Shamir et al., 1993; Bass, 1995; Karim et al., 2016). A mainstream study is to view leadership as a top-down hierarchical influence process, in which leaders play

an irreplaceable role and have a significant impact on the firm or organization (Slater and Narver, 1995; Song and Long, 2017). In the 20th century, the era of industrial economy, the limited speed of change in the external environment and the level of employee knowledge prompted companies to consider specialization and division of labor in pursuing economic benefit. Therefore, pyramidal hierarchical structure with authoritative authority as the core was widely distributed in all types of organizations and brought better organizational effectiveness (Fletcher, 2004). Thus, there have been many discussions on the characteristics or behavioral characteristics of effective leadership. Moreover, the important role of different leadership characteristics, such as transformational leadership (Bass, 1995) and charismatic leadership (Shamir et al., 1993), on organizations has been recognized.

Since entering the 21st century, with the rapid development of information technology and network technology, the era of the industrial economy is rapidly changing to the era of knowledge economy, and the organizational environment has become increasingly dynamic, uncertain, and unpredictable. Organizations must learn continuously to adapt to the complex external environment, and flat organizational forms that can quickly transfer information and respond to competitive needs are gradually favored by enterprises (Meisel and Fearon, 1999; Yang et al., 2004). In the context of the dynamic organizational environment, the original hierarchical concepts in organizations are gradually weakened, and decentralization and de-leadership have become important trends. Moreover, the traditional top-down leadership model is beginning to be considered unsuitable for meeting the adaptive challenges of the knowledge economy (Uhl-Bien et al., 2007). The role of traditional leadership in organizational development has been seriously questioned (Avolio et al., 2009).

However, the advent of the knowledge economy does not mean that leadership is no longer important; rather, it places new demands on leaders and leadership models. Leaders should no longer think of themselves as the highest point of the pyramid, but rather be rooted at the grassroots level, focusing on employees and organizational development (Feng et al., 2014). The top-down hierarchical influence in organizations is weakening. However, leaders play a more important role in using a bottom-up approach to lead employees, respond to changes in the external environment, and facilitate the achievement of organizational goals (Morris et al., 2005). Based on the bottom-up leadership view, a series of meaningful studies have been conducted in the academic circle, and many new leadership types have been proposed and developed, such as humble leadership (Owens and Hekman, 2012) and inclusive leadership (Carmeli et al., 2010).

Other scholars have pointed out that considering subordinates' development as the endpoint is still an idealized view (Hao et al., 2021). The more common reality is that the relationship between employees, leaders, and organizations is symbiotic and co-prosperous, and the development of employees usually depends on the development and growth of the organization (Hao et al., 2021). Based on this, scholars proposed the concept of platform leadership, which is used to explain the new model

of effective leadership behavior characteristics under the background of a dynamic organization and the rise of knowledge workers. Hao (2016) specified that apart from motivating employees' potential in a bottom-up manner, leaders should continuously focus on organizational development and make the organization a platform for the aggregation and integration of resources from all parties and the realization of value. Simultaneously, the platform needs to be continuously optimized and improved to cope with the dynamic changing environment faced by the organization and obtain or generate more high-quality resources through the joint growth of the organization, leaders, and employees, which is called platform leadership. Compared to other leadership traits, platform leadership emphasizes the interactive relationship between leaders, employees, and organization, and it may have a more intuitive impact on organizational learning and capacity.

In summary, the relationship between leadership, organizational development, and the competitive advantage shows great differences at different times. In today's highly competitive globalization and rapidly developing knowledge-based economy, enterprises' formation of a sustainable competitive advantage relies more on constructing internal knowledge management capabilities and controlling the external competitive environment (Liao et al., 2016). Platform leadership emphasizes the symbiotic and co-prosperous relationship among employees, leaders, and organizations. It emphasizes the aggregation of organizational resources and the improvement of employees' capabilities. Based on contingency theory and resource-based view (RBV), this study argues that platform leadership places more emphasis on shaping organizational learning capabilities in the knowledge economy, which is conducive to the formation of organizational dual learning capabilities and thus brings sustainable competitive advantages to the enterprise. However, whether platform leadership is in line with the current competitive needs and whether it can bring a sustainable competitive advantage to the enterprise is yet to be verified. Therefore, this study explores the mechanism of platform leadership on enterprises' sustainable competitive advantage through a questionnaire survey. It reveals the mediating role of ambidextrous learning in this process.

LITERATURE REVIEW AND HYPOTHESES

Sustainable Competitive Advantage

Competitive advantage is a source of additional profits for enterprises. However, high profits will also attract competitors in the market to imitate enterprise behaviors and weaken the competitive advantage of enterprises. The combination of unique resources and internal and external environment brings some specific competitive advantages with high barriers to imitation for the company. Due to its uniqueness, this kind of competitive advantage can contribute additional profits to the company in the long term (Prabowo et al., 2021). Sustainable competitive advantage refers to the competitive advantage that existing and potential competitors cannot copy (Barney, 1991; Yang

et al., 2021). RBV posits that enterprises have different tangible and intangible resources, some of which can be transformed into unique capabilities. These unique resources and capabilities are the source of lasting competitive advantage of enterprises. Enterprises with heterogeneous and incompletely transferable resources can better meet consumer demand, participate in market competition, create greater economic value, and thus establish sustainable competitive advantage (Oliver, 1997; Davcik and Sharma, 2016). Compared with general competitive advantage, sustainable competitive advantage lays more emphasis on enterprise resources' inimitability and non-substitutability, which results in the sustainability of competitive advantage and a long-term positive impact on the firm (Khouroh et al., 2020). The studies conducted on the sustainable competitive advantage mainly started from the organizational level, such as knowledge acquisition (Asimakopoulos et al., 2020; Yang et al., 2021), organizational learning (Yang et al., 2021), dynamic capability (Khouroh et al., 2020; Prabowo et al., 2021) and so on. However, questions about how these organizational-level capabilities are acquired, and which influencing factors have an impact on these capabilities need further discussion.

Platform Leadership

With the rapid development of the knowledge economy, enterprises face increasingly intensified market competition and a rapidly changing market environment. "Decentralization" has become an important development trend of organizations (Uhl-Bien et al., 2007). Organizational management pays more attention to employee's self-realization needs and hopes to realize the flattening, coordination, flexibility, and decentralization of management (Xin et al., 2020). Management should focus on maintaining the employee-leader relationship and pay attention to the common development among employees, leaders, and organizations. Accordingly, the new type of leader not only focuses on the success of his or her career, but also pays more attention to enlarging the common platform with employees and constantly expands the common platform with employees (Sang et al., 2010). Moreover, Hao et al. (2021) clarified the specific concept of platform leadership and provided a way to measure it based on previous research. The literature indicates that platform leadership should promote the common growth of employees, leaders, and organizations by building a common career platform on the basis of stimulating employees' potential (Hao, 2016; Hao et al., 2021). Accordingly, it should provide a measurement and dimensional division of platform leaders, including "tolerance," "charisma," "revolution planning," "platform building," "platform optimization," and "mutual growth" (Hao et al., 2021). Previous empirical studies only focused on the impact of platform leadership at the employee level (Hao et al., 2021). However, the influence of platform leadership may go far beyond that.

Contingency theory states the importance of adapting to the internal and external environments of the organization, then choosing the appropriate management model and style to the different conditions and environments (Luthans and Stewart, 1977). The contingency theory of leadership states that no one leadership style can fit all organizations and

environments, and leaders should adapt to changes in the external environment (Ruekert et al., 1985; Kerr et al., 2016). Management styles adapt to the organization and environment will be conducive to the improvement of team efficacy, team performance, and even enabling strategic alignment (Karim et al., 2016; Williams et al., 2017; McAdam et al., 2019). With the development of knowledge economy and the gradual flattening of organizations, platform leadership emphasizes the common development among employees, leaders, and organizations, to obtain or produce more high-quality resources—a leadership model that meets the requirements of the environment and organizations (Michael, 2012; Xin et al., 2020; Hao et al., 2021). The positive effect of platform leadership on organizational development and team performance is predictable.

Employees pay attention to the organization's evaluation of their contributions and support for their development, and this attention forms a comprehensive feeling called perceived organizational support (Eisenberger et al., 1986). Organizational support theory suggests that employees who perceive organizational or team support will timely give positive signals to the organization, be enthusiastic about their work, display positive work attitudes and behaviors that are consistent with corporate development requirements, and positively influence employee and team performance (Rhoades and Eisenberger, 2002; Hui et al., 2007; Lavelle et al., 2009; Zagencryk et al., 2010). The characteristics of platform leadership, such as inclusiveness, platform building, platform optimization, and common growth, fully reflect the platform leaders' attention to the organization and employees. Thus, platform leadership provides a prerequisite for employees to repay the team and contribute to the platform and organization.

Additionally, according to the RBV theory, a non-negligible relationship exists between organizational resources and sustainable competitiveness. Rose et al. (2010) pointed out that organizational resources include all the assets that an enterprise can control to implement its strategies and improve its efficiency. Moreover, the sustainable competitive advantage depends on the valuable and scarce resources that cannot be completely imitated or replaced by others. The employee support provided by platform leadership will enhance employees' enthusiasm for work and promote the generation of work behaviors that meet the corporate development requirements. Besides, according to contingency theory, leadership that matches the environment will have a long-term, continuous and diffuse influence on organizations (McAdam et al., 2019). In other words, the positive impact of platform leadership on enterprises is not temporary. Platform leadership creates continuously valuable, scarce, and irreplaceable organizational resources for the company and promotes the generation of a sustainable competitive advantage for the organization. Thus, the platform leadership approach agrees with both the external environment matching, as evidenced by the power change management theory, and the employee development support advocated by the organizational support theory, which brings valuable and irreplaceable organizational resources to the company, thus enhancing the sustainable competitive advantage of the company.

Accordingly, this paper proposes the following hypothesis:

H1: Platform leadership positively impacts sustainable competitive advantage.

Ambidextrous Learning

Organizational learning is an adaptive process of organizations to the external environment (March and Simon, 1958); it is also an important source of firm's innovative advantage (Ge et al., 2016). March and Simon (1958) further interpreted the internal mechanism of organizational learning and proposed the concept of ambidextrous learning; that is, the organization pursues both exploratory and exploitative learning (Yang et al., 2012, 2021). Exploratory learning refers to the learning of product and process development skills that are completely new to the company's existing experience and the ability to collect, learn, and research new knowledge that is different from the existing knowledge accumulation (Noni and Apa, 2015; Zhou et al., 2021). This type of learning acquires relevant knowledge and resources different from the organization's existing knowledge accumulation, and the organization must obtain the knowledge through communication and cooperation with relevant external organizations (Zhu et al., 2014). Moreover, exploratory learning has strong uncertainty (Xie et al., 2014). Meanwhile, exploitative learning is the organization's restructuring of information, resources, and knowledge based on the existing knowledge base (Noni and Apa, 2015; Huang et al., 2020). It emphasizes slow change and innovation in an existing product or knowledge domain (Li et al., 2013) and pays attention to efficiency, refinement, and implementation (Xie et al., 2014; Zhou et al., 2021).

Exploratory and exploitative learning are compatible and mutually reinforcing (Huang et al., 2020; Yang et al., 2021). In terms of the correspondence between the type of knowledge and organizational learning, exploratory learning is related to the knowledge acquired by the firm that is unfamiliar, future, and foreign (Yang et al., 2021; Zhou et al., 2021). Conversely, exploitative learning is associated with known, existing, and local knowledge (Niebles et al., 2008; Huang et al., 2020; Yang et al., 2021).

Platform leadership emphasizes support, understanding, and tolerance for employees; it does not mind the occasional mistakes in work and learning and gives employees and the organization more opportunities for trial (Hao et al., 2021). A more inclusive and relaxed work environment helps stimulate the creativity of employees and teams (Carmeli et al., 2010) and drives them to collect, learn, research new knowledge, and develop new competencies. Besides, platform leadership focuses on platform building and mutual growth, which strengthens communication and learning with those outside the organization (Sang et al., 2010; Hao et al., 2021). Then, it creates good conditions for teams and organizations to learn new knowledge, which in turn plays a positive role in organizational exploratory learning.

Simultaneously, platform leaders pay considerable attention to the growth of the organization and employees, give their subordinates sufficient space to complete the learning of

intra-organizational knowledge, actively promote intra-organizational common knowledge, and are willing to create a good learning atmosphere within the company (Hao et al., 2021). Learning-oriented leadership behavior will improve organizational learning (Slater and Narver, 1995; Baker and Sinkula, 1999), and platform leaders' encouragement of intra-organizational knowledge learning and exchange will also play a positive role in organizational exploitative learning.

Accordingly, this paper proposes the following hypothesis:

H2: Platform leadership positively affects exploratory learning.

H3: Platform leadership positively affects exploitative learning.

The role of ambidextrous learning for competitive advantage has been confirmed by many researchers (Sijabat et al., 2020; Wang and Fang, 2021). In related studies, exploratory learning and exploitative learning are always used to explain the mechanism of the effects of certain organizational capabilities on sustainable competitive advantage (Yang and Wang, 2020; Yang et al., 2021). In a complex, competitive environment, organizations should constantly learn to adapt to the challenges posed by the external environment (Yang et al., 2004). In cultivating a sustainable competitive advantage, organizational learning ability is an essential part. Therefore, the leadership model that can promote the improvement of organizational learning ability is vital.

Exploratory learning emphasizes acquiring relevant knowledge and information in new fields, and knowledge in relevant fields affects the firm's recognition and perception of opportunities (Ge et al., 2016). The continuously accumulated experience and knowledge help enrich the variety of organizational knowledge resources. Moreover, the sufficient number and type of knowledge resources are important inducements for the organization to form irreplaceable resources and capabilities, which help the firm to continuously improve its competitive ability (Yang et al., 2021). Exploratory learning affects enterprises' ability to adapt to the new environment and decision-making speed and emphasizes experiment and innovation (Li et al., 2013; Sijabat et al., 2020; Zhou et al., 2021). It breaks existing learning paths and practices, promotes the reorganization and reconstruction of resources, and improves organizational environment adaptability. It also develops dynamic capabilities and forms sustainable competitive advantages.

According to the contingency theory, the appropriate management adapted to the internal and external environments has a positive impact on organizational behavior (Luthans and Stewart, 1977; McAdam et al., 2019). Platform leaders, as the suitable leaders for the current competitive environment, focus on platform building and platform optimization, drive the exchange of knowledge outside the organization and create an inclusive innovation environment. All are important conditions for the formation of organizational exploratory learning capability and an important guarantee for the formation of sustainable competitive capability.

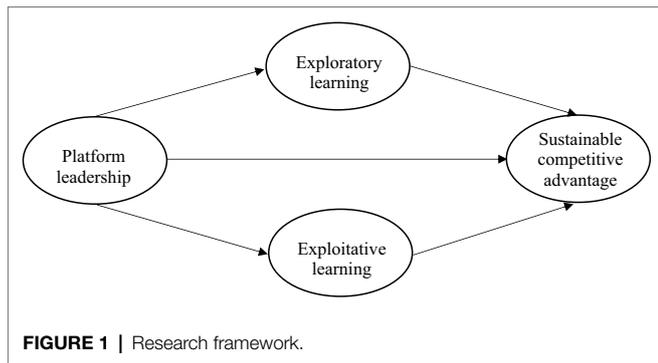


TABLE 1 | Profile of sampled firms.

Characteristics of Firms		Frequency	Percentage (%)
Industry characteristics (Industry)	high-tech industries	120	45.11
	other industries	146	54.89
Firm age (Age)	1–5 years	16	6.02
	6–10 years	56	21.05
	11–20 years	128	48.12
	over 20 years	66	24.81
Number of employees (Size)	less than 100	49	18.42
	100–500	141	53.01
	more than 500	76	28.57
Ownership (Ownership)	State owned	82	30.83
	Privately owned	129	48.5
	Foreign owned	35	13.16
	Sino-foreign joint	20	7.52

Exploitative learning emphasizes the understanding and usage of existing knowledge and resources, and by expanding the content and depth of knowledge resources, it helps organizations enhance dynamic capabilities and sustainable competitiveness (Zollo and Winter, 2002; Wang and Fang, 2021; Zhou et al., 2021). Repeatedly learning and improving existing knowledge and resources help enterprises understand market knowledge and current competitive situation. These methods also improve their ability to obtain and take advantage of timely opportunities. Simultaneously, through the use of knowledge and experience accumulated continuously, enterprises form and consolidate their own resource advantages and create sustainable competitive ability.

Organizational support theory states that employees who perceive organizational support will display positive work attitudes and behaviors that are consistent with corporate development requirements (Zagencryk et al., 2010; Matusik et al., 2021). Platform leadership’s encouragement of knowledge flow within enterprises will active employee learning organizational knowledge, then help improve the exploitative learning ability of organizations, thus contributing to the formation of the sustainable competitive capability of enterprises.

Accordingly, this paper proposes the following hypothesis:

H4: The effect of platform leadership on a sustainable competitive advantage is mediated by exploratory learning.

H5: The effect of platform leadership on a sustainable competitive advantage is mediated by exploitative learning.

Based on the above hypotheses, this study proposes the following research framework **Figure 1**.

RESEARCH METHODS

Data Collection and Sample

To verify the hypotheses, we applied a questionnaire survey to collect data. The survey was conducted between April 1 and August 30, 2021. Most questionnaires used mature scales. To ensure the validity of data and avoid ambiguity caused by terminology, expression, and other reasons, the research group conducted a preliminary survey before the formal survey. Fifteen managers, EMBA, and MBA students who have a long-term cooperative relationship with the research group were selected to conduct a preliminary questionnaire test. The questionnaire was improved according to the testers’ opinion to ensure that the respondents could fully understand the meaning of each item. Pre-survey data were excluded from the final data.

We obtained the final data from China, which is a vast country that encompasses various regions. Different regions have different cultures, government policies, and locational conditions. To reduce the influences of these situational factors on the research results, we strategically selected the northeast region for our research. As the research focuses on platform leadership and ambidextrous learning, respondents were required to have some knowledge of the company’s innovation capability and competitiveness. Thus, we chose middle-level and above managers in relevant enterprises.

To ensure the integrity and reliability of the data, the research adopted a survey method combining online directional distribution and offline field distribution to collect the data. Finally, under the coordination of alumni and relevant government departments, 289 questionnaires were collected, and 23 random and incomplete questionnaires were excluded. Finally, 266 valid questionnaires were obtained. The detailed characteristics of sampled firms are shown in **Table 1**.

Variables and Measures

This section introduces the main research variable and control variables. It also presents descriptive statistics and the correlation matrix for all variables (**Table 2**).

Main Research Variable

To ensure the reliability and validity of the questionnaire, this study mainly referred to relevant scales published in authoritative journals to measure the main variables. We revised and improved the scales by using trial investigation and discussion with experts. The questionnaire consisted of four parts, including three construct measurements and control variable measurement. All measures were adapted from existing scales found in previous studies. The measurement of the platform leadership (PL) is adopted from Hao et al. (2021). Moreover, the measurement

TABLE 2 | Summary statistics and correlation matrix.

Variables	Mean	SD	1	2	3	4	5	6	7
SCA	5.113	1.057							
EE	59.318	0.971	0.394**						
EY	4.956	0.982	0.364**	0.289**					
PL	5.239	0.674	0.400**	0.421**	0.405**				
Age	2.92	0.834	0.021	0.013	0.046	0.184**			
Ownership	1.97	0.862	-0.017	0.061	-0.009	-0.001	-0.266*		
Industry	0.45	0.499	0.071	0.106	0.05	-0.045	-0.091	-0.130*	
Size	2.1	0.679	0.018	-0.061	0.001	0.047	0.395**	-0.105	-0.203**

* $p \leq 0.05$; ** $p \leq 0.01$.

of exploratory learning (EY) and exploitative learning (EE) was prepared and adopted from Atuahene-Gima and Murray (2007) and Chung et al. (2015). Lastly, the measurement of the sustainable competitive advantage (SCA) mainly referred to Yang and Wang (2020) and Yang et al. (2021). This study conducted a tick-the-box survey. All the items in the construct measurements were measured using a 7-point Likert scale ranging from “strongly disagree=1” to “strongly agree=7.”

Control Variables

Besides, previous studies have suggested that a firm's ambidextrous learning and the competitive advantage may be influenced by firm age (*age*), firm size (*size*), ownership (*ownership*), and industry characteristics (Camisón and Villar-López, 2014; Ma and Wu, 2020; Yang and Wang, 2020). For industry characteristics (*industry*), relevant research should compare high-tech and other industries (Ge et al., 2016). Accordingly, in terms of industry characteristics, industries with high technology content, such as software, computer, network, telecommunications, electronics, communications, polymer, chemical, and biopharmaceutical, are divided into high-tech industries and set as 1, whereas other industries are set as 0. We included these control variables in the study, and the results of relevant variables are shown in **Tables 1 and 2**.

RESULTS

Measurement Model Analysis

We assessed the unidimensionality of the latent variables using confirmatory factor analysis. The model fit indices were as follows: $\chi^2=870.937$, degree of freedom (df)=743, $p < 0.001$, $\chi^2/df=1.172$, comparative fit index (CFI)=0.980, Tucker-Lewis index (TLI)=0.978, incremental fit index (IFI)=0.980, root mean square error of approximation (RMSEA)=0.025, thus meeting the requirements of the cutoff values (Hair et al., 2013).

We also measured the convergent and discriminant validity of the constructs. The convergent validity of the constructs was assessed using composite reliability (CR) and average variance extracted (AVE) values (Fornell and Larcker, 1981; Hair et al., 2013). **Table 3** show each construct's Cronbach's α and CR values. Platform leadership is composed of six constructs (*Tolerance*, *Charisma*, *Platform Building*, *Revolution Planning*, *Platform Optimization*, and *Mutual Growth*), each of which

contains 3–5 measurement items (Hao et al., 2021), and each construct's Cronbach's α and CR values are calculated separately. Cronbach's α values of all the constructs ranged from 0.742 to 0.928, exceeding the recommended minimum standard of 0.70 (Fornell and Larcker, 1981). All factor loadings were higher than 0.65, indicating strong convergent validity (Anderson, 1987). Moreover, all of the CR values were greater than 0.850, which is greater than the minimum acceptable value of 0.7. Furthermore, the AVE values exceed the suggested standard of 0.50, which ultimately confirms the necessary reliability and convergent validity.

Fornell and Larcker (1981) suggested that we used AVE to measure discriminant validity. **Table 3** demonstrates that the square root of the AVE for each construct (highlighted in bold on the diagonal) is higher than the correlation between any pair of distinct constructs, providing evidence of discriminant validity.

Common Method Variance

Common method variance (CMV) was a concern in this study, as each questionnaire was finished by a single respondent (Podsakoff et al., 2003). We tried reducing the potential influence of CMV by carefully selecting scale items and separating them within the lengthy questionnaire. Then, we used two methods to check for CMV. First, Harman's single-factor test was used to examine the effect of homology bias (Podsakoff et al., 2003). The results showed that the variance explanation degree of the first factor was 31.36%, which is lower than 50%, indicating that CMV was not a serious concern. Second, we completed the correlation coefficient test of latent variables (**Table 3**). The absolute value of correlation coefficient between latent variables was less than 0.709, far less than 0.9, indicating no significant common variance deviation in the research data (Podsakoff et al., 2003). The analysis indicates that CMV does not pose any risk or concerns for the results of this study.

Hypothesis Testing

First, we employed multiple linear regression, using SPSS 24.0, to test the relationship between platform leadership and a sustainable competitive advantage (H1), the relationship between platform leadership and exploratory learning (H2), and the relationship between platform leadership and exploitative learning (H3). In addition, we performed collinearity tests. The results show that the maximum variance inflation factor value is 1.309, below the cutoff point of 4.0, indicating that the research results

TABLE 3 | Convergent and discriminant validity.

Constructs	1	2	3	4	5	6	7	8	9
SCA	0.730								
EE	0.568	0.731							
EY	0.608	0.615	0.727						
MG	0.664	0.462	0.554	0.789					
PO	0.655	0.512	0.490	0.604	0.797				
RP	0.496	0.656	0.523	0.555	0.526	0.841			
PB	0.575	0.567	0.541	0.532	0.482	0.556	0.776		
CH	0.681	0.635	0.532	0.626	0.582	0.584	0.709	0.745	
TO	0.609	0.515	0.555	0.525	0.399	0.409	0.422	0.706	0.729
Cronbach's α	0.928	0.889	0.880	0.827	0.820	0.742	0.826	0.873	0.856
AVE	0.679	0.649	0.608	0.622	0.635	0.707	0.601	0.556	0.531
CR	0.927	0.902	0.886	0.868	0.874	0.878	0.858	0.862	0.850

Bold values: Square root of AVE for each construct.

TABLE 4 | Results of multiple linear regression.

Variables	SCA			EY		EE	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	
<i>Control Variables</i>							
Age	0.017	-0.069	0.058	-0.027	0.069	-0.021	
ownership	0.001	-0.019	0.013	-0.006	0.089	0.068	
industry	0.079	0.090	0.055	0.067	0.113	0.124	
Size	0.027	0.042	-0.009	0.006	-0.056	-0.040	
<i>Main Research Variable</i>							
PL		0.415***		0.413***		0.432***	
R ²	0.006	0.172	0.005	0.169	0.022	0.201	
Adjusted R ²	-0.009	0.156	-0.010	0.154	0.007	0.186	
F	0.423	10.818***	0.352	10.611***	1.447	13.095***	

*** $p \leq 0.001$.

are not affected by multicollinearity issue (Pallant, 2016). The results are shown in **Table 4**.

The independent variables in model 1 contained only control variables, and the dependent variable was a sustainable competitive advantage. Model 2 adds the variable of platform leadership. The empirical analysis results show that platform leadership had a significant positive correlation with a competitive advantage ($\beta=0.415, p<0.001$), thereby supporting H1. The dependent variable in Models 3 and 4 is exploratory learning. Model 4 shows that platform leadership has a significant positive influence on exploratory learning ($\beta=0.413, p<0.001$). In the same way, the results in Model 6 show that platform leadership has a significant positive influence on exploitative learning ($\beta=0.432, p<0.001$), supporting H2 and H3.

Then, we employed the bootstrap method to test the mediation effects. Using the SPSS macro program Process3.4, we demonstrate the mediating role of exploratory and exploitative learning based on 5,000 iterations at the 95% confidence interval (CI; see **Table 5**).

In the mediating effect test of exploratory learning and exploitative learning, the total effect of platform leadership on a sustainable competitive advantage is 0.651 at 95% CI [0.473, 0.829], not including 0. The direct effect of platform leadership on a sustainable competitive advantage is 0.356 at 95% CI [0.159, 0.553]. The indirect effect of exploratory learning (0.131 at 95% CI [0.044, 0.259]) is significant, supporting H4. Similarly,

the indirect effect of exploitative learning (0.163 at 95% CI [0.062, 0.298]) is significant, thus supporting H5 (**Figure 2**). Items for constructs are shown in **Table 6**.

CONCLUSION

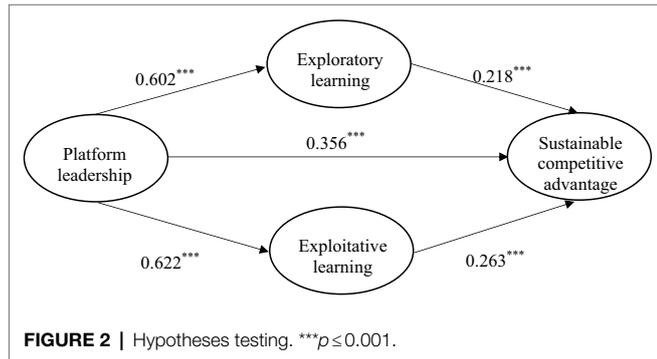
This paper combines the RBV theory with the contingency theory to validate the positive impact of platform leadership on a sustainable competitive advantage through data. Additionally, this paper verifies the mediating role of ambidextrous learning, in which platform leadership contributes to the improvement of exploratory and exploitative learning in the organization, and ultimately to the improvement of sustainable competitiveness. In this context, our study contributes to both theory and practice.

Discussion

With the advent of the knowledge-based economy, organizations have been developing to be more suitable for information exchange and learning to meet the increasingly competitive marketplace (Meisel and Fearon, 1999; Yang et al., 2004). In this context, the importance of leadership in business has been widely debated in academia, and de-leadership was once an accepted development approach (Uhl-Bien et al., 2007; Avolio et al., 2009). However, this paper concludes that choosing the

TABLE 5 | Mediating effect result (N = 266).

Effect type	Path relationship	Effect value	SE	95% CI	t-value	p-value
Total effect	PL → SCA	0.651	0.090	[0.473, 0.829]	7.216	0.000
Direct effect	PL → SCA	0.356	0.100	[0.159, 0.553]	3.559	0.000
Total indirect effect	PL → SCA	0.295	0.073	[0.167, 0.459]		
Indirect effect1	PL → EY → SCA	0.131	0.055	[0.044, 0.259]		
Indirect effect2	PL → EE → SCA	0.163	0.059	[0.062, 0.298]		



ambidextrous learning capabilities and other means. Therefore, the paths of platform leadership for a sustainable competitive advantage of enterprises are more complex than expected and can be explored more deeply by future research.

Theoretical Contributions

This study has three theoretical contributions. First, it complements the research on the impact of platform leadership on organizational behavior and capability, which is a continuation and improvement of leadership theory in the current competitive environment. Previous studies on platform leadership have mostly focused on theoretical exploration and dimensional model construction (Michael, 2012; Hao, 2016; Xin et al., 2020; Hao et al., 2021). In particular, related empirical studies focus on the role of platform leadership on employees' innovative behavior (Hao et al., 2021). However, compared to previous studies, this present study breaks through the research related to the impact of platform leadership from the level of individual behavior to the level of organizational behavior and organizational capability, which is an important addition to the research on platform leadership and leadership theory.

Second, this study has expanded the application of contingency theory in the era of knowledge economy, which is an important addition of contingency theory. The contingency theory proposes that management models must respond and change according to the organization's internal and external conditions to gain management advantages and improve team performance (Luthans and Stewart, 1977; Karim et al., 2016; Williams et al., 2017). The recent studies applied contingency theory to leadership mainly focus on using a bottom-up approach to lead employees, respond to changes in the external environment, and facilitate the achievement of organizational goals (Morris et al., 2005; Owens and Hekman, 2012; Javed et al., 2020; Ziegert et al., 2021). This study's results show that platform leadership, as a leadership model that can balance the development of employees, platforms, and leaders, can lead to sustainable competitive advantage and contribute to the improvement of organizational ambidextrous learning capabilities, which is a leadership model adapted to the current knowledge economy environment. Simultaneously, the results of this study once again prove that a leadership model that adapts to the internal and external environment of the organization has a positive effect on the development of the company, refuting the useless leadership view in the knowledge economy. Moreover, it is an important complement to and development of the contingency theory and leadership theory.

Third, this study combines RBV theory and contingency theory to further interpret the formation of a sustainable

right leadership model is still the key to sustainable competitiveness even in a highly competitive market. Platform leadership is a leadership model that focuses on the tripartite development of platform, leader, and employees; it has a significant positive effect on the sustainable competitiveness of an enterprise. For enterprises, platform leadership, with its tolerance, unique personal charisma, emphasis on platform building, platform optimization, revolution planning, and mutual growth (Hao et al., 2021), will be conducive to the formation of irreplaceable organizational resources, generate long-term positive effects for the organization and ultimately contribute to the formation of sustainable competitiveness of the enterprise.

Additionally, this paper presents and tests for the first time the positive contribution of platform leadership to ambidextrous learning. Platform leadership focuses on employee development and platform optimization and plays a positive role in promoting the flow of organizational knowledge within the company, which will promote the development of the organization's ability to leverage learning. Simultaneously, studies have evaluated the positive effect of platform leadership on employee innovation behavior (Hao et al., 2021). This shows that platform leadership, with its tolerance leading to employee learning and innovation, and focusing on the interaction of information from the platform to the outside of the organization, lays a good foundation for exploratory learning.

Finally, this study examines the mediating role of ambidextrous learning in the relationship between platform leadership and sustainable competitiveness of the firm. The results of this study indicate that platform leadership ultimately contributes to the improvement of sustainable competitiveness of the firm by driving the improvement of organizational exploratory and exploitative learning capabilities. Additionally, the findings show that ambidextrous learning is an incomplete mediating role. These findings suggest that platform leadership leads to sustainable competitiveness by enhancing organizational

TABLE 6 | Measurement of scale.

Constructs	Items
Tolerance (TO)	TO1: My leader does not mind if his subordinates are better than himself in some aspects TO2: My leader does not mind occasional mistakes in his subordinates' work TO3: My leader does not mind sharing honors and opportunities with his subordinates TO4: My leader does not mind and often encourages his subordinates to give him advice TO5: My leader respects his subordinates' differences in personalities and abilities
Charisma (CH)	CH1: My leader always stays positive in good times and bad CH2: My leader can put himself in his subordinates' shoes CH3: My leader does not give up when things get tough CH4: My leader can make decisions quickly and accurately when encountering emergencies or important cases CH5: My leader can deal with problems objectively and fairly
Platform Building (PB)	PB1: My leader has full confidence in his subordinates' work ability and personal character PB2: My leader believes that the interests of his subordinates agree with those of the organization PB3: My leader is committed to continuous improvement of existing organizational systems PB4: My leader has sufficient socio-economic resources to help the organization achieve its goals
Revolution Planning (RP)	RP1: My leader has a long-term plan for developing the company/team RP2: My leader can quickly identify and summarize the essence of problems RP3: My leader can clearly set and describe the vision of the organization Platform Optimization ($\alpha=0.856$)
Platform Optimization (PO)	PO1: My leader is good at motivating subordinates to pursue higher goals PO2: My leader encourages subordinates to embrace and learn all the knowledge beneficial to organizational development and personal improvement PO3: My leader encourages subordinates to constantly seek new ideas and approaches in solving problems PO4: My leader communicates frequently and proactively with subordinates emotionally
Mutual Growth (MG)	MG1: My leader often pays attention to their growth and gives his subordinates guidance and education MG2: My leader continues to learn advanced professional knowledge and leadership skills MG3: My leader creates opportunities to fully empower subordinates to take charge of a project MG4: My leader often communicates with subordinates about new technologies and knowledge to help them grow
Exploratory Learning (EY)	EY1: In information search, we focused on mastering project strategies that involved experimentation and high market risks EY2: We preferred to collect information with no identifiable strategic market should ensure experimentation in the project EY3: Our aim was to acquire knowledge to develop a project that led us into new areas of learning, such as new markets and technological areas EY4: We collected novel information and ideas that went beyond our current market and technological experiences EY5: We collect new information that forced us to learn new things in the product development project
Exploitation Learning (EE)	EE1: We search for information to refine common methods and ideas in solving problems in the project EE2: Search for ideas and information that we can implement well to ensure productivity rather than those ideas that could lead to implementation mistakes in the project and in the marketplace EE3: We searched for usual and proven methods and solutions to product development problems EE4: We used information acquisition methods (e.g., survey of current customers and competitors) that helped us understand and update the firm's current project and market experiences EE5: We emphasized the use of knowledge related to our existing project experience
Sustainable Competitive Advantage (SCA)	SCA1: The quality of the products or services that my firm offers is better than that of the competitor's products or services SCA2: My firm is more capable of R&D than the competitors SCA3: My firm has better managerial capability than the competitors SCA4: My firm's profitability is better SCA5: The corporate image of my firm is better than that of the competitors SCA6: The competitors are difficult to take the place of my firm's competitive advantage

competitive advantage. In a knowledge-based economy, academic and practical communities have paid less attention to leadership than before, and the role of leadership for firms has been questioned by the proliferation of ideas, such as decentralization and de-leadership (Uhl-Bien et al., 2007; Avolio et al., 2009). The studies conducted on the sustainable competitive advantage of firms have also mostly started from the organizational level (Asimakopoulos et al., 2020; Khourouh et al., 2020; Prabowo et al., 2021; Yang et al., 2021). This paper shows that sustainable

competitive advantage can be built from the individual level. Platform leadership, as the appropriate leadership at present, can also be regarded as an important enterprise resource. The results state that platform leadership can promote dual learning capabilities and the generation of non-substitutable resources, thus increasing the firm's sustainable competitive advantage. This study extends and develops the RBV theory by exploring the causes of a sustainable competitive advantage from a new perspective of platform leadership.

Managerial Implications

The findings of this study also provide important insights for corporate development. First, companies should attach importance to the vital role of platform leadership to lay a foundation for the formation of a sustainable competitive advantage. Compared with other leadership, platform leadership can balance the development of employees, platforms, and leaders better. In the operation practice, the stable, harmonious, and mutually supportive tripartite relationship among employees, leaders, and platforms will provide driving force for the development of organizations and have a positive impact on sustainable competitive advantage. Companies should recognize the long-term impact of platform leadership on their competitive advantage. Institutions ought to be adopted to encourage the steady formation and development of platform leadership. Enterprises can select the right leaders according to the connotation of platform leadership or encourage leaders to transform into platform leaders by the enterprise system. Additionally, companies can give platform leaders the appropriately broad authority to ensure that the positive effects of platform leadership on the organization can be successfully implemented over the long term.

Second, research has demonstrated that organizational learning can be improved and developed by choosing the right leadership model. It is a consensus among academics and practitioners that improving organizational learning capability leads to a sustainable competitive advantage. This study shows that the right type of leadership can lead to the improvement of organizational learning ability. Through the joint of employees, platforms, and leaders, platform leaders will extend its contribution to the enterprise from the employee level to the organizational level. Platform leadership has a significant positive impact on exploratory learning and exploitative learning, which in turn promotes the formation of unique resources that are difficult to replicate. Therefore, relevant enterprises can start with the key dimensions of platform leadership model, then gradually promote the formation of good organizational learning habits. Especially for those companies in fast-growing industries, the rapid changes in the external environment that companies face rely heavily on organizational learning capabilities. The selection of platform leadership model will facilitate the multi-value of employees, leaders, and the platform, forming an organizational atmosphere of continuous learning. Continuous organizational learning capability will provide a constant competitive advantage and the long-term development of enterprises.

Limitations and Future Directions

This study has following limitations that have implications for future research. First, as one of the first papers to study the effect of platform leadership on sustainable competitive advantage, our research views platform leadership concept as a whole.

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Future research could adopt the same research method to explore the subdimensions of platform leadership, such as “tolerance,” “charisma,” “revolution planning,” “platform building,” “platform optimization,” and “mutual growth” (Hao et al., 2021). Second, the results of this study indicate that ambidextrous learning is an incomplete mediating role, which means the paths of platform leadership for sustainable competitive advantage are more complex. Future research could choose other perspectives to further improve the mechanism of platform leadership on sustainable competitive advantage. Third, this paper chooses questionnaire method to complete this research, and all our respondents are Chinese residents. According to the contingency theory, the internal and external environments of the organization are important factors in choosing the appropriate leadership model (Luthans and Stewart, 1977; Williams et al., 2017). China’s economy has grown rapidly in recent years and its business environment is quite representative in the international market. However, in some economically underdeveloped areas, the applicability of the findings of this paper remains to be considered. Future studies may consider regions with different economic development to further examine the complex effects of regional economic development on the findings of this paper.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

XY: conceptualization, funding acquisition, project administration, methodology, investigation, writing—review, and supervision. RJ: investigation, validation, and writing—original draft. CZ: formal analysis, methodology, and writing—review and editing. All authors contributed to the article and approved the submitted version.

FUNDING

This research was funded by the National Social Science Foundation of China (Grant No. 18BGL032), Soft Science Foundation of Sichuan Province (Grant Nos. 2019JDR0190 and 2021JDR0109), Soft Science Foundation of Chengdu (Grant No. 2019-RK00-00402-ZF), the Fundamental Research Funds for the Central Universities (Grant Nos. 2021ZY SX20 and 2021ZZ006), and Sichuan university (Grant No. 2021CXC23).

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The Impact of Consumer Purchase Behavior Changes on the Business Model Design of Consumer Services Companies Over the Course of COVID-19

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OPEN ACCESS

Edited by:

Xiaoyu Wang,
Shanghai University of Finance
and Economics, China

Reviewed by:

Yijie Ai,
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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 20 November 2021

Accepted: 10 February 2022

Published: 03 March 2022

Citation:

Tao H, Sun X, Liu X, Tian J and
Zhang D (2022) The Impact
of Consumer Purchase Behavior
Changes on the Business Model
Design of Consumer Services
Companies Over the Course
of COVID-19.
Front. Psychol. 13:818845.
doi: 10.3389/fpsyg.2022.818845

The COVID-19 pandemic has had a profound psychological and behavioral impact on people around the world. Consumer purchase behaviors have thus changed greatly, and consumer services companies need to adjust their business models to adapt to this change. From the perspective of consumer psychology, this paper explores the impact of consumer purchase behavior changes over the course of the pandemic on the business model design of consumer services companies using a representative survey of 1,742 individuals. Our results show that changes in consumer purchase behavior have a significant impact on the design of consumer services firms' business models. Specifically, changes in consumers' purchase object, motive, and timeframe are more likely to spark a novelty-centered business model design, whereas changes in purchase method tend to inspire an efficiency-centered one. Our findings provide a theoretical reference for consumer services companies in designing business models when faced with unexpected crises.

Keywords: consumer psychology, consumer purchase behavior, efficiency-centered business model, novelty-centered business model, consumer services company

INTRODUCTION

The COVID-19 outbreak has abruptly disrupted the global political and economic order (Fernandes, 2020), significantly impacting consumer services sectors such as retailing, hospitality, and tourism (Pantano et al., 2020). The pandemic has resulted in unprecedentedly large-scale lockdowns across the world (Kuckertz et al., 2020), severely restricting people's daily activities. As a result, more consumer services companies are experimenting with new technologies and platforms in order to meet the changing consumer demands, leading to new consumption patterns. To cope with the restrictions, some consumer services companies have developed alternative business models, such as "contactless delivery" and "social cinema."

The government's strict restriction on population movement has led to seismic shifts in people's livelihoods and daily lives. More people are suffering from depression and loneliness, and some have resorted to alcohol, drugs, or even self-harm for relief (Alsukah et al., 2020). These unhealthy emotions and behaviors have caused quite shifts in individuals' consumption psychology: people in a dire circumstance may develop a "nothing to lose" mentality and become more prone to

risk-taking, resulting in more impulse purchases (Hill et al., 1997; Harris et al., 2002); they might also develop post-traumatic stress disorder (PTSD) and future anxiety, resulting in fewer purchases to increase savings (Nolen-Hoeksema and Morrow, 1991; Kılıç and Ulusoy, 2003; Kun et al., 2013). During the COVID-19 pandemic, consumer psychology and purchase behavior have fundamentally changed.

Purchase behavior is a special and specific behavior that directly reflects people's needs, desires, pursuit of material and spiritual interests (Braithwaite and Scott, 1990). Factors that affect changes in purchase behavior include social factors, cultural factors, demographic factors, and situational factors (Cici and Bilginer Özsaatçı, 2021). Therefore, the COVID-19 pandemic as a social factor is also affecting different changes in purchase behavior. Scholars generally believe that a large number of consumers showed panic buying behavior or impulsive buying behavior in the early stage of the COVID-19 pandemic (Aljanabi, 2021; Stuart et al., 2021), and even accompanied by compulsive buying behavior (Samet and Gözde, 2021). While purchase behavior in the middle of the COVID-19 pandemic is characterized by mobility (Gao et al., 2020; Zhang et al., 2020; Lu et al., 2021). The application of digital technology has created favorable conditions for consumers to participate in online shopping, and consumers' online purchase activities have increased significantly (Jiang and Nikolaos, 2021). However, the changes in purchase behavior in the above literature focus on changes in a single dimension, and do not systematically sort out the changes in consumer purchase behavior under the COVID-19 pandemic. Therefore, according to the basic theory of marketing, this study systematically sorts out the multiple dimensions of changes in consumer purchase behavior under the COVID-19 pandemic, and improves the items of the purchase behavior changes in each dimension, so as to provide supplements for the theory of consumer behavior.

Countries around the world have adopted special measures such as regional blockades in the process of fighting the epidemic. These measures are a shock to traditional business models and require corresponding changes to traditional business models. However, there are currently different perspectives on the impact of purchase behavior on corporate marketing models, including traditional brick-and-mortar store purchase models, green marketing models, B2B transaction models, and online marketing models (Beuckels and Hudders, 2016; Nguyen et al., 2016; Sundström et al., 2019; Wei and Ho, 2019). However, there is little literature analyzing the impact of purchase behavior on firms' business models from the perspective of sudden crisis events. Besides, there are many external factors affecting business model design, such as technological change (Øiestad and Bugge, 2014), contextual factors (Zott and Amit, 2013; Ghezzi et al., 2015), local market opportunities (Sinkovics et al., 2014), and third-party partnerships in the customer value proposition development (Velu, 2015). Among the above-mentioned external factors affecting business model innovation, less research is based on the impact of residents' behavior. Therefore, it is particularly important to study the impact of changes in consumer purchase behavior on business model design in the context of the COVID-19 pandemic.

To answer these questions, this paper examines consumers' psychological changes over the course of the COVID-19 pandemic based on the theory of environmental psychology, affective psychology, and consumer psychology. The stimulus-organism-response (S-O-R) model (Mehrabian and Russell, 1974) is used to explain how the pandemic triggered people's psychological alteration, which in turn sparked changes in their purchase behavior. Then, we conduct a representative survey of 1742 individuals to explore the impact of customer purchase behavior changes on the business model design of consumer services companies using the expectation confirmation theoretical model (Oliver, 1980). The remainder of this article is structured as follows: Section 2 is devoted to conceptual basis and research assumptions; Section 3 presents the research design; Section 4 is the empirical analysis; Section 5 concludes the paper.

CONCEPTUAL BASIS AND RESEARCH ASSUMPTIONS

Consumer Purchase Behavior Changes During the COVID-19 Pandemic

According to disaster psychology, different psychological changes of residents caused by different periods of emergencies make purchasing behaviors show distinctive characteristics, such as panic buying behaviors, impulse buying behaviors, compulsive buying behaviors and online buying behaviors. In the initial stage of the COVID-19 outbreak, although only the individuals who experienced the event will be directly affected, the negative emotions caused will be transmitted to the entire society through social networks. The public is prone to irrational emotions, including anxiety and depression (Clauw et al., 2003; Klitzman and Freudenberg, 2003). Public anxiety, especially in the face of a large-scale pandemic, can easily lead to the spread of negative emotions (Hull et al., 2003). In addition, consumers' perception of uncertainty, scarcity, and severity and other psychological factors will increase, causing customers to panic buying behavior (Omar et al., 2021). The specific performance is to stock up on some necessities and reduce the purchase of non-essential items (Roşu et al., 2021). The fear of out-of-stocks and supply chain disruptions brought about by the COVID-19 pandemic will also increase consumers' impulse buying behavior. The worse consumers perceive the COVID-19 outbreak, the stronger their inner fears, and the more likely they will lead to their impulsive purchases of health products. The COVID-19 pandemic has increased the perceived pressure of consumers, and some consumers are accompanied by compulsive purchasing behavior. By increasing their buying behaviors, they can relieve their inner anxiety and tension (Samet and Gözde, 2021). Besides, online purchasing behaviors have become increasingly popular with consumers after the COVID-19 outbreak. In the face of the government's home isolation measures, it has become more and more common for consumers to use online shopping for food and other items. People who are aware of the risks of going out are more willing to buy fresh food online (Lu et al., 2021). Consumer purchase behavior is no longer limited by

time and space, and consumers use mobile tools such as mobile phones to achieve shopping freedom (Zhang et al., 2020). Among the above-mentioned studies have carried out detailed research on a certain characteristic of changes in consumer purchase behavior, but have not systematically sorted out changes of the psychological characteristics and behavioral characteristics of consumers. Changes in consumer purchase behavior are reflected in many aspects, not just a single dimension of change.

The stimulus-organism-response (S-O-R) model reveals the influence of the environment on individual emotions. “Stimulus” refers to any environmental factor that causes an individual’s intrinsic response to the environment. “Organism” represents the individual’s emotional state and cognitive process (Zinkhan et al., 1992). “Response” is the individual’s response to the external stimulus (Hunt and Downing, 1990). In short, the S-O-R theory states that external stimulus triggers people’s emotional and cognitive changes, which in turn lead to different behaviors. Therefore, the COVID-19 pandemic as the external stimulus will change people’s consumption psychology and hence their purchase behavior in terms of purchase object, motive, place, timeframe, and method.

In terms of purchase object, the outbreak of the epidemic has made consumers put forward higher requirements for products or services. When consumers face an emergency, they choose problem-solving products or services over emotional healing products or services (Yeung and Fung, 2007; Cai et al., 2020). Utilitarian products, as opposed to hedonic items, are more effective in addressing consumers’ immediate needs (Yang et al., 2020). Consumers caught in the pandemic would increase their purchases of utilitarian products such as disinfectants, masks, and health foods. On the other hand, when people are under pressure or are anxious about external threats, instead of directly addressing the issues, they often activate a psychological defense mechanism—the cognitive and behavioral tendencies that individuals unconsciously adopt in the face of frustration or conflict in order to relieve tension and anxiety (Cramer, 1991)—to protect themselves (Baumeister et al., 1998). The COVID-19 pandemic has triggered people’s psychological defense mechanism, leading to more cautious buying. Consumers are not only more price-sensitive, but they also demand higher-quality and more reliable products. In terms of purchase objects, consumers pay more attention to the quality of the objects they buy. The increase in online purchasing activities has also made consumers more willing to disclose their personal information (Gao et al., 2020).

In terms of purchase motive, previous scholars can divide purchase motivation into hedonic motivation, social motivation and utilitarian motivation (Voss et al., 2003). This framework, which shapes consumer motivation for product categories, has been widely used in the field of consumer behavior. In recent years, the application of new technologies has become more and more extensive. Therefore, new media is used by more and more people and brings more fun to consumers. Driven by hedonic motivation, consumers are more keen on new media shopping methods such as Douyin and Kuaishou (Koch et al., 2020). The contribution of social responsibility can improve consumers’ willingness to purchase in advance (Tong et al., 2021).

During the COVID-19 pandemic, many Chinese companies have donated financial and material resources during the pandemic, which helped build positive customer perceptions and attitudes toward their products (Yin et al., 2019). Therefore, driven by social motivation, consumers are more willing to choose brands that have contributed to society. In addition, consumers’ herd mentality makes them more utilitarian in the process of purchasing goods, and thus more willing to choose products with higher evaluation (Samet and Gözde, 2021). Driven by the above motivation, consumers choose more and more brands of goods.

In terms of purchase place, the government’s home isolation measures have made consumers’ offline shopping channels difficult, and their online purchases have become more and more common (Zhang et al., 2020; Lu et al., 2021). Specifically, consumers have gradually developed the habit of purchasing some daily necessities online. At the same time, the rapid development of social media has brought more shopping convenience to consumers. As a result, when consumers shop on social platforms such as WeChat (Larios-Gómez et al., 2021), they are able to pick their favorite products more quickly (Ali et al., 2021). As the number of consumers on social platforms increases, the number of consumers in offline venues decreases accordingly. Although consumers’ offline purchasing activities have decreased, consumers have become more demanding of offline shopping places. In order to reduce the risk of infection, when consumers shop offline, they pay more attention to the safety, convenience and goodwill of shopping places (Butu et al., 2020). As a result, consumers have also changed significantly in terms of purchase place.

When it comes to purchase timeframe, advances in technology stimulate consumers’ perception of the value of time. The new shopping habits that consumers have formed during the COVID-19 epidemic have made their sense of time sharper than before the COVID-19 outbreak. Consumers expect the fastest way to obtain goods and services (Kyowon et al., 2020), improving their shopping efficiency. The development of Internet technology and the wide application of mobile terminals have enabled consumers to satisfy their desire to shop anytime, anywhere. Therefore, consumers prefer a shopping method with unlimited time to purchase goods and less time-consuming in terms of purchase timeframe.

In terms of purchase method, in order to avoid contact with uncertain external services and reduce the risk of infection, consumers choose contactless delivery methods based on safety needs (Larios-Gómez et al., 2021). Through the contactless delivery method, consumers can effectively relieve their inner anxiety and smoothly maintain the order of daily life.

Consumer Purchase Behavior Changes and Business Model Design

People’s fear and anxiety about the pandemic are unlikely to abate in the near future, and the resulting changes in consumer demand might eventually damage the supply chain performance of consumer services companies (Ivanov, 2020). These companies have already been experiencing significant challenges with their existing business models due to strict social isolation, delayed

return-to-work, and disrupted logistics. The pandemic is putting some major businesses to the test since consumers may not restore their previous buying habits anytime soon (Pantano et al., 2020). According to the Expectation Confirmation Theory, consumer services companies have to adjust their business models to meet new customer expectations in order to obtain consumer satisfaction.

Changes in consumer purchase behavior under the COVID-19 pandemic have had an impact on the design of novelty-centered business models. Novelty-centered business models place more emphasis on exploiting new opportunities in new ways (Foss and Saebi, 2017), and their essence is to satisfy new customer value propositions, need or experience through innovations in the content, structure or governance of the activity system. Although the COVID-19 pandemic has led to a decline in consumers' purchase power, the requirements for product quality upgrades will not change. Changes in purchase object drives consumer services companies to design novelty-centered business models. With the improvement of consumers' overall consumption level, the enhancement of consumption power and the upgrade of consumption preferences, their satisfaction with standardized products gradually decreases, and the trend of pursuing more diversified and personalized products or services will continue. As consumer preferences increase in diversification, companies must launch new products and price them appropriately in the face of a fiercely competitive market, especially in the context of environmental uncertainty exacerbated by the COVID-19 pandemic. Novelty-centered business models can bring customers better products and experience through innovative methods on the basis of product technology innovation.

When it comes to purchase motive, consumers prefer products from companies with a reputable image or a strong sense of social responsibility. Branded products increase consumers' perceived usefulness (Bhattacharjee, 2001), which is precisely what novelty-centered business models could accomplish. Therefore, consumers expect companies to design novelty-centered business models. In terms of purchase method, consumers prefer novel purchase methods and services such as mobile payment and contactless delivery. This suggests that consumer demand for novel payment methods has not yet been completely satisfied. People who get exposed to the same products or services repeatedly will eventually get bored due to the diminishing marginal utility of overexposure (Line et al., 2016). Bored customers will eventually feel less satisfied. Thus, consumer services companies should adopt a novelty-centered business model design in order to re-establish customer satisfaction. Moreover, consumers tend to favor a shorter purchase timeframe and a safer purchase place, indicating their expectation to reduce perceived risks (Garaus and Garaus, 2021). To meet that expectation, firms would be better served by novelty-centered business model design. Therefore, changes in consumer purchase behavior have led to the emergence of novelty-centered business models. In summary, the following assumption is made:

H1a: Changes in purchase object facilitate the design of novelty-centered business models.

H1b: Changes in purchase motive facilitate the design of novelty-centered business models.

H1c: Changes in purchase place facilitate the design of novelty-centered business models.

H1d: Changes in purchase timeframe facilitate the design of novelty-centered business models.

H1e: Changes in purchase method facilitate the design of novelty-centered business models.

Changes in consumer purchase behavior under the COVID-19 pandemic have had an impact on the design of efficiency-centered business models. Consumer purchase behavior is a process from information acquisition, formation of purchase intention to purchase decision-making problem. Consumer purchase intention is an important factor that determines the final purchase decision. And information is an important factor that affects consumers' purchasing intention and ultimately making purchasing decisions. Generally speaking, consumers are risk-averse, so they will collect a lot of relevant information before purchasing, so as to turn the uncertainty of purchasing a certain product into certainty. With the rapid development of information technology, whether the contradiction between the explosive growth of information and the limited attention of consumers can be resolved has become an inevitable requirement for enterprises to gain a competitive advantage. The rapid development of information technology also brings the risk of personal information being infringed on consumers at all times in the transaction, especially in the field of online consumption, the black industry chain of "stealing" and "illegal use" of consumers' personal information shows an explosive growth trend. Whether companies can keep the personal information of consumers collected in business activities strictly confidential has become a matter of close concern to consumers. Efficiency-centered business models emphasize that enterprises can improve business efficiency by reducing transaction costs, improving information transparency and sharing, and improving transaction security. With this, information can be efficiently shared between customers and enterprises, and the "information island" between the two can be reduced, so that consumers can trust enterprises and generate purchase intentions.

In terms of purchase object, people are more rational in choosing what to purchase. This increases consumer demand for efficiency in the products or services purchased from consumer services companies. In this case, companies should choose an efficiency-centered business model design since it emphasizes improving the efficiency of business transactions. Customers are satisfied, and their expectations are confirmed when they perceive that the efficiency of the goods or services exceeds the expected efficiency. In addition, with regards to purchase motive, consumers tend to favor brands that are well rated and contribute to society. Consumers perceive branded products as allowing them to make the right choice more quickly. Efficiency-centered business models are consistent with this consumer perception. In terms of purchase place, people prefer to shop online or on social media platforms, highlighting their expectations for a safe and convenient shopping environment. Efficiency-centered business models are essential for firms to meet such customer

expectations. As mentioned above, consumers prefer a shorter purchase timeframe, indicating that consumers' time efficiency expectations have not been fully satisfied and the increasing need for consumer services companies to develop efficiency-centered business models. In terms of purchase method, the fact that consumers have become more favorable in mobile payment and contactless delivery reflects the growing consumer demand for efficient payment and delivery methods. Hence, consumer services companies need to design an efficiency-centered business model in order to increase customer satisfaction. Therefore, in addition to novelty-centered business models, the change in consumer purchase behavior has also created a demand for efficiency-centered business models. In summary, the following assumption is made:

- H2a:** Changes in purchase object facilitate the design of efficiency-centered business models.
- H2b:** Changes in purchase motive facilitate the design of efficiency-centered business models.
- H2c:** Changes in purchase place facilitate the design of efficiency-centered business models.
- H2d:** Changes in purchase timeframe facilitate the design of efficiency-centered business models.
- H2e:** Changes in purchase method facilitate the design of efficiency-centered business models.

On the basis of drawing on relevant research and theoretical achievements, this research innovatively constructs a theoretical research model of consumer purchase behavior on business model innovation under the background of normalization of the epidemic (Figure 1).

RESEARCH DESIGN

Survey Design and Variable Measurements

The data used in this paper was obtained through a representative survey. In order to ensure the reliability of the questionnaire, the design of the changes in consumer purchase behavior questionnaire adopted the literature method to select the measurement variables and corresponding items of the related research on consumer purchase behavior. On this basis, researchers related to consumer behavior were invited to evaluate the questionnaire, and potential consumers were selected as the survey objects for interviews, and some difficult and ambiguous questions were revised and supplemented. The scales for business model design mainly refer to the mature scales of relevant international studies. Then, modifications were made to account for the unique circumstances of the COVID-19 pandemic. On this basis, 58 individuals were selected for pre-investigation. Based on the test results, questions with relatively low factor loadings were further revised. Then, a rating scale is developed. The questionnaire take a form of a five-point Likert scale, where 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Not sure*, 4 = *Agree*, and 5 = *Strongly agree*. The main variables include basic demographic characteristics, the changes in consumer purchase behavior

(purchase object, motive, place, timeframe, and method), and business model designs (novelty- and efficiency-centered).

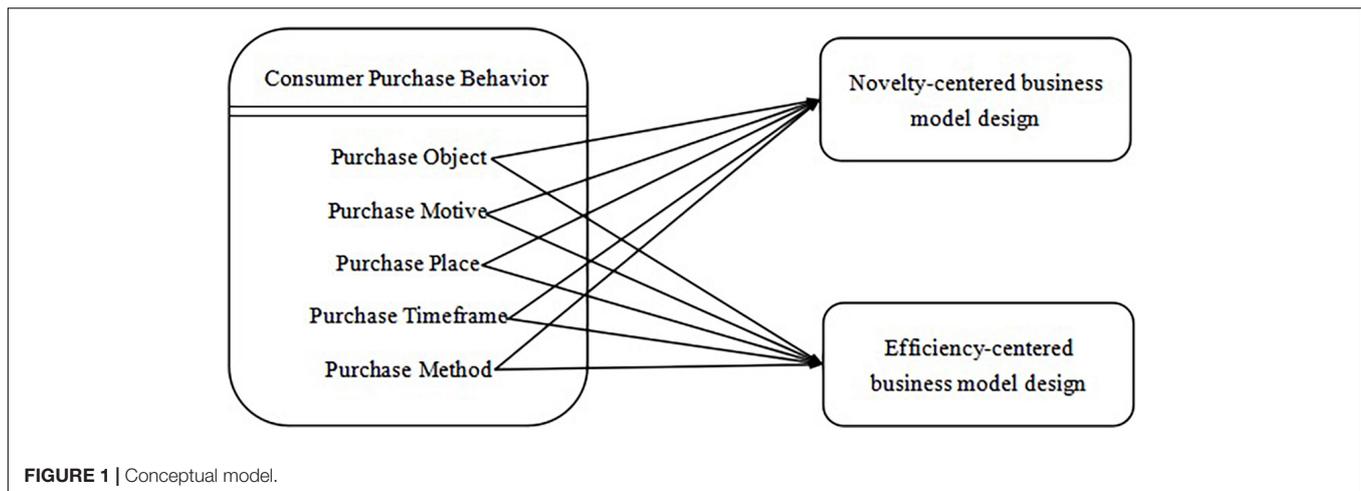
Dependent Variable

Business model design (BMD) was chosen as the dependent variable. Based on Zott and Amit (2009), we categorized business model design into novelty-centered business model design (NBM) and efficiency-centered business model design (EBM). The survey questionnaire was similar to that provided by Zott and Amit, with a few modifications to account for the COVID-19 pandemic. NBM was measured by ten items: (1) *'The merchant offers a wider range of goods to attract new customers'*; (2) *'The merchant offers a wider range of services to attract new customers'*; (3) *'The merchant offers a broader selection of brands'*; (4) *'The merchant is using more of a combination of physical and online shops to offer goods or service'*; (5) *'The merchant has adopted a wider variety of payment methods'*; (6) *'The merchant has become an industry benchmark'*; (7) *'The merchant is more creative in its store design'*; (8) *'The merchant offers more innovative products'*; (9) *'The merchant offers more innovative services'*; (10) *'The merchant's business model is new'*. EBM was measured by eight items: (1) *'The merchant has made my purchase of goods or services more efficient'*; (2) *'The merchant made my shopping time shorter'*; (3) *'The merchant has given me more information about the goods'*; (4) *'The merchant has given me more information about the services'*; (5) *'The merchant gave me more ways to buy and settle my bill'*; (6) *'The merchant made fewer errors in the sales process'*; (7) *'The merchant offers cheaper goods or services'*; (8) *'My communication with the merchant is faster and more efficient.'*

Explanatory Variable

Consumer purchase behavior changes (CPC) were the explanatory variable. Based on Valaskova et al. (2021) and Vázquez-Martínez et al. (2021), we described consumer purchase behavior changes from five dimensions: changes in purchase object (PO), changes in purchase motive (PR), changes in purchase place (PP), changes in purchase timeframe (PT), and changes in purchase method (PW). As before, we made a few modifications to the questions measuring these variables to account for the COVID-19 pandemic. The specific measurements of each dimension were as follows.

According to marketing theory, changes in purchase object refers to the goods or services that consumers buy. Based on Zhang and Zheng (2019), Consumers' choice of purchase object is mainly reflected in price, quality and service. The measurement of the purchase object is measured from the above three aspects. At the same time, combining the characteristics of purchasing behavior under the COVID-19 pandemic (Cai et al., 2020; Gao et al., 2020; Yang et al., 2020) and the results of interviews with consumers, the changes in purchase object (PO) were measured by nine items. As follows: (1) *'I am more likely to buy technology products (e.g., sports bracelets, etc.)'*; (2) *'I am more likely to buy high protein products (e.g., milk, etc.)'*; (3) *'I am more likely to buy high-end products'*; (4) *'I am more likely to buy personalized items'*; (5) *'I am more cautious about buying non-essential products'*; (6) *'I have higher expectations of customer service for the products I buy'*; (7) *'I am more concerned about the quality and efficacy of*



products'; (8) 'I am more concerned about the price of products'; (9) 'I am more likely to allow merchants access to my personal information.'

The hedonic shopping motivation research scale according to Mark and Kristy (2003) and the utilitarian shopping motivation research scale by Martínez-López et al. (2014) formed the basis of the measurement scale of change in purchasing motivation in this study. On this basis, items unrelated to the COVID-19 pandemic were eliminated, and some items were improved to form a new measurement scale. The changes in purchase motive (PR) were measured by five items: (1) 'I am more likely to buy highly rated products'; (2) 'I am more likely to try new brands'; (3) 'I am more likely to buy products recommended by acquaintances'; (4) 'I am more likely to buy products recommended in short video apps such as Douyin (Chinese TikTok) and Kuaishou'; (5) 'I prefer brands that have contributed to society during the COVID-19 pandemic.'

Marketing practice differentiates the place of purchase into online and offline (Srikanth et al., 2011). Based on Volpe et al. (2013), we measured the change in offline purchase location in purchase place. Ali et al. (2021) and Larios-Gómez et al. (2021) provided us with measurement items for changes in online purchase place. The changes in purchase place (PP) were measured by five items: (1) 'I am more likely to shop in a one-stop store'; (2) 'I am more likely to buy goods in a contactless store'; (3) 'I am more concerned about the safety of the shopping environment'; (4) 'I am more concerned about the reputation of merchants'; (5) 'I am more willing to shop on social media platforms such as WeChat.'

Based on Eastlick and Feinberg (1999), Consumers' requirements for purchase timeframe were reflected in flexibility, speed and convenience. The survey questionnaire was similar to that provided by Eastlick, with a few modifications to account for the COVID-19 pandemic. Combined the results of the interviews, the changes in purchase timeframe (PT) were measured by three items. As follows: (1) 'I am more likely to spend an unlimited amount of time shopping'; (2) 'I am more likely to spend less time shopping'; (3) 'I am more organized in my shopping activities, such as making detailed shopping lists, planning shopping routes, and so forth.'

Finally, based on Larios-Gómez et al. (2021) and the results of interviews with consumers, the changes in purchase method (PW) were measured by three items: (1) 'I am more willing to accept contactless delivery services'; (2) 'I am more willing to use mobile payment'; (3) 'I am more willing to use self-checkout.'

Control Variable

Following existing literature, we selected respondents' gender (Gender), age (Age), education attainment (Edu), and monthly income level (Income) as control variables.

To ensure measurement precision and accuracy, the data were analyzed using the item response theory (IRT) model rather than factor analysis, as the latter results in information loss (Xue et al., 2019). The Item Response Theory (IRT) model estimates variables through an iterative computation process, making sufficient use of existing information. The IRT model also takes into account the difficulties of survey questions, making the estimations closer to real practice (Xue et al., 2021). Therefore, we utilized the IRT model to measure business model design (BMD), including novelty-centered business model design (NBM) and efficiency-centered business model design (EBM).

Rabe-Hesketh et al. (2004) propose two types of IRT model, i.e., one-parameter logistic IRT (1PL-IRT) model and two-parameter logistic IRT (2PL-IRT) model. However, it is unrealistic to apply the 1PL-IRT model in real practices. Therefore, the 2PL-IRT model is widely used to measure latent variables. Given the fact that the 2PL-IRT model can only be applied to estimate binary variables, Zheng and Rabe-Hesketh (2007) integrate the partial credit model (PCM) into the 2PL-IRT model, namely the 2PL-PCM, to measure latent variables with multiple categories. Therefore, following Xue et al. (2019), we employed the 2PL-PCM to measure BMD and NBM. The 2PL-PCM model specifications are as follows.

$$\Pr(x_{in} = j|\theta_n) = \frac{\exp\{\sum_{m=2}^j \gamma_i(\theta_n - \delta_{im})\}}{1 + \sum_{l=2}^{k_i} \exp\{\sum_{m=2}^l \gamma_i(\theta_n - \delta_{im})\}} \quad (1)$$

$$\ln \frac{\Pr(x_{in} = j|\theta_n)}{\Pr(x_{in} = j-1|\theta_n)} = \gamma_i(\theta_n - \delta_{ij}) \quad (2)$$

Data

This paper aims to investigate the impact of consumer purchase behavior changes on the business model design of consumer services companies during the COVID-19 pandemic. The intended population for this research was identified as individuals who have shopped during the COVID-19 pandemic and have a basic understanding of consumer services business models. We fielded the survey from 18 April 2020 to 23 July 2020. All questionnaires were anonymous, and rigorous distribution and return protocols were followed. Questionnaires were distributed in three main ways: first, upon contact confirmation, our team members conducted on-site interviews with the respondents and distributed the questionnaires; second, using the team members' social connections, the questionnaires were distributed to those who qualified; Third, the questionnaires were distributed through email. In the end, a total of 1,887 questionnaires were distributed, and 1,742 were valid following careful screening.

The demographic profile of the respondents is as follows. Male respondents account for 43.456%, while female respondents account for 56.544%. In terms of age, 0.459% of the respondents are under the age of 18; 30.540% are between 18 and 25 years old; 25.316% are between 26 and 35 years old; 19.518% are between 36 and 45 years old; 19.346% are between 46 and 55 years old; 4.822% are 56 years and above. Regarding education attainment, 1.607% of the respondents have a junior secondary certificate or below; 6.257% have a senior secondary certificate (including high school and vocational and technical school certificate); 48.565% have a university certificate; 43.571% have a postgraduate certificate or above. Finally, in respect of monthly income level, 19.460% of the respondents earn no income; 6.889% earn less than RMB 2,000 per month; 18.657% earn RMB 2,001–5,000 per month; 24.799% earn RMB 5,001–8,000 per month; 30.195% earn RMB 8,001 or more per month.

Common method variance (CMV) is likely to lead to biased results for variables obtained from survey questionnaires (Xue et al., 2019). Therefore, we employed the Harman's single factor test to examine the existence of the CMV. The test results showed that the common factor only explains 18.733% of total variance, indicating that the common method bias is not a concern for this paper.

EMPIRICAL ANALYSIS

This section presents the empirical analysis conducted on the collected survey questionnaires. It includes four parts: (1) descriptive statistical analysis and correlation coefficient analysis; (2) analysis of consumer purchase behavior changes by demographic characteristics (including gender, age, monthly income level, and education attainment); (3) regression modeling; (4) robustness tests.

Descriptive Statistical Analysis and Correlation Coefficient Analysis

Table 1 showed the descriptive statistics of the main variables. All variables have a relatively small mean value, indicating that respondents' willingness to change their behavior for the

pandemic is low. A plausible explanation is that people became less vigilant and concerned as the pandemic was gradually brought under control. On the other hand, the novelty-centered business model has a higher mean value than the efficiency-centered business model, suggesting that following the pandemic, respondents tend to favor the novelty-centered business model over the efficiency-centered one. This is because as the outbreak gradually subsides, people become less pessimistic and hence more interested in new things. In addition, the standard deviations of all variables are small, indicating small variations for variables used in this study. This is also reflected in the extreme deviations, with the largest extreme deviation being only 5. Moreover, all the variables range from -3 to 2 , indicating no extreme values observed.

Table 1 also showed the correlation coefficients between the main variables. The results indicate a significant and positive correlation between consumer purchase behavior changes and both types of business model designs. However, the correlation between consumer purchase behavior changes and novelty-centered business model design is more significant; the impact of consumer purchasing behavior changes on novelty-centered business model designs is likely to be greater. However, the exact relationships between the variables remain to be tested further below.

Analysis of Consumer Purchase Behavior Changes by Demographic Characteristics

Over the course of the COVID-19 pandemic, consumer purchase behaviors have changed dramatically. These changes exhibited a number of differences according to demographic characteristics. **Figure 2** illustrated the differences in consumer purchase behavior changes by gender, age, monthly income level, and education attainment. Details were discussed in the following four sub-sections.

Gender

Figure 2A displayed the pandemic-induced changes in consumer purchase behavior by gender. The changes in purchase object and timeframe exhibited an apparent gender variation. Females usually tend to act more impulsively than males (Hesham et al., 2021). The pandemic have prompted male consumers to be more rational in shopping; therefore, the purchase behavior change of male consumers is greater. In terms of purchase place and motive, a relatively small gender variation is shown. Lastly, no significant gender variation is found for changes in purchase method.

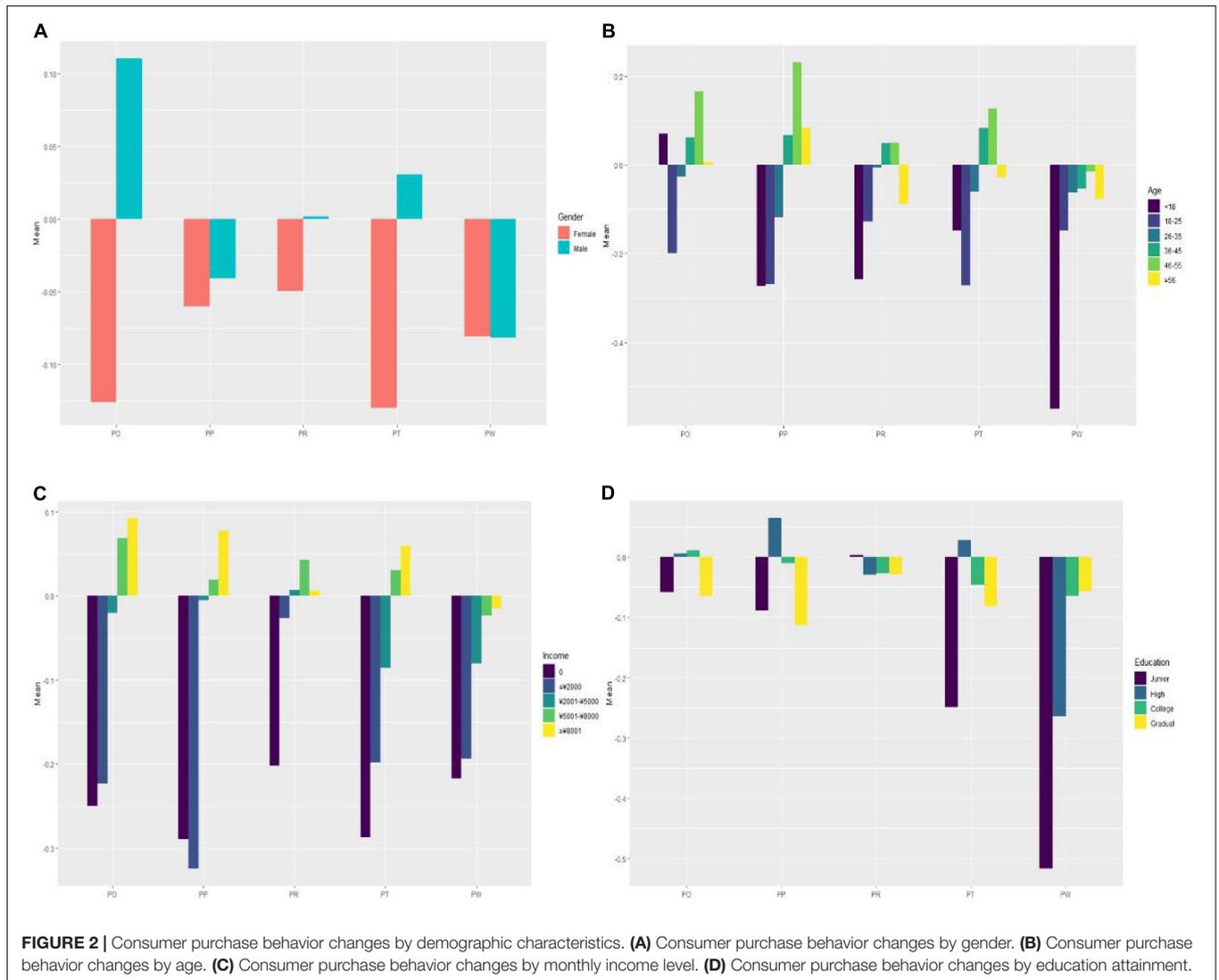
Age

Figure 2B showed the pandemic-induced change in consumer purchase behavior by age group. Observably, all parameters of consumer purchase behavior changed exhibit age variation. Individuals aged 18–25 and 26–35 showed a smaller change in purchase object, but those aged under 18, 36–45, 46–55, and 56+ showed the opposite. The change in purchase place followed a similar pattern, with the exception that persons aged under 18 exhibited a lesser change. In terms of purchase motive and timeframe, the variation across age groups was minor; individuals

TABLE 1 | Descriptive statistics and correlation coefficients.

	Obs.	Mean	SD	Min.	Max.	NBM	EBM	PO	PR	PP	PT	PW
NBM	1742	0.170	0.865	-2.000	2.000	1.000						
EBM	1742	-0.160	0.862	-3.000	1.000	0.807**	1.000					
PO	1742	-0.020	0.842	-3.000	2.000	0.562**	0.504**	1.000				
PR	1742	-0.030	0.749	-3.000	2.000	0.509**	0.433**	0.659**	1.000			
PP	1742	-0.050	0.801	-3.000	1.000	0.469**	0.468**	0.626**	0.565**	1.000		
PT	1742	-0.060	0.780	-2.000	1.000	0.452**	0.442**	0.592**	0.430**	0.566**	1.000	
PW	1742	-0.080	0.792	-2.000	1.000	0.418**	0.455**	0.434**	0.400**	0.500**	0.481**	1.000

***, **, * represent significant at the 1, 5, and 10% significant level, respectively; T-values are provided in parentheses.



aged 36–45 and 46–55 showed a greater change while other age groups showed less change. Lastly, the change in purchase method was relatively small across all age groups. The reason for that is: young people had already adapted to the online lifestyle before the COVID-19 outbreak, therefore no significant change after; but for the elderly, although they tend to be more skeptical of the internet, they now have little choice but to purchase

online due to the pandemic isolation and lockdown. Overall, the middle-aged and elderly have changed the most in their purchase behavior.

Monthly Income Level

Figure 2C depicted the pandemic-induced changes in consumer purchase behavior according to monthly income levels. As can

be seen, there was a significant variation. Individuals with no income or a monthly income of less than RMB 2,000 exhibited smaller change in their purchase object, place, timeframe, and method. People with a monthly income between RMB 5,001 and RMB 8,000 or above RMB 8,001 showed a greater change in their purchase object, place, and timeframe. In terms of purchase method, less variation was shown across monthly income levels. This is because the pandemic has prevented people from returning to work, resulting in a reduction in current or future household income, and because it has also affected people's emotions and cognitions by instilling fear and anxiety about the future in them, prompting people to save preventively.

Education Attainment

Figure 2D showed the changes in consumer purchase behavior by education attainment. The changes in consumer purchase object and motive varied less across different education attainment levels compared to the changes in purchase place, timeframe, and method. Individuals with postgraduate or higher education attainment showed a small change in all aspects of purchase behavior. Unlike other demographic characteristics, education attainment had less of an impact on consumer purchase behavior.

Regression Modeling

To examine the impact of consumer purchase behavior changes on the business model design of consumer services companies, this paper constructed a regression model as follows. As shown in equation (3), BMD represents business model design, which includes the novelty-centered business model design (NMB) and the efficiency-centered business model design (EBM). CPC is consumer purchase behavior changes, which includes the changes in purchase object (PO), the changes in purchase motive (PR), the changes in purchase place (PP), the changes in purchase timeframe (PT), and the changes in purchase method (PW). The

relationships between BMDs and CPCs are examined using the following model:

$$BMD = \beta_0 + \beta_{CPC} + \beta_1 Age + \beta_2 Gender + \beta_3 Income + \beta_4 Edu + \epsilon \tag{3}$$

Table 2 displayed the regression results for the relationship between the pandemic-induced changes in consumer purchase behavior and novelty-centered business model design. The regression result for Model 1 (M1) showed that the changes in consumer purchase object has a positive impact on the novelty-centered business model design (0.584, $p < 0.001$). The regression coefficient of the change in purchase object and novelty-centered business model was 0.584, and it was significantly positively correlated at the 1% level. That was, the greater the changes in the purchase object, the more inclined the consumer services companies is to design a novelty-centered business model. H1a is validated. Similarly, the results for Models 2–5 showed that the change in consumer purchase motive, place, timeframe, and method all have a positive impact on the novelty-centered business model design (0.583, $p < 0.001$; 0.516, $p < 0.001$; 0.505, $p < 0.001$; 0.459, $p < 0.001$, respectively). The regression coefficient of the change in purchase motive, place, timeframe, and method and novelty-centered business model was 0.583, 0.516, 0.505, 0.459, and it was significantly positively correlated at the 1% level. That was, the greater the changes in the purchase motive, place, timeframe, and method, the more inclined the consumer services companies is to design a novelty-centered business model. H1b, H1c, H1d, and H1e are validated. Model 6 integrated all parameters of consumer purchase behavior changes in order to test their combined impact on novelty-centered business model design. The results were consistent with Models 1–5, thus confirming the robustness of the findings. Therefore, consumer purchase behavior changes under the COVID-19 pandemic significantly contribute to the novelty-centered business model design of consumer services

TABLE 2 | Consumer purchase behavior changes and novelty-centered business model design.

Variable	NBM					
	M1	M2	M3	M4	M5	M6
PO	0.584***(0.021)					0.287***(0.030)
PR		0.583***(0.024)				0.220***(0.030)
PP			0.516***(0.024)			0.061*(0.030)
PT				0.505***(0.024)		0.123***(0.028)
PW					0.459***(0.024)	0.157***(0.025)
Age	-0.011(0.072)	0.027(0.075)	-0.151(0.077)	-0.076(0.078)	0.073(0.078)	-0.051(0.069)
Gender	-0.082*(0.036)	0.011(0.038)	0.056(0.039)	-0.027(0.039)	0.039(0.040)	-0.033(0.035)
Income	0.000(0.007)	0.005(0.008)	0.005(0.008)	0.006(0.008)	0.003(0.008)	-0.002(0.007)
Edu	-0.024(0.027)	-0.050(0.028)	-0.020(0.028)	-0.046(0.029)	-0.086***(0.029)	-0.042(0.025)
Constant	0.338(0.260)	0.226(0.271)	0.739***(0.279)	0.599*(0.282)	0.206(0.285)	0.551*(0.249)
ΔR^2	0.317	0.259	0.221	0.204	0.180	0.386
F-test	162.575***	122.575***	99.628***	90.209***	77.208***	122.706***
VIF _{Max}	2.140	2.135	2.136	2.135	2.140	2.455

***, **, * represent significant at the 1, 5, and 10% significant level, respectively; T-values are provided in parentheses.

TABLE 3 | Consumer purchase behavior changes and efficiency-centered business model design.

Variable	EBM					
	M7	M8	M9	M10	M11	M12
PO	0.526***(0.022)					0.228***(0.031)
PR		0.495***(0.025)				0.108***(0.031)
PP			0.515***(0.023)			0.120***(0.031)
PT				0.495***(0.024)		0.127***(0.029)
PW					0.495***(0.023)	0.231***(0.026)
Age	-0.025(0.074)	0.012(0.078)	-0.173*(0.077)	-0.096(0.078)	0.050(0.077)	-0.084(0.071)
Gender	-0.134*** (0.038)	-0.050(0.039)	-0.005(0.039)	-0.088*(0.039)	-0.021(0.039)	-0.076*(0.036)
Income	0.006(0.008)	0.011(0.008)	0.010(0.008)	0.010(0.008)	0.006(0.008)	0.002(0.007)
Edu	0.007(0.028)	-0.016(0.029)	0.014(0.028)	-0.011(0.029)	-0.053(0.029)	-0.012(0.026)
Constant	-0.057(0.270)	0.168(0.283)	0.377(0.279)	0.226(0.282)	-0.140(0.279)	0.235(0.255)
ΔR^2	0.258	0.188	0.220	0.196	0.208	0.347
F-test	121.876***	81.455***	99.122***	86.036***	92.247***	103.833***
VIF _{Max}	2.140	2.135	2.136	2.135	2.140	2.455

***, **, * represent significant at the 1, 5, and 10% significant level, respectively; T-values are provided in parentheses.

companies. Moreover, the variance inflation factor (VIF) of each model was less than 10. This indicated that multicollinearity in the models was not serious, and hence has no effect on the results.

Table 3 presented the regression results for the relationship between the pandemic-induced changes in consumer purchase behavior and the efficiency-centered business model design. Models 7–11 showed that the changes in purchase object, motive, place, timeframe, and method all have a significantly positive impact on the efficiency-centered business model design under COVID-19 (0.526, $p < 0.001$; 0.495, $p < 0.001$; 0.515, $p < 0.001$; 0.495, $p < 0.001$; 0.495, $p < 0.001$, respectively). H2a, H2b, H2c, H2d, and H2e are validated. Model 12 examined the combined effect of all parameters of consumer purchase behavior changes on efficiency-centered business model design. The results were consistent with Models 7–11, confirming the robustness of the results. Therefore, consumer purchase behavior changes over the course of the pandemic have a positive effect on the efficiency-centered business model design of consumer services companies. The variance inflation factor (VIF) of each model was less than 10. Again, this indicated that multicollinearity was not serious in the models, and hence had limited impact on the results.

Based on the above evidence, consumer purchase behavior changes under the pandemic have a positive impact on both novelty- and efficiency-centered business model design. However, there is a significant variance in the magnitude of the coefficients, suggesting that consumer purchase behavior changes may have varying degrees of impact on each type of business model design. Specifically, the pandemic-induced changes in purchase object, motive, and method are more conducive to the novelty-centered business model design of consumer services companies (0.584 > 0.526; 0.593 > 0.495; 0.505 > 0.495, respectively); the changes in consumer purchase place have an equal effect on novelty- and efficiency-centered business model designs; and the changes in purchase method have a weaker

impact on the novelty-business model design than the efficiency-centered business model design (0.459 < 0.495).

The changes in consumer purchase motive, object, and timeframe have a greater positive impact on the novelty-centered business model design. Consumers can retrieve much information on the internet to reduce their risks and uncertainty, thereby increasing trust in decision-making (Hussain et al., 2020). People are also more likely to purchase products or services recommended by others, and the internet is an effective way to obtain such information. As such, the changes in consumer purchase motive create an opportunity for consumer services companies to develop novelty-centered business models. During the pandemic, people have become more rational and quality-oriented in shopping, and consumer demand has shifted from quantity-focused to quality-and-quantity-focused. In this context, the market demands a wider range of products and services from companies, which can be achieved through novelty-centered business models. Therefore, the changes in purchase object have a positive impact on novelty-centered business model designs. In terms of purchase timeframe, when online shopping and home delivery cannot fulfill consumer demands in a timely manner due to pandemic disruptions and limited manpower, the consumer preference for community and near-home stores emerges. Therefore, the changes in consumer purchase timeframe have promoted novelty-centered business models, such as the physical community business model.

On the other hand, the changes in purchase method have predominantly favored efficiency-centered business models. The COVID-19 pandemic has put people at unprecedented risks. In order to reduce the risk, consumers have grown more interested in contactless delivery and mobile payment, which incorporate the omnichannel supply and provides the option to shop at any time. The customer need for low-risk, efficient, mobile, and fragmented shopping experiences opens up new business prospects for efficiency-centered business models. Therefore, the

TABLE 4 | Alternative measures.

Variable	NBM					EBM				
	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22
PO	0.726*** (0.028)					0.653*** (0.029)				
PR		0.614*** (0.025)					0.516*** (0.026)			
PP			0.544*** (0.026)					0.521*** (0.026)		
PT				0.509*** (0.023)					0.478*** (0.023)	
PW					0.478*** (0.024)					0.500*** (0.023)
Control	Yes									
Constant	1.271*** (0.251)	1.561*** (0.254)	2.057*** (0.257)	1.918*** (0.254)	1.644*** (0.265)	1.865*** (0.258)	2.237*** (0.263)	2.511*** (0.257)	2.390*** (0.256)	1.943*** (0.260)
ΔR^2	0.283	0.255	0.210	0.231	0.197	0.231	0.181	0.193	0.204	0.215
F-test	138.212***	119.940***	93.396***	105.452***	86.206***	105.431***	77.994***	84.349***	90.316***	96.482***
VIF _{Max}	2.137	2.135	2.137	2.134	2.138	2.137	2.135	2.137	2.134	2.138

***, **, * represent significant at the 1, 5, and 10% significant level, respectively; T-values are provided in parentheses.

TABLE 5 | Adding control variable (occupation).

Variable	NBM					EBM				
	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32
PO	0.724*** (0.028)					0.652*** (0.029)				
PR		0.616*** (0.026)					0.517*** (0.027)			
PP			0.544*** (0.026)					0.521*** (0.026)		
PT				0.509*** (0.023)					0.477*** (0.023)	
PW					0.479*** (0.024)					0.500*** (0.023)
Control	Yes									
Constant	1.288*** (0.293)	1.719*** (0.295)	2.149*** (0.301)	2.069*** (0.297)	1.834*** (0.308)	1.902*** (0.301)	2.401*** (0.307)	2.595*** (0.302)	2.548*** (0.300)	2.145*** (0.302)
ΔR^2	0.283	0.256	0.210	0.231	0.198	0.229	0.180	0.191	0.203	0.214
F-test	63.345***	55.550***	43.080***	48.583***	40.118***	48.000***	35.842***	38.455***	41.241***	44.169***
VIF _{Max}	5.377	5.382	5.377	5.383	5.378	5.377	5.382	5.377	5.383	5.378

***, **, * represent significant at the 1, 5, and 10% significant level, respectively; T-values are provided in parentheses.

changes in consumer purchase method have a positive impact on efficiency-centered business model design for consumer services companies.

Finally, the changes in purchase place have a similar impact on novelty- and efficiency-centered business model design. Since COVID-19, there has been an increasing consumer demand for more diverse, personalized, convenient, and accessible shopping locations. Consumers want to shop in an innovative one-stop store that provides a safe or contactless environment, and this can be achieved by a business model that emphasizes both novelty and efficiency. Consumer services companies need to

increase the diversity of their products and services while at the same time reducing their transaction costs to improve operational efficiency. Therefore, the changes in purchase place encourage both novelty- and efficiency-centered business model designs.

Robustness Checks Alternative Measures

In the previous section, we used the Item Response Theory (IRT) model to measure the variables related to consumer purchase behavior and business model design. To check the robustness

of the results, we re-measured the variables using the weighted average method. The regression results were all significant, as shown in **Table 4**. All parameters of consumer purchase behavior changes have a significant impact on both novelty- and efficiency-centered business model design. The empirical results remain consistent with our prior findings. Therefore, our baseline results are robust.

Control for Occupation

Another concern is the influence of missing variables on the relationship between consumer behavior changes and business model design. In the survey questionnaire, the respondents also provided information about their occupations. On the one hand, consumers' occupation might alter their consumption behavior; while on the other hand, merchants might adjust their business strategies with respect to consumers with different occupations. As such, consumers' occupation might affect the impact of consumer behavior changes on business model design, rendering the baseline results biased. Therefore, following Xue et al. (2019), we introduced respondents' occupation into the baseline regressions and re-estimate the models. The results are displayed in **Table 5**. It shows that the results are highly consistent with baseline findings, with all regression coefficients being highly significant and positive ($p < 0.01$). Accordingly, our baseline results are again robust and reliable.

CONCLUSION

First of all, after the outbreak of the epidemic, there have been subtle changes in consumer buying groups. Male buying behavior has changed more. For example, they will increase the purchase of some necessities (Vázquez-Martínez et al., 2021). In the face of crisis, people's utilitarian motivation is more significant (Voss et al., 2003). Therefore, people's demand for daily necessities will increase substantially. In addition, the elderly no longer reject the purchase behavior through mobile methods, and many online shopping activities have been increased. This also makes life service companies need to further segment the market in terms of population in the future, such as adding more preferential activities for online service items for the elderly, so as to facilitate such people to further enhance their willingness to purchase.

Second, our findings suggest that changes in consumer purchase behavior have a significant positive impact on business model design. This influence reflects that consumers have put forward higher requirements for the marketing model of life service companies after experiencing the impact of the COVID-19 outbreak. According to the results of the study, changes in purchase object, purchase motive and purchase timeframe have a more profound impact on novelty-centered business model design. This shows that under the impact of the epidemic, consumer services companies should take rapid response measures, and carry out business model innovation according to the characteristics of the COVID-19 outbreak and changes in purchase behavior, such as: online transfer of sales model, expansion of target market, socialization and

fragmentation of marketing model, unmanned retail, contactless service and enterprise platform integration.

Third, changes in purchase place and purchase method have a significant impact on efficiency-centered business model design. This shows that consumers currently hope that consumer services companies can reduce their selection costs, procurement costs and payment costs as much as possible, so as to ensure that they can obtain the required products or services more efficiently.

According to the research conclusions, this paper draws the following management implications: First, the consumer services companies based on new technologies should reduce their costs as much as possible and provide products or services efficiently. The company makes full use of the construction of new infrastructure such as Artificial Intelligence, Industrial Internet, and Internet of Things to power it, and makes innovations on this basis. In the future, the development direction of consumer services companies should be a deep and efficient combination of online and offline. In this way, a consumer-centric dynamic management model can be realized, and business models can be flexibly adjusted to respond to transform according to changes in the external environment. Second, enterprises should deeply explore consumers' consumption preferences and stabilize the target market. The consumer market is unstable. While continuing to invest, companies should pay attention to the improvement of quality and service models, and deeply explore the consumption preferences of different consumers. On this basis, companies should continuously improve business models and stabilize the consumer market. Third, enterprises need to carefully introduce new models and services. During the outbreak of the epidemic, marketing models of live stream, community and short video have rapidly emerged. Not only have various e-commerce platforms started to adopt this marketing model, but some brand retailers have also begun to develop the live stream industry. According to the findings, consumers are enthusiastic about these emerging marketing models. At the same time, the unmanned retail model is also arousing the interest of consumers, and various intelligent retail products and services are put into operation, such as intelligent express cabinets, contactless distribution and unmanned convenience stores. The rapid development of these two types of models is affected by the epidemic environment, and managers should also consider the resources and capabilities of their own enterprise while rapidly innovating and introducing new models. At the same time, enterprises need to maintain a sense of crisis, cautiously introduce unfamiliar industries, and reasonably adopt various business models.

There are also limitations of this study that deserve future research attention. First, we explore the positive impact of consumer behavior changes on business model design in the consumer services sector. However, such relationship might vary across different sectors, cultures, and institution backgrounds. Future studies might examine it in a different research setting. Second, the picture of the nexus between consumer behavior changes and business model design might be incomplete. Future research might zoom into the consumption process or after-consumption behavior, investigating how the key findings might change with regard to different consumption stages.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

HT collected literature. XS designed the research and wrote the manuscript. XS and HT performed the empirical analysis. XL

provided the data. JT cleared data. DZ did the additional tests. All authors rewrote sections of the manuscript, contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This research was supported by the National Social Science Foundation of China (Grant Number: 21BTJ019) and the Social Science Planning Foundation of Shandong Province (21CGLJ16).

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The Willingness of the Elderly to Choose Nursing Care: Evidence From in China

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OPEN ACCESS

Edited by:

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Chongqing University, China

Reviewed by:

Jing Jia,
Anhui University, China
Yuanyuan Liu,
Xiamen University, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 29 January 2022

Accepted: 21 February 2022

Published: 11 March 2022

Citation:

Wang C, Zhang F, Pan C, Guo S,
Gong X and Yang D (2022) The
Willingness of the Elderly to Choose
Nursing Care: Evidence From
in China. *Front. Psychol.* 13:865276.
doi: 10.3389/fpsyg.2022.865276

With the accelerating aging of the population and the worsening psychological conditions of older people, the traditional mode of family support for the elderly in China does not always meet the physical and psychological needs of the elderly, and more social support modes for the elderly are needed. Based on 3,513 valid questionnaires on the long-term care and protection needs of Chinese residents, this paper uses a logit regression model to analyze the factors influencing the willingness of the elderly to choose nursing care. The results show that intergenerational family support for the elderly is a significant psychological driver on the willingness of the elderly to choose nursing care. Compared with the elderly living with family, empty nesters or older people living alone are more inclined to select nursing care when they have difficulties taking care of themselves. The physical health of the elderly affects their willingness to choose nursing care, and elderly individuals with more hospitalizations are less likely to select nursing care. In addition, elderly females who are relatively young, have a high level of education, have a high income, have a nursing home near the residence, and are already covered by medical insurance are more willing to choose nursing care. The results of this study are of great importance for improving the medical services and aging care services for the elderly and providing theoretical support for alleviating the psychological and social pressure brought by population aging.

Keywords: nursing care, willingness, psychological and social support, intergenerational support, China

INTRODUCTION

Currently, population aging has become a globally prominent problem. The *World Population Prospects* released by the United Nations (UN) in 2019 reports that the growth of the elderly population aged 65 years and older is the fastest. At present, this population accounts for approximately 9% of the global population, and it is expected to increase to 20% by 2050 (United Nations Department for Economic and Social Affairs, 2019). In the aging process, disabilities, and chronic diseases are closely related to the physical and psychological health of the elderly. The elderly population is significantly increasing, and the population aged 80 years and above will increase from 143 million to 426 million over the next 30 years. Epidemiological evidence suggests that stroke and poststroke cognitive impairment

(PSCI) may significantly impact the needs for nursing care (Donnelly et al., 2020). The elderly are at a higher risk for multiple comorbidities, functional dependence, and cognitive impairment (Amblàs-Novellas et al., 2020). The physical and psychological health problems of the elderly brought by population aging increase the burden of family care.

In the process of modernization, the environment and health are closely related; therefore, environmental issues also affect the health of the elderly. Data reported in *STATE OF GLOBAL AIR/2018* indicate that more than 95% of the world's population is breathing dirty air that exceeds the allowed particulate matter (PM) concentration in global air quality guidelines; notably, the situation is even more severe in underprivileged countries (Tian et al., 2020, 2022; Yang et al., 2020; Wan et al., 2021). In 2016, approximately 6.1 million deaths worldwide were attributable to air pollution, including stroke, heart disease, lung cancer, and chronic lung diseases (IHME [The Institute for Health Metrics and Evaluation], 2018). The Institute for Health Metrics and Evaluation (IHME) proposes that air pollution has caused a substantial number of casualties worldwide and has caused many older people to seek care at hospitals. Reductions in living spaces for older people and the deterioration in air quality have affected the personal networks of the elderly (Gottlieb, 1985). Environmental issues have increased the incidence and types of chronic diseases, leading to a substantial increase in health expenditures (Moon and Choi, 2018) and creating new challenges for nursing care and public health systems.

The physical and psychological problems of the elderly brought by population aging and air pollution have increased the urgency and diversity of needs for elderly care, particularly in developing countries. According to *World Population Aging 2017*, by 2050, 79% of the population aged 60 years or above will live in developing countries and regions (UN [United Nations], 2017). The process of industrialization and urbanization in developing countries has accelerated the pace and scale of population aging, but the service level of elderly care has not met the growing demand for elderly care. Furthermore, the industrial structure of developing countries, where industry and manufacturing are dominant, creates more serious environmental problems. As a developing country with the largest elderly population, China entered an aging society in 1999. In the subsequent 20 years, population aging has shown a trend of rapid development. According to the National Bureau of Statistics of China, at the end of 2019, the population aged 60 years and older was 253.88 million, accounting for 18.1% of the total population, and there were 176.03 million people aged 65 years and older, accounting for 12.6% of the total population. According to relevant estimates, 2053 could be the peak for China's aging population. At that time, the elderly population in China will reach 487 million, accounting for a quarter of the total elderly people in the world.

The typical family structure of "4 elderly, 1 couple, and 1 child," the weakening of the traditional family support mode for the elderly, the changes in the social division of labor, and the reduction in the labor force population have all led to a substantial gap in elderly care. The World Health Organization (WHO) predicts that by 2050, 110.5 million people will need daily care, accounting for 6% of the total population. Of these, 66 million are

older people aged 60 years and over, accounting for 59.7% of the people in need of daily care (WHO [World Health Organization], 2015a). The aging of China's population is accompanied by the aging of the aged, chronic diseases, disability, and empty nesters. First, the percentage of very older people in the elderly population in China is gradually increasing. According to the national census, China's elderly people aged 80 and above increased from 11.99 million to 35.8 million, The proportion of the elderly population aged 80 and above increases from 1.0 to 2.5%, an increase of 1.5 percentage points, which is significantly faster than the overall level worldwide (United Nations Department for Economic and Social Affairs, 2019). Older peopleSecond, there is little optimism regarding the health of Chinese older people. More than 180 million older people suffer from chronic diseases. As high as 75% of older people have one or more chronic diseases, and 50% have more than two chronic diseases. Chronic diseases account for 91.2% of elderly deaths in China and have a significant impact on health. Third, the increase in the number of elderly with disabilities and dementia increases the need for care. According to *The fourth sample survey on living conditions of urban and rural elderly in China* (2016), there were 40.63 million disabled and semi-disabled elderly in China, accounting for 18.3% of all older adults aged 60 years or older; this population will exceed 73 million in 2034. Fourth, unlike other countries, with modernization and urbanization, the number of empty nesters in China has increased year by year. In 2016, 50% of the Chinese elderly population was empty nesters, with over 70% in large and medium cities, creating challenges for traditional family support for the elderly. The care needs gradually diversify with aging. To meet the needs of the elderly in China regarding long-term care and medical care, different social support modes for elderly care are required.

Healthy aging is an essential indicator of the development and progress of human society. In 2015, the WHO released the *World report on aging and health*, which defines healthy aging as "the process of developing and maintaining the functional ability that enables well-being in older age"; the report emphasizes that "healthy aging is more than just the absence of disease. For most older people, the maintenance of functional ability has the highest importance" (WHO [World Health Organization], 2015b); furthermore, it suggests that long-term care is required when the elderly with severe disabilities cannot maintain their normal daily life without assistance. Long-term care is divided into nursing professional care and family nonprofessional care; the specialized long-term care provided by nursing homes is critical. As pointed out in the report, today's society has realized that excessive reliance on family care may be detrimental to the well-being of the elderly; additionally, the burden to women, as traditional caregivers, is notable. Therefore, "debates will be needed about future reliance on families, the state or private sectors in caring for older persons." At present, China is constructing an elderly care system based on family care, supported by community care, supplemented by nursing care, and combined with medical care. With the promulgation of relevant policies, nursing elderly care has gradually been accepted by people, and the number and scale of nursing homes have increased rapidly. Statistical Communiqué of the

People's Republic of China on the 2020 National Economic and Social Development shows that by the end of 2020, there were 38,000 nursing homes for the elderly, with 8,238,000 beds in nursing homes. However, behind the booming development of nursing homes, there is a gap in demand for elderly care and a high vacancy rate.

Therefore, it is of great significance to explore the factors influencing the willingness of the elderly to choose nursing care, to provide the necessary amount of nursing elderly care, to maintain the function ability of the elderly, and to improve the quality of life of the elderly. Research on factors influencing the willingness of the elderly in China to choose nursing care has mainly been addressed considering three dimensions: individual, family, and society. Zhang and Wei (2014) employed the data from "The survey on demands of the elderly for aging support services in Xicheng District" of Beijing, and adopted the Anderson Model as the analytical framework. The regression results indicated that those four kinds of factors are significantly associated with the intention to nursing care of the elderly without activities of daily living disability (ADL) disability. However, for the elderly with ADL disability, their intentions are highly related to tendency and enabling factors and demands for services (Zhang and Wei, 2014). Yu and Liao (2015) applied the ordered logistic model to take an empirical analysis on social old-age insurance treatment differences and willingness of institutions for old-age care from urban and rural residents, based on sample survey from urban and rural areas of South China, Central China, East China, North China and northeast area. The result indicates that the differences of social old-age insurance treatment affect the consumption decisions of individuals or families and their willingness of institution for old-age care. Luo et al. (2018) collected data from 641 elders aged 60 years old and above in six community health centers in Shanghai. They found that shame and adaptability of elders, and the services provided by nursing homes were the predictors of the elders' willingness. Studies have shown that factors such as the elderly themselves, their families and community services have significant impacts on the willingness of the elderly to choose nursing care. However, in the previous studies, the small sample size or the choice of sampling method made the overall sample less representative and the sampling error larger.

In this paper, based on an analysis and discussion of the data generated by probability-proportional-to-size (PPS) sampling from 7 cities (Beijing, Guangzhou, Ningbo, Qingdao, Changchun, Chongqing, and Lanzhou) in China, the significant factors that influence the willingness of the elderly in China to choose nursing care were obtained. Based on the theory of healthy aging, relevant policies and recommendations are proposed according to the analysis results.

MATERIALS AND METHODS

Data

In 2016, researchers for "Research on the Needs of Long-term Care Security in China" used the PPS sampling method to select 3,528 resident families from 24 communities, 6 blocks, and 3

districts in each of 7 cities in China, in order to comprehensively and systematically understand the living conditions of elderly people and their families as well as their needs and willingness to choose long-term care. The questionnaire was designed according to the following three steps: The first step was to gather information regarding the primary conditions of the respondents and their families. The second step was to collect information regarding the respondents' health status and their needs and willingness to choose long-term care. The third step was to gather information regarding the respondents' needs and willingness for long-term care financing. Respondent refers to the elderly individual in the selected family who answered the survey questions. Because some older people were unable to answer the questions themselves or needed their relatives to help provide their responses, spouses, children, or other relatives and friends who were familiar with the family situation were allowed to answer for the respondent.

The questionnaire contains seven parts. Part A obtained the basic information of the respondent. Part B obtained the family status of the respondent. Part C assessed the burden of medical expenses and medical insurance coverage of the respondent and his/her family. Part D obtained the death status of elderly relatives and friends. Part E obtained the health status of the respondent. Part F assessed the respondent's needs and willingness for long-term care services. Part G assessed the respondent's willingness to participate in long-term care insurance.

The method used by the research team to select the sample for the study was as follows: first, stratified sampling was used to select communities, blocks, and districts, and then systematic sampling was used to select households. Sampling was divided into five steps. In the first step, the 20 pilot provinces and cities in China implementing the long-term care insurance system were divided into 6 regions, i.e., North China, South China, East China, Northeast China, Southwest China, and Northwest China. Among them, 7 cities were selected as the sample cities. In the second and third steps, 24 communities in 6 blocks and 3 districts were selected from each city using the PPS sampling method. The fourth step was to determine the households with older people aged 50 years or older from household registration data to form the sampling frame. Then, 21 households were sampled from each community using systematic sampling. The research team stipulated that no less than 500 respondents should be in each city. In the fifth step, in each selected family, the research team interviewed an older person aged 50 years or older and a young person and middle-aged person present at the time of the survey. A total of 5,998 valid questionnaires were obtained, i.e., 3,513 questionnaires from the elderly and 2,388 questionnaires from young and middle-aged people. This study used data from 3,513 questionnaires obtained from elderly individuals to analyze and explore factors affecting the willingness of the elderly in China to choose nursing homes when they begin to have difficulties in taking care of themselves.

Statistical Analyses

Among the elderly who provided the 3,513 valid questionnaires, 34.07% were male, and 65.93% were female; therefore, the male to female ratio was unbalanced. This imbalance may be

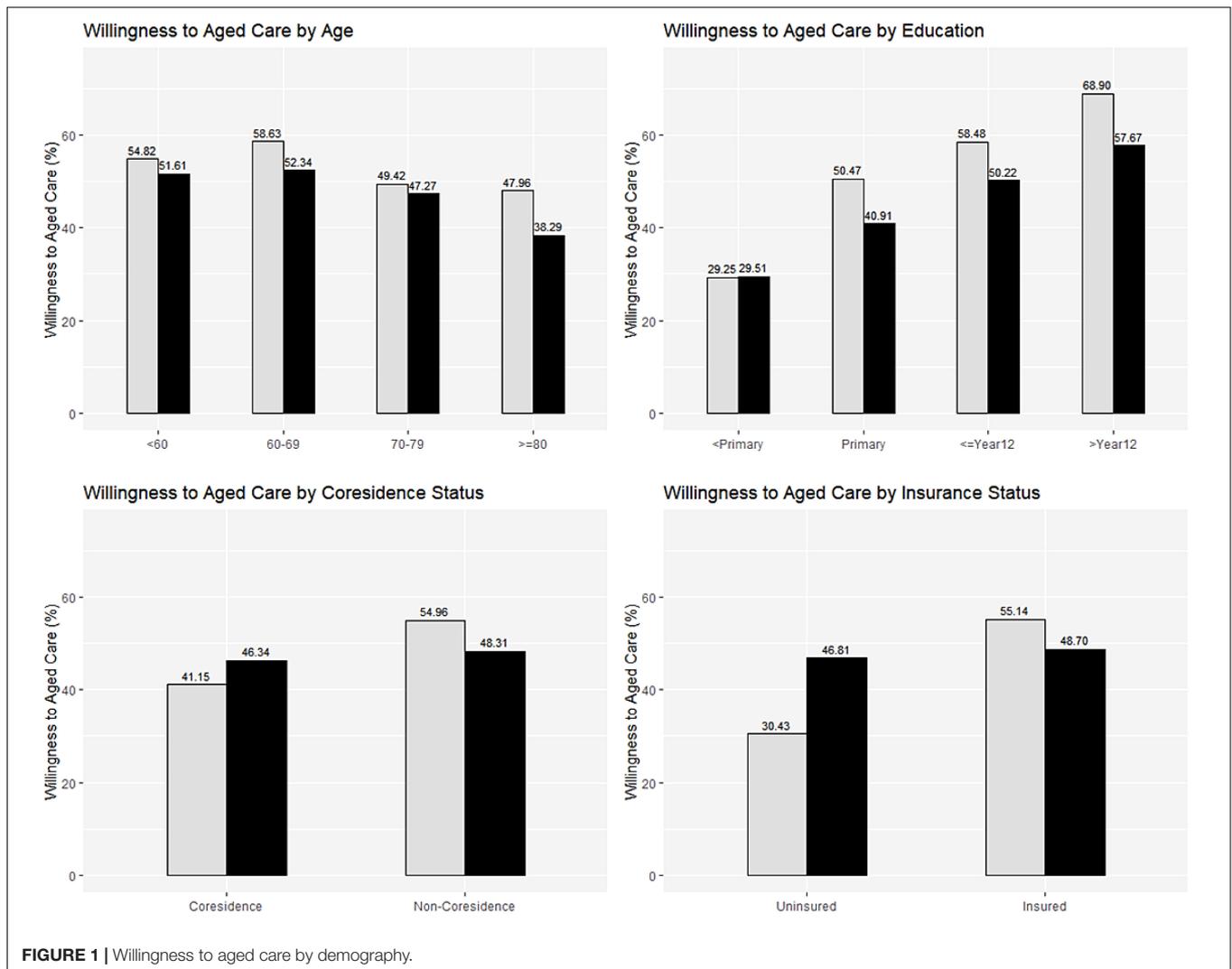
that women's average life expectancy is higher than that of men (Austad, 2006), which also confirms the trend of more older women than older men in China's sixth census. Generally speaking, the status of women in the family or society is lower than that of men, and whether in the economic level or in the spiritual level, women and men both have different pension needs. When taking care of oneself begins to become difficult, approximately 50% of the elderly are willing to choose nursing homes, only approximately 30% choose care at home, and approximately 20% have not thought about receiving care at a nursing home; these data indicate that most older people in China have gradually accepted nursing care. More than 90% of older adults do not live with their children, indicating that the phenomenon of empty nesters in China is predominant among the elderly. Empty nesters are more likely to feel lonely and are at increased risk for depression (Cheng et al., 2015). Although the age of the respondents primarily ranged from 60 to 69 years old, the percentage of older people aged 80 years or older was also high, approximately 12.64%. Significantly older people are at an increased risk of having an unhealthy physical condition, increasing their burden of care (Bloom et al., 2015). Based on the survey, 35.55% of older people reported that a nursing home was located near their place of residence, 36.38% of older adults reported that no nursing home was nearby, and 28.07% of the elderly reported that they did not know if a nursing home was located nearby. To some extent, these data reflect some issues regarding nursing homes in China, such as a lack of a unified plan and layout, the feeling by community residents of a separation from life, and inadequate publicity. Combined with the proportion of the willingness to provide for the aged in institutions, some older people in China are influenced by traditional concepts and lack of planning for the future pension mode. The elderly without pension institutions near their residence will not take the initiative to understand the situation of pension institutions. From the perspective of insurance coverage for the elderly, only 3.3% of the elderly were not covered through social medical insurance, indicating that the elderly in China have a high medical insurance coverage rate. As the proportion of the elderly population in China has continued to increase, the government has paid more attention to and reformed the medical insurance system for older people, and the enthusiasm of older people regarding their participation in the insurance system has dramatically increased (Table 1).

To more clearly and intuitively demonstrate the changes in the willingness of the elderly in China to choose nursing care, this paper visualized the data. In Figure 1, gray represents females, and black represents males. It can be seen from the figure that with increasing age, the willingness of the elderly aged 60 and above in China to choose nursing homes gradually decreases. Meanwhile, the elderly aged 50 to 59 are less willing to choose nursing homes than those aged 60 to 69. In particular, 54.4% of women chose nursing homes, which is 6% higher than the percentage of men who chose nursing homes, indicating that there is a gender difference in the willingness of the elderly to choose nursing care. Compared with women, as they increase in age, men were less willing to go to a nursing home. After grouping the elderly based on gender and education level, there were

TABLE 1 | Questionnaire sample information.

Variable	Type	Category	Count	Percent
Nursing Care Willingness	Categorical	Willingness	1,842	52.43
		No Willingness	999	28.44
		Never thought	672	19.13
Gender	Categorical	Male	1,197	34.07
		Female	2,316	65.93
Age(years)	Continuous	<60	746	21.24
		60-69	1,437	40.90
		70-79	886	25.22
		≥80	444	12.64
Marital Status	Categorical	Married	2,655	75.58
		Widowed	721	20.52
		Divorced	94	2.68
		Never married	43	1.22
Education	Categorical	<Primary	314	8.94
		Primary	769	21.89
		Year 6 to 12	2,006	57.10
		>Year 12	424	12.07
Monthly Income	Continuous	<1,000	1,014	28.86
		1,000-2,999	1,479	42.10
		≥3,000	1,020	29.04
Coresidence	Categorical	Coresidence	274	8.13
		Non-Coresidence	3,098	91.87
Hospital Times	Categorical	0	2,508	71.39
		1	676	19.24
		2	213	6.06
		3	66	1.88
		4	50	1.42
Nursing Care Nearby	Categorical	Yes	1,249	35.55
		No	1,278	36.38
		Unknown	986	28.07
Insurance	Categorical	Insured	3,397	96.70
		Uninsured	116	3.30

also significant differences among different groups regarding the willingness of the elderly to choose nursing care. With the increase in years of education, the willingness of the elderly to choose nursing care increased significantly, and the increase in the willingness of elderly females was notable. Notably, there was no gender difference in the willingness of uneducated older people to choose nursing care. However, among educated older adults, the proportion of women who chose nursing care was much higher than that of men, approximately 10% higher than that of men. Generally, women play a long-term role as caregivers for family members. Therefore, when these women age, experience reduced physical health, and cannot take care of their families, they often think that they cannot receive good care from their families; therefore, they are more inclined to choose social care (Wang and Liu, 2020). Additionally, the more educated the elderly are, the more tolerant and open they are, and the more likely they will accept untraditional modes of social support for care. Under normal circumstances, the higher one's education level, the higher is that individual's economic income. For uneducated older women, their financial income



may not be sufficient to cover the expenses of a nursing home; therefore, their willingness to choose nursing elderly care is not much different from that of their male counterparts. However, for older women with a high level of education, covering the expenses of a nursing home is not an obstacle regarding the choice to receive care at a nursing home, thus creating a difference between men and women. In addition, compared with men, women's financial literacy and financial security are relatively low (Xue et al., 2019, 2020, 2021). When they have more income, they are more likely to spend for themselves rather than make other investments.

Whether parents and children live together has a certain impact on the elderly's pension willingness. Overall, the elderly who do not live with their children are more inclined to provide for the aged in institutions. This may be due to the function of family support in the family where parents and children live together is stronger, and the elderly's demand for socialized pension is not high. For most of the empty female nesters, without children at their side makes their mother's role gradually weakened, and they are more likely to have a sense of loneliness.

Therefore, whether or not to live with their children will have a more significant impact on the psychology and life of elderly women. The older women are more inclined to provide for the aged in institutions when they haven't childless company. At the same time, the elderly who participate in social medical insurance are more willing to choose nursing pension, especially female elderly. 43% and 55.14% of the older women who did not participate in the insurance and participated, respectively, which was about 25% different. Interestingly, whether parents live with their children or whether they are insured does not have a significant impact on the male elderly, but it is pronounced for the female elderly. This may be because, compared with men, older women are more vulnerable to insecurity, more economically dependent, and less likely to have access to long-term care resources.

Regression Modeling

To examine the effect of each factor on the willingness of the elderly to choose nursing care, this paper adopted the following

logit regression model, in which the subscript *i* represents individual *i*.

$$PR(Nur_i = 1 | Cor_i, Hos_i, \dots, Nea_i) = \frac{F(\beta_0 + \beta_1 Cor_i + \beta_2 Hos_i + \dots + \beta_9 Nea_i)}{1 + e^{-(\beta_0 + \beta_1 Cor_i + \beta_2 Hos_i + \dots + \beta_9 Nea_i)}}$$

where *F* denotes the cumulative standard logistic distribution, β_0 is the intercept term; β_1 - β_9 are the parameters of the explanatory variables to be estimated.

In this paper, the willingness of the elderly to choose nursing care (Nur) was set as the dependent variable. In the questionnaire, "If there is a nursing home, would you choose to receive care there when you begin to have difficulties taking care of yourself?" was a single response question with 3 answer choices, i.e., willing, unwilling, and never considered. A value of 1 was assigned to "willing", and 0 was assigned to the other 2 responses.

For independent variables, first, this study used the respondents' living arrangements (Cor) to measure the intergenerational support received by the elderly, and living arrangement refers to whether the older person lives with their children. A value of 1 was assigned to the condition that the older person was living with his/her children, and 0 was assigned to the other conditions. Second, this paper used the number of hospitalizations (Hos) in the past year to measure the physical condition of the respondents. The response options for number of hospitalizations were 0, 1, 2, 3, and 4 or more, and the assigned values were 0, 1, 2, 3, and 4, respectively. Last, this paper used the question "What type of medical insurance coverage do you have?" (Ins) to assess the insurance status of the respondents; 0 indicated no insurance, and 1 indicated insurance coverage. In addition, there were other independent variables, including gender (Gen), age (Age), marital status (Mar), education level (Edu), monthly income (Min), and whether there was a nursing home near the place of residence (Nea). The variables in the model are described in **Table 2**.

RESULTS

This paper used a logit regression model (1) to study the effect of each factor on the willingness of the elderly to choose nursing care and determine the impact of each variable and its trend. The results are displayed in **Table 3**.

The results showed that intergenerational support had a significant impact on the willingness of the elderly to choose nursing care. Compared with empty nesters or the elderly living alone, the elderly living with children were more inclined to choose to receive care at home, and their chance of choosing nursing care was 0.8 times (i.e., 20% less) that of empty nesters or the elderly living alone. Empty nesters or older people living alone have inadequate family care resources; they suffer from a long-term lack of communication and are prone to mental illness, leading to cognitive decline (van Gelder et al., 2006). Additionally, as they grow older, they may find it more challenging to live alone, or they may not completely take care of themselves. At this point, an elderly individual may choose nursing care instead of family care. Currently, the housekeeping and catering services provided by many nursing homes can significantly reduce the labor burden of the elderly, and in nursing homes, there are groups of older people with similar ages and similar experiences with whom to chat and talk, which reduces loneliness.

In terms of the physical condition of older people, compared with healthy older people, unhealthy older people tended to choose to receive care at home. However, studies have shown that older people who are unhealthy or have chronic diseases tend to choose nursing homes (Lee and Kwok, 2005). The following reasons may account for the different results. (1) The elderly in China have doubts about the level of medical services provided by nursing homes. They believe that nursing homes can only provide basic living needs and cannot provide adequate medical services. (2) Unhealthy older people need more comfort from their families, which is currently lacking in services provided by nursing homes. At present, there is not enough interaction between nursing homes and the families of the elderly; therefore, the elderly think that they have been abandoned if they live in nursing homes. (3) As the parents of only children gradually become elderly, they are more inclined to enjoy their life in nursing homes when they are in good health, thus reducing the burden to their only children.

TABLE 2 | Variable descriptions.

Variable	Full name	Measure
Dependent variable	Nur	Nursing Care Willingness
Explanatory variable	Cor	Co-residence
	Hos	Hospital Times
	Ins	Insurance
	Gen	Gender
	Age	Age (years)
	Mar	Marital Status
	Edu	Education
	Min	Monthly Income
	Nea	Nursing Care Nearby

TABLE 3 | Baseline regression results.

Variable	Coef.	Odds Ratio	Std. Err.	P> z
Cor	-0.2221	0.8008	0.1054	0.091*
Hos	-0.1113	0.8947	0.0400	0.013**
Ins	0.3418	1.4074	0.2881	0.095*
Gen	-0.3344	0.7158	0.0563	0.000***
Age	-0.0102	0.9899	0.0042	0.018**
Mar	-0.0379	0.9628	0.0901	0.685
Edu	0.2308	1.2596	0.0400	0.000***
Min	0.0001	1.0001	0.0000	0.000***
Nea	0.2200	1.2461	0.0923	0.003***
Constant	-0.3451	0.7081	0.2761	0.376

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In addition, compared with females, elderly males tended to choose to receive care at home; the likelihood of them choosing a nursing home was 0.7 times that of women. Gender had a significant impact on the willingness to receive elderly care, indicating that there is a significant gender difference in the willingness of the elderly in China to receive elderly care. Therefore, services provided through nursing care should be more diversified. There was a significant negative correlation between the willingness of the elderly to choose nursing care and age; the older the elderly were, the more likely they were to choose care at home. Older people feel lonely and insecure as they grow older and want their children to be there for them. Additionally, the elderly, who may have developed long-term routines and behaviors, do not want to leave the familiarity of their place of residence to live in a strange nursing home. The education level and the willingness of the elderly to choose elderly care were significantly correlated. The more educated an elderly individual was, the more open and inclusive he/she was, and the more receptive he/she was to nursing care. There was a significant positive correlation between the monthly income of the elderly and the willingness of the elderly to choose elderly care. The better the financial situation of the elderly, the higher their ability was to pay and the stronger their willingness was to choose nursing care. Compared with older people who did not have a nursing home near their residence, older people who did have a nursing home nearby were more likely to accept nursing elderly care. This may have occurred because older people are more willing to choose nursing homes in familiar areas. On the one hand, they are more familiar with the service level of nursing homes; on the other hand, it is convenient for family members to visit them in nursing homes. Compared with uninsured older people, insured older people had a higher probability of choosing nursing elderly care, 1.5 times (i.e., 50% higher) that of older people without any medical insurance; insurance coverage had a significant impact on the choice of mode for elderly care. Compared with uninsured older people, insured older adults with disabilities and dementia living in designated nursing homes can obtain the corresponding subsidies and professional care.

Although the probability of older people with a partner choosing a nursing home was lower than that of older people without a partner, the effect of the marital status of older people was not statistically significant, indicating that the presence or absence of a partner had no substantial impact on the willingness

of the elderly to choose elderly care. This result may be related to cultural differences between China and the West. Unlike the Western family relationship with the spousal relationship as the core, in China, the parent-child relationship is the core of the family relationship. Therefore, whether an elderly individual has a partner does not cause a significant difference in their choice of elderly care (Gierveld et al., 2012).

ROBUSTNESS CHECKS

This paper further adopted a probit model and used a variable replacement method to conduct robustness tests; the results are shown in **Tables 4, 5**, respectively.

In **Table 4**, the probit regression results showed that the significance of each variable did not change. In terms of the regression coefficient, non-empty-nesters and the elderly with more hospitalizations had significantly lower willingness to choose nursing homes; compared to uninsured older people, the insured elderly's willingness to choose a nursing home was considerably higher, which is consistent with our main findings. Very old males tended to choose to receive care at home, and with increases in education level and monthly income, older people were more likely to choose nursing care. Additionally, the older people who had a nursing home nearby were more inclined to choose nursing care. The probit model results were highly consistent with the conclusions of the main tests, indicating that the regression results in this study are robust and that the research conclusions are reliable.

TABLE 4 | Results for robustness test with an alternative model.

Variable	Coef.	Std. Err.	Z	P> z
Cor	-0.1373	0.0809	-1.70	0.089*
Hos	-0.0692	0.0277	-2.50	0.012**
Ins	0.2135	0.1253	1.70	0.088*
Gen	-0.2059	0.0490	-4.20	0.000***
Age	-0.0063	0.0027	-2.34	0.019**
Mar	-0.0222	0.0582	-0.38	0.703
Edu	0.1434	0.0196	7.32	0.000***
Min	0.0001	0.0000	3.30	0.001***
Nea	0.1377	0.0460	3.00	0.003***
Constant	-0.2172	0.2420	-0.90	0.370

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

TABLE 5 | Results for robustness test with an alternative measure.

Variable	Coef.	Std. Err.	Z	P> z
Cor	-0.2395	0.1315	-1.82	0.069*
Hos	-0.1131	0.0447	-2.53	0.011**
Ins	0.3839	0.2036	1.89	0.059*
Gen	-0.3135	0.0782	-4.01	0.000***
Age	-0.0078	0.0042	-1.87	0.062*
Mar	-0.0746	0.0953	-0.78	0.434
Edu	0.2527	0.0306	8.25	0.000***
Min_new	0.00003	0.0000	3.41	0.001***
Nea	0.2181	0.0742	2.94	0.003***
Constant	-0.5374	0.3830	-1.40	0.161

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

This paper also replaces “income from last month” (Min) with “total family income from last month” (Min_new) for the robustness test. The test results are shown in **Table 5**. The sign and significance of the coefficients of substitution variables and other variables did not change, which again confirms that the conclusions of this paper are reliable.

CONCLUSION

With the increasing global population aging and the worsening psychological conditions of older people, physical and psychological problems involving the elderly population are constantly emerging. The elderly care mode is gradually changing from traditional family support to modern social support. Based on an empirical study of 3,513 questionnaires completed by elderly residents in 7 cities in China, this paper draws the following conclusions. (1) Intergenerational family support is a significant psychological factor influencing the willingness of the elderly to choose care. Empty nesters and older people living alone are more likely to choose nursing homes when they have difficulties taking care of themselves, indicating that China's traditional concept of family support for elder care is still fundamental. Although the function of family support for the care of the elderly is weakening, the spiritual consolation provided by family members is of great importance to the elderly. Older people are more willing to receive care in a familiar living environment. (2) From the perspective of the physical health of older people, older people with more hospital stays tend to choose to receive care at home. It can be inferred that the healthier older people are present, the higher the tendency is of choosing nursing care when they begin to have difficulties taking care of themselves. Nursing homes are responsible for the specialized long-term care of disabled and semi-disabled elderly. However, at present, older people do not trust the humanized and professional services provided by nursing homes, leading to a mismatch between supply and demand. Through empirical analysis, this paper concludes that older people with weak intergenerational support and good health are more willing to choose nursing homes when they begin to have difficulty taking care of themselves. In addition, elderly females who are relatively young, have a high level of education, have a high income, have a nursing home near their residence, and are already covered by medical insurance are more willing to choose nursing care.

The main contribution of this paper is to use authoritative data obtained through scientific sampling to analyze the factors that influence the willingness of the elderly in China to choose nursing care. Based on the theory of healthy aging and conclusions from this study, the following recommendations are provided. First, the concept of people-oriented care should be established, i.e., provide a friendly living environment for the elderly, feed the elderly with multilevel care services, including physical, psychological, and social interactions, under the premise of maintaining self-esteem, self-reliance, and independence, and protect the legitimate rights, interests, and fundamental rights of the elderly.

Second, the long-term care insurance system needs to be further improved to provide financial security for the elderly with disabilities and dementia. Currently, the number of beds in nursing homes in China continues to increase, while the occupancy rate is not high; the main reason for this discrepancy is that the income earned by elderly individuals is not enough to cover the costs of a nursing home. Most older people do not choose nursing homes, which is not entirely a matter of their preference but more of their inability to pay the cost. This also causes an operational dilemma for nursing homes, especially private nursing homes (Tang and Feng, 2015). The long-term care insurance system can assume certain economic risks for the elderly when they have difficulties in taking care of themselves, can help to transform the potential demand of nursing care for the elderly into effective demand, and can promote the sustainable development of nursing homes.

Third, nursing homes should integrate teams of interdisciplinary professionals. Elderly care involves sociology, medicine, rehabilitation, psychology, social work, and nursing. In particular, the elderly with disabilities and dementia, who have multiple comorbidities and cannot take care of themselves, require psychological comfort and social support. The multilevel needs of the elderly interact with each other, and different older people have commonalities and heterogeneity. The idea of integration is used to provide all-round, diverse, and high-quality services. The critical role of nursing homes in the long-term care service system should be fully realized to extend professional services to communities and families.

Fourth, the medical services in nursing homes should be actively promoted. In its interpretation of healthy aging, the WHO emphasizes the importance of the functional ability of the elderly. This study finds that unhealthy older people do not trust the service quality of nursing homes, affecting the willingness of those older people to choose nursing homes. Most older people in nursing homes have multiple comorbidities; therefore, authoritative medical treatment, proper treatment of sudden illness, and scientifically based rehabilitation of physical functions are essential factors for the elderly to choose nursing homes.

Fifth, nursing homes should pay attention to humanistic care and family support. A nursing home is a place where older people live, and older people need emotional care and need to express themselves. This study finds that the more physically unhealthy the elderly are, the less likely they are to leave home because older people need a sense of security and belonging provided by their families after their physical function deteriorates. Therefore, nursing homes should be conveniently located within communities so that family members can visit elderly family members. The environmental design of nursing homes must create the sense of a warm and safe home, a design that requires caregivers to have patience and provide love to make all elderly residents feel cared for and valued, even when they are away from home. Nursing homes should also establish close contact with the family members of elderly residents so that the family members can understand and actively participate in the life of their elderly family members. Family affection plays a vital role in maintaining different psychological functions in elderly individuals.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The data used to support the findings of this study is available upon request. Requests to access these datasets should be directed to CW, cheng2676@163.com.

AUTHOR CONTRIBUTIONS

CW, FZ, CP, SG, XG, and DY contributed to conception and design of the study. CW, FZ, and XG organized

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the database and performed the statistical analysis. All authors wrote the first draft of the manuscript, contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This research was supported by the Shandong Province Social Science Popularization Applied Research Project (Grant No. 2021-SKZC-21) and Qingdao City Social Science Planning Project (Grant No. QDSKL2101158).

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Board Network and CSR Decoupling: Evidence From China

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This paper investigates the influence of board network centrality on corporate social responsibility (CSR) decoupling. CSR decoupling refers to the gap between corporate internal and external actions in CSR practices. Specifically, we measure CSR decoupling as the difference between corporate social disclosure (CSD) and corporate social performance (CSP). This paper uses a sample of Chinese A-share listed firms during 2009–2018, takes the technical dimension score (T-score) and content dimension score (C-score) of RKS ratings as proxies of CSD and CSP, and obtains CSR decoupling as the difference between CSD and CSP. Our results show that (1) board network centrality is positively related to over-decoupling in the pre-adoption period (2009–2014) of the new environmental law but negatively related to over-decoupling in the post-adoption period (2015–2018) and (2) centrality is not related to under-decoupling in the pre-adoption period but a significantly positive related in the post-adoption period. Our finding reveals a complex role of the board network in CSR practices in China.

OPEN ACCESS

Edited by:

Shiyang Hu,
Chongqing University, China

Reviewed by:

Huan Dou,
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Dong Yang,
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and Economics, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 15 November 2021

Accepted: 17 January 2022

Published: 11 March 2022

Citation:

Zhao W, Zhong M, Liao X, Ye C and
Deng D (2022) Board Network and
CSR Decoupling: Evidence From
China.
Front. Psychol. 13:815341.
doi: 10.3389/fpsyg.2022.815341

Keywords: decoupling, environmental, social and governance (ESG), CSR washing, symbolic and substantive strategy, emerging market, director social network

INTRODUCTION

Previous studies based on network theory find that social networks built by top managers, e.g., CEOs and directors, affect not only corporate financing, investment, and other traditional business practices (Chuluun et al., 2014; Feng et al., 2019) but also corporate social responsibility (CSR) practices. For example, Harjoto and Wang (2020), Lai et al. (2020), and Nandy et al. (2020) find that boards with higher network centrality can bring social capital to the firm and stronger advantages in information access and exchange, which helps firms to improve corporate social performance (CSP). However, these studies implicitly assume that the firm discloses its CSP truthfully and no misalignment between its CSP and corporate social disclosure (CSD). In the real world, the existence of information asymmetry, moral hazard and so on leads to a misalignment between CSD and actual CSP, that is, CSR decoupling (García-Sánchez et al., 2020; Sánchez et al., 2021; Shahab et al., 2021). Specifically, some firms adopt symbolic management in their CSR practices and tend to disguise and exaggerate their actual CSP levels by making excessive and selective CSD (Walker and Wan, 2012; Mahoney et al., 2013; Yu et al., 2020). On the other hand, high CSD may be a stimulus for firms to face higher social expectations and legal pressure, and they may have incentives to reduce the CSD that matches their actual CSP (Carlos and Lewis, 2018). Thus, a research question is generated: do firms use their advantages of board networks to increase or decrease the misalignment between CSD and CSP, specifically, the positive or negative gap between CSR disclosure and

performance? For example, firms may take advantage of social networks to reinforce the application of symbolic strategies, thereby widening the positive gap, or they may take advantage of social networks to mitigate social expectations and legal pressure, and make more CSD, thereby reducing the negative gap.

As the most important developing market in the world, the Chinese economy has begun to change from barbaric growth to sustainable growth in recent years. Since the implementation of the mandatory CSR reporting policy in 2009, the Chinese CSR system has achieved great development (Yin and Zhang, 2012; Shen et al., 2020), and socially responsible investors (SRIs) have sprung up (SynTao., 2019). However, some deficiencies still exist in the CSR regulatory systems, such as weakly related litigation and public opinion supervision systems, a lack of detailed reporting guidelines, information assurance, influential CSR ratings and executable regulatory policies (Situ and Tilt, 2018; Yin and Quazi, 2018; Wu and Pupovac, 2019). Therefore, Chinese firms still have enormous discretion in the breadth, depth, and quality of their CSD. Situ et al. (2018) shows that the environmental policies of the Chinese government can only affect whether firms disclose CSR information, but the impact on the level of disclosure is extremely limited. This “excessive freedom” causes a terrible problem of the decoupling between CSP and CSD, which troubles market regulators and participants (Zhang and Chen, 2019).

Based on Chinese A-share firms listed on the Shanghai and Shenzhen stock exchanges for the period of 2009–2018, we provide evidence for the relationship between board network centrality and CSR decoupling. We use the mean value of four network centrality indicators namely, degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality, after sorting them into 10 quantiles as proxies of board network centrality. CSR decoupling is measured as the difference between the CSD and CSP. We use the standardized technical dimension score (T-score) and content dimension score (C-score) provided by Rankins Ratings (RKS) as proxies for CSD and CSP. Over-decoupling and under-decoupling indicate that a firm has disclosed too much or less in CSD compared with the actual CSP. Our analysis suggests that board network centrality has a significantly positive (negative) influence on over-decoupling in the pre-adoption (post-adoption) period of the new environmental law. Meanwhile, board centrality is not related to under-decoupling in the pre-adoption period but significantly positive related in the post-adoption period.

Our study makes three main contributions. First, we contribute to the CSR literature based on network theory. Previous studies have suggested that there is a positive relationship between board networks and CSP (Harjoto and Wang, 2020; Lai et al., 2020; Nandy et al., 2020), but little is known about the impact of board networks on CSR decoupling. We argue that board network centrality plays a complex role in CSR practices of China.

Second, this paper examines the role of foreign investors in CSR decoupling in China and enriches the understanding of corporate governance mechanisms in emerging markets. The existing literature has confirmed the impact of foreign investors on the CSR practices of Chinese firms (McGuinness et al.,

2017; Li et al., 2021). Our evidence shows that foreign investors play a vague role in the relationship between board centrality and CSR decoupling. Specifically, when the regulations get strengthening, foreign investors increase over-decoupling in the firms with high board centrality.

Third, our evidence suggests that changes of Chinese CSR regulation have an important impact on corporate decisions in CSR practices. We find that the relationship between board centrality and CSR decoupling endures significant changes because of the adoption of the 2015 new environment law. The findings add to the previous studies on Chinese CSR regulation policies (Zhang et al., 2017; Liu et al., 2020; Yu et al., 2021).

THEORETICAL BACKGROUND AND HYPOTHESES

Board Network and Corporate Practices

Existing literature based on network theory has shown that through direct and indirect connections within networks, network members can gain access to and share critical resources and information in time and enrich knowledge, which forms important social capital (Burt, 1987, 1992; Nahapiet and Ghoshal, 1998; Woolcock and Narayan, 2000). Because of the different positions of members in the networks, Adler and Kwon (2002) argue that the advantages conferred by one's position within the networks can be converted to some advantages, and the degree of the position advantage is defined as network centrality.

Board of directors is an important part of the top management team; hence, its network plays a critical role in corporate practices. Firms with higher board network centrality have a higher ability to exchange and use information that allows them to make more effective decision-making than their peers. Existing literature indicates that firms with higher board centrality tend to have better access to finance (Larcker et al., 2013; Chuluun et al., 2014; Renneboog and Zhao, 2014; Rousseau and Stroup, 2015; Feng et al., 2019), greater performance in mergers and acquisitions (Renneboog and Zhao, 2014; Rousseau and Stroup, 2015), and better financial performance (Larcker et al., 2013).

Further studies argue that board networks have a significant impact on CSR. Due to the advantage of social capital accumulation, information access, and so on, Harjoto and Wang (2020) indicate that firms with higher board centrality have higher CSP. Similarly, Nandy et al. (2020) find that there is a positive relationship between director centrality¹ and CSP by using listed firms from 17 countries, and this positive effect is more pronounced after the 2008 financial crisis. Lai et al. (2020) further complement the effect of corporate governance, institutional ownership, public awareness, and the high commitment of stakeholders on the relationship between board

¹Generally, firms that employ more directors of higher centrality have higher board centrality.

centrality and CSP. Moreover, in emerging market research, there is some indirect evidence supporting a positive relationship between board centrality and CSP. Li et al. (2019) find that the relationship between director network centrality and philanthropic donation is positive, and corporate donation is the most important part of discretionary components in CSR (Lin et al., 2015). Compared with CSP, the evidence for CSD is short, but some indirect evidence may support that a positive influence of board centrality on CSD. Muttakin et al. (2018) finds that board social capital is positively related to CSD, and high board centrality is positively related to social capital (Larcker et al., 2013). Evidence from Sun et al. (2020) find that board of interlocks, which is related to the concept of board centrality, has a positive influence on CSD in the Chinese market.

Board Network and CSR Decoupling

The existing literature shows that CSR decoupling refers to the gap between internal and external actions in CSR practices (Tashman et al., 2019), specifically, CSP reflects corporate internal actions (Hinze and Sump, 2019) and CSD reflects corporate external actions (Dhaliwal et al., 2012). Therefore, CSR decoupling refers to the gap between CSP and CSD. CSR decoupling mainly includes two forms. First, firms decouple their commitment in the CSD from the actual CSP. Specifically, firm's commitment to CSD does not match their CSP (Sauerwald and Su, 2019). Second, firms decouple their CSD level from the CSP level; that is, the CSD level provided in the annual report or CSR report is higher or lower than the level of actual CSP (Delmas and Burbano, 2011; García-Sánchez et al., 2020).

Existing literature explains the driving mechanism of CSR decoupling from different theoretical perspectives. Tashman et al. (2019) based on the neo-institutional theory, argue that institutional characteristics in different markets drive CSR decoupling of multinational enterprises. Based on the agency theory, Shahab et al. (2021) argue that more powerful CEOs are more short-sighted and have higher CSR decoupling in their firms; Parra-Domínguez et al. (2021) find that CSR decoupling is lower in family firms, because the family firms suffer lower agency cost. Based on the overconfidence theory, Sauerwald and Su (2019) find that managerial overconfidence increases CSR decoupling. Based on the information asymmetry theory, Zhang, (2021) finds that analyst coverage helps to alleviate the information asymmetry between stakeholders and firms, thereby reducing CSR decoupling. Similarly, Sánchez et al. (2021) find that assurance of CSR reports helps reduce information asymmetry, thus decreasing decoupling practices.

Regarding the influence of board network centrality on CSR decoupling, we build a theoretical framework mainly based on the information asymmetry theory (Myers and Majluf, 1984). Compared with actual CSP, when a firm has a higher CSD, there exists a positive gap in the firm. We define the positive gap as over-decoupling in the following. Specifically, firms implement symbolic management strategies in CSR

practices (Walker and Wan, 2012; Tashman et al., 2019). Symbolic management refers to the fact that a firm's actual practices do not conform to its espoused policies, resulting in misalignment between the two (Meyer and Rowan, 1977; Carpenter and Westphal, 2001; Fiss and Zajac, 2006).

We argue that firms with higher board network centrality widen the over-decoupling. First, boards with high centrality can expand the asymmetry information barrier between firms and their stakeholders. Specifically, boards with higher centrality have stronger power to influence public opinion, which means they can relieve the possible exposure risk of symbolic management. Especially in China, news media and other public opinion channels are subject to stronger restrictions (Wang et al., 2019). For example, Piotroski et al. (2014) indicates that Chinese politicians restrict and eliminate adverse news from firms with strong connections for their own interests. Therefore, in China, boards with higher centrality are more likely to use their network directly or indirectly to connect with political authority, intervening in news reports, social media and other public opinion systems, thereby weakening the exposure risks of symbolic management. Similar logic has also been found in other corporate practices; for example, firms with higher board centrality implement more inefficient mergers and acquisitions (Tao et al., 2019) and higher earnings management (Abdul Wahab et al., 2020), because they are more likely to circumvent the influence of public opinion supervision. Second, boards with higher centrality help to reduce information asymmetry among them and their connecting firm, making it easier for their firms to obtain and utilize information (Larcker et al., 2013), namely, allowing them to effectively observe and learn the successful experience of symbolic practices from other peers and then use them in their own firms (Nandy et al., 2020). Hence, we formulate hypothesis 1:

Hypothesis 1: Board network centrality increases CSR over-decoupling.

Another misalignment between CSD and CSP is the negative one. To be specifically, compared with the actual CSP, firms tend to have a lower CSD, which is defined as under-decoupling in this paper. The main reason for under-decoupling is that firms are worried about the incremental legitimacy pressure caused by a high level of CSD (Carlos and Lewis, 2018). When a firm discloses more information, it will attract more attention from stakeholders (Cormier and Magnan, 2014; Ji et al., 2015), which also provides evidence for external stakeholders (such as SRIs and green NGOs) in inquiries and lawsuits; thus, firms have to carefully decide the scope and accuracy of the CSD to prevent facing incremental pressure (Carlos and Lewis, 2018). Especially in China, firms' motivations for CSR practices are more complicated, even some ones are dark (Qian and Chen, 2021), such as covering up firms' political costs. Lin et al. (2015) and Jia and Zhang (2018) find that some Chinese firms engage in CSR practices in exchange for gaining more political connections. Therefore, these firms prefer to engage in CSR practices "silently" rather than attracting the attention of other

stakeholders, which leads to a lower CSD (Marquis and Qian, 2014).

Based on the previous framework, we argue that board network centrality has no impact on under-decoupling. When a firm chooses a low CSD to circumvent stakeholders' attention to its actual CSP, it has established an information asymmetry barrier for itself. In other words, without incremental disclosure, legitimacy threats related to CSD will disappear in the under-decoupling firms. In this case, the sensitivity of board centrality and decoupling should not exist. Hence, we formulate hypothesis 2:

Hypothesis 2: Board network centrality has no impact on CSR under-decoupling.

Figure 1 reports the theoretical framework for our hypothesis development.

MATERIALS AND METHODS

Data Sources

The original samples are Chinese A-share listed firms on the Shanghai and Shenzhen stock exchanges for the 2009–2018 period. We collect our data from multiple sources: (1) financial data of the capital market and firms are from CSMAR; (2) following Larcker et al. (2013), we calculate board centrality by Pajek, and the original data of corporate board is from CSMAR; (3) RKS rating comes from Rankings, and the available range is from 2009 to 2018. Therefore, our final sampling period is 2009 to 2018.

We perform the following preprocessing steps: (1) we exclude firms from the financial industry and firm-year observations with missing data; (2) to avoid the impact of extreme values, we winsorize all continuous variables at the

1 and 99% levels. After screening, our final sample consists of 5,729 firm-years.

Measurements of Main Variables

Board Network Centrality

Referring to historical studies (El-Khatib et al., 2015; Larcker et al., 2013), this study creates a proxy of network centrality (Centrality) by using four commonly used measures; that is, degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality. Specifically, we sort four centrality measures into 10 quantiles and then take the mean value of four processed variables as the proxy of board network centrality.

Degree centrality measures the number of direct connections between firms through sharing at least one board member. The more connections a firm has, the higher the centrality of the firm's board network, and the stronger the firm's ability to obtain information. Closeness centrality measures the firm's closeness to other firms through the shortest connection and measures the firm's efficiency in obtaining information from others through the board network. The closer the connections with other firms, the more information and resources will be transmitted through fewer firms, information and resources will be exchanged faster, more accurately and in more detail, and the quality of information will be higher. Betweenness centrality measures how often a firm sits at the shortest "bridge" position between the other two firms. If a firm sits on the shortest connection of multiple pairs of firms, then the firm plays a vital role in connecting firms and exchanging information and resources by promoting, obstructing or even changing the communication between other firms. Eigenvector centrality considers not only the number of directly connected firms but also the number of indirectly connected firms. In other words, if a firm's directly connected firm has many connections, then the firm will also have higher connection accordingly,

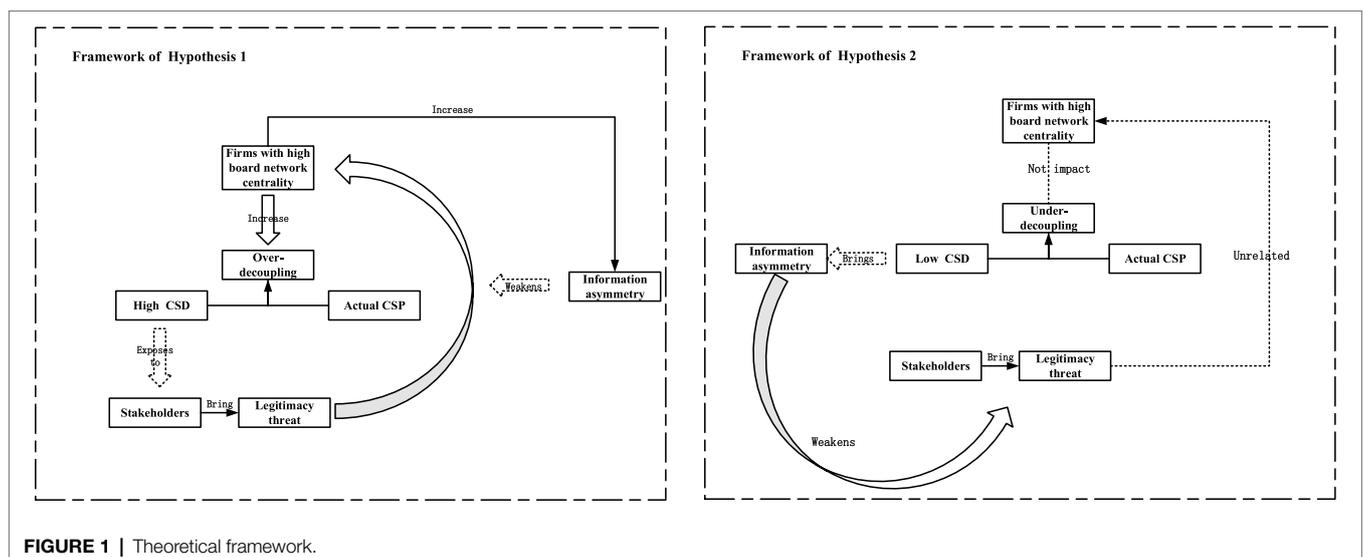


FIGURE 1 | Theoretical framework.

which means that it has more power to influence other firms in terms of information dissemination and exchange through these well-connected firms and enjoy more and more stable information flow and greater visibility.

CSR Decoupling

CSR decoupling refers to the misalignment between firms' internal and external CSR actions (Tashman et al., 2019). Internal actions are firms' real CSR practices, such as the inputs on donations and environmental protection and so on, and larger CSR inputs ultimately reflect higher CSP. External actions generally focus on communication and visible disclosure that firms adopt to create a good reputation in the views of the public, including the commitment and statement of CSR practices and so on, which reflects firm's CSD level. There are three main types of definition for CSR decoupling: (1) the difference between a firm's CSD level rated by third-party ratings and its actual CSR performance or inputs (García-Sánchez et al., 2020; Zhong et al., 2021); (2) the difference between internal (e.g., employee welfare expenditure) and external CSR actions (e.g., employee improvement commitment; Sánchez et al., 2021; Shahab et al., 2021); (3) the difference between level of optimistic tone from CSR reports and CSR performance (Sauerwald and Su, 2019; Zhang, 2021).

Considering the reality of the Chinese market, we refer to García-Sánchez et al. (2020), and define CSR decoupling as the difference between CSD and CSP. Following Liao et al. (2019), we use the technical dimension score (T-score) and content dimension score (C-score) provided by RKS ratings proxies for CSD and CSP.² We normalized both CSD and CSP on the scale of [0, 1] to make these two variables comparable; after this, we obtain the decoupling variable as the difference between CSD and CSP. Then, according to the direction of CSR decoupling, the samples are divided into the following two groups. The positive difference indicates that a firm's CSD level is higher than CSP level; that is, positive decoupling, defined as Gap_over. The economic meaning of Gap_over is that firms tend to use more CSD to improve their social reputation, instead of inputting more resources in actual practices to get better CSP. The negative difference indicates that a firm performs better than its disclosure, that is, negative decoupling, defined as Gap_under. The economic meaning of Gap_under is that firms input more resources in actual CSR practices, but lack of related CSD, because they are afraid they are exposing more to stakeholders (Kim and Lyon, 2015; Carlos and Lewis, 2018). To better understand, we refer to the calculation method of investment efficiency (Chen et al., 2011), and we take the absolute values of both CSR decoupling variables; the higher the value is, the larger the gap between CSD and CSP.

²Although widely used by previous studies, the Hexun rating has serious problems in terms of their indicator design, for example, rating scores are heavily influenced by financial performance, the shareholder dimension score accounts for nearly 70% of the total score, and the environmental dimension score only accounted for 0.3% in 2017 (Zhong et al., 2019).

Control Variable

Following previous studies, e.g., Su (2019) and Wen and Song (2017), control variables are employed as follows: (1) resource abundance variables, resources controlled by firms and the ability to acquire resources are related to CSR engagement. CASH, equal to the logarithm of firm cash holdings. ROA, measured as the return-on-assets ratio. BTM, the book-to-market ratio. LEV, measured by the asset-liability ratio.

(2) Reputation variables, the visibility of firms in society is related to their CSR engagement. SIZE, equal to the logarithm of total assets, stands for the visibility of the firm and the political cost that the firm may face. AGE, measured as the natural logarithm of the firm listing period. (3) Corporate governance variables, firms with better governance have stronger motivations and mechanisms to engage in CSR. TOP1, defined by the percentage of stock held by a firm's largest shareholder. MSH, measured as the percentage of stockholdings by top management team. IB, measured as the ratio of independent directors on the board. BSIZE, measured as the natural logarithm of the total number of directors. DUAL is a dummy variable; if one person is both CEO and chairman, the value is 1, otherwise 0. Finally, to control for variation across time and industry, we include year and industry dummies.

Model Design

For Hypotheses 1 to 2, we design model (1):

$$\text{CSP}_{i,t} / \text{CSD}_{i,t} / \text{Gap}_{i,t} = \alpha_0 + \beta_1 \text{Centrality}_{i,t-1} + \sum \beta_j \text{Control variables}_{i,t} + \sum \text{Year \& Indu effects} + \epsilon_{i,t} \quad (1)$$

where CSP and CSD represent CSP and disclosure, which equal to the scores of Content and Technicality dimension of RKS ratings; Gap represents CSR decoupling, specifically, we define three kinds of Gap, Gap_abs, which are equal to the absolute values of the positive gap and negative gap between CSD and CSP, Gap_over, which are equal to the absolute values of the positive gap, and Gap_under, which are equal to the absolute values of the negative gap; the larger the gap is, the higher the value. Centrality is our independent variable, which is equal to the mean value of four network centrality variables (degree, closeness, betweenness and eigenvector) after sorting them into 10 quantiles. Control variables refer to the set of control variables mentioned above. Finally, the year and industry effects are included in the regression. Following Petersen (2009), t-statistics are clustered at the firm and year level.

MAIN RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics of our main variables used in the regression analysis of full samples of the full sample of 5,729 firm-year observations from 2009 to 2018. The mean value of the dependent variable Centrality is 6.13. The average

TABLE 1 | Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	P25	P50	P75	Max
Centrality	5,729	6.13	2.528	1	4.25	6.5	8.25	10
Corporate social performance (CSP)	5,729	17.29	5.871	6.15	13.18	16.35	20.39	35.51
Corporate social disclosure (CSD)	5,729	7.189	1.933	3.85	5.74	6.91	8.19	14.01
Gap_abs	5,729	.135	.095	0	.06	.12	.193	.567
Gap_over	2,045	.117	.089	0	.048	.099	.17	.567
Gap_under	3,684	.144	.096	0	.069	.131	.202	.553
CASH	5,729	21.01	1.466	15.1	19.99	20.92	21.91	26.49
ROA	5,729	.043	.061	-.854	.016	.037	.067	.482
BTM	5,729	.668	.253	.037	.474	.679	.87	1.43
LEV	5,729	.491	.201	.008	.343	.506	.643	1.513
SIZE	5,729	23.06	1.447	18.27	22.01	22.91	23.92	28.51
AGE	5,729	2.399	.643	0	2.079	2.565	2.89	3.367
TOP1	5,729	37.59	16.11	3	24.49	36.48	49.87	89.41
MSH	5,729	.029	.09	0	0	0	.003	.843
IB	5,729	.375	.059	.091	.333	.364	.4	.8
BSIZE	5,729	2.196	.21	1.386	2.079	2.197	2.303	2.89
DUAL	5,729	.176	.381	0	0	0	0	1

scores for CSP and CSD, namely, C-score and T-score of RKS ratings,³ are 17.29 and 7.189, respectively. Furthermore, the mean value for key independent variables Gap_abs, Gap_over and Gap_under are .135, .117 and .144, respectively. For the control variables, our descriptive statistics are consistent with historical literatures. For examples, the mean values of ROA and LEV are .043 and .491 in our sample, which are consistent with Wen and Song (2017). The mean values of IB and BSIZE are .375 and 2.197, respectively, which are consistent with Su (2019). Further, the mean values of DUAL and AGE are consistent with Zhang (2021).

Correlation Analysis

Table 2 presents the correlation coefficients for key variables in main analysis. The correlation between Centrality and CSP (CSD) is .181 (.216) at the 1% level. These results are consistent with the previous studies (e.g., Harjoto and Wang, 2020). Due to our design of decoupling variables, the samples between the variables Gap_over and Gap_under do not overlap with each other, accordingly, there is no correlation between them.

Regression Results

The Chinese legislature carried out a major amendment to the Environmental Protection Law of China (referred to as “the new environmental law”) in April 2014, which significantly enhanced the law enforcement authority of environmental protection departments, expanded and strengthened the scope and quality of mandatory information disclosure (Zhang et al., 2017), it has become an important signal of the improvement of the Chinese CSR regulatory system (Yu et al., 2021). For example, since 2015, the number of Chinese institutional investors, NGOs and related practices based on CSR (ESG) themes has increased dramatically. According to Syntao. (2021), the number

of public funds for ESG theme increases rapidly. Changes in the regulatory system cause fundamental changes that may affect stakeholder pressure for symbolic practices (Marquis et al., 2016). These changes remind us that it is better to conduct an analysis of different periods. Thus, in the regression of model (1), except for using the whole sample, we also run regressions with two separating subgroups: the pre-adoption group and post-adoption group of the new environmental law. We define a dummy variable Post, which equals 0 if the firm-years belong to 2009 to 2014, or 1 during 2015 to 2018.⁴

Table 3 reports the regression results of model (1). Columns (1) to (3) show the coefficients between Centrality and performance variable CSP are all positive, specifically, .0325 ($p < .05$) in the whole period, .0307 (not significant) and .0296 ($p < .05$) in the pre-adoption and post-adoption periods, respectively. The coefficients indicate that board network centrality is positively related to CSP, and this positive relationship is more pronounced in the post-adoption period of the new environmental law. Columns (4) to (6) show the regression results for the disclosure variable CSD. Similar to the results of CSP, the coefficients of Centrality are all positive, but more pronounced in the post-adoption period. The above evidence is consistent with previous research, e.g., Harjoto and Wang (2020), which finds that board centrality increases CSR. The more pronounced coefficients of Centrality in the post-adoption period suggest that it's necessary to take into consideration of the influence of the new environmental law.

For CSR decoupling, columns (7) to (9) report the regression results for the over-decoupling variable Gap_over. The coefficients on Centrality are complex. The coefficient is not significant in the whole period. However, the coefficients are .0023 ($p < .05$) in the pre-adoption period but $-.0026$ ($p < .05$) in the post-adoption period. The coefficient in column (8) partly supports

³Their theoretical upper limits are 45 and 15.

⁴The new environmental law took effect on 1 January 2015.

TABLE 2 | Pearson's correlation.

Variable	Centrality	CSP	CSD	Gap_abs	Gap_over	Gap_under	CASH	ROA	BTM	LEV	SIZE	AGE	TOP1	MSH	IB	BSIZE	DUAL
Centrality	1																
CSP	.181***	1															
CSD	.216***	.680***	1														
Gap_abs	-.030**	.163***	-.094***	1													
Gap_over	-.020	-.274***	.215***	1	1												
Gap_under	-.030*	.321***	-.194***	1	N/A	1											
under																	
CASH	.270***	.404***	.375***	.022*	-.057***	.055***	1										
ROA	-.018	.058***	-.003	.0170	-.062***	.051***	.064***	1									
BTM	.124***	.195***	.165***	.042***	.0200	.045***	.440***	-.277***	1								
LEV	.132***	.123***	.092***	.0170	-.052**	.050***	.350***	-.388***	.455***	1							
SIZE	.297***	.441***	.419***	.0170	-.058***	.048***	.869***	-.050***	.588***	.506***	1						
AGE	.187***	-.0002	.078***	-.0190	.071***	-.050***	.143***	-.152***	.125***	.241***	.230***	1					
TOP1	.066***	.165***	.072***	.0170	-.082***	.044***	.210***	.048***	.167***	.078***	.256***	-.072***	1				
MSH	-.139***	-.092***	-.052***	-.031**	-.001	-.038**	-.163***	.102***	-.148***	-.197***	-.231***	-.415***	-.099***	1			
IB	.0210	.028**	.050***	.001	.038*	-.0140	.122***	-.0140	.0190	.029**	.105***	-.027**	.076***	.049***	1		
BSIZE	.175***	.167***	.083***	.048***	-.054**	.088***	.166***	-.007	.151***	.113***	.223***	.075***	.023*	-.156***	-.398***	1	
DUAL	-.072***	-.065***	-.028**	-.00900	.0190	-.0150	-.069***	.061***	-.119***	-.105***	-.110***	-.173***	-.100***	.390***	.092***	-.159***	1

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

Hypothesis 1, indicating that board centrality is positively related to over-decoupling, but only when CSR institutional regulation is weak. However, when institutional regulation strengthened after 2015, the relationship became negative. Columns (10) to (12) show the regression results for under-decoupling variable Gap_under. The results are as complex as Gap_over. We find that the coefficients on Centrality in the whole and post-adoption periods are not significant, supporting Hypothesis 2. However, in the post-adoption period, the coefficient is .0020 ($p < .10$), which supports our corner about the regulation change, namely, due to the enhanced supervision by the new environmental law, firms with high board centrality furtherly decrease their CSD, resulting in larger under-decoupling.

During the post-adoption period, centrality is negatively (positively) related to over-decoupling (under-decoupling). Our explanation is that boards with high centrality have higher information acquisition and utilization efficiency (Harjoto and Wang, 2020; D. Larcker et al., 2013), and they can understand institutional policy changes and related impacts more easily and deeply, then adjust corresponding strategies. Specifically, the new environmental law provides a more favorable foundation for stakeholders' rights protection and supervision from CSR information (Zhang et al., 2017). As a reaction to the law, over-decoupling firms with high board centrality are more easily to notice the increasing cost of symbolic management, thereby reducing symbolic management. Meanwhile, under-decoupling firms with high board centrality can further strengthen the original information strategy, revealing less information and widening information asymmetry.

Robustness Checks Test Based on Original Centrality

In the main analysis, we use the mean value of four board network centrality variables (degree, closeness, betweenness and eigenvector) after sorting them into 10 quantiles as a proxy of board network centrality. In this analysis, we directly use four original network centrality variables as an alternative measurement for board centrality for robustness checks to ensure the robustness of the results. For brevity, we only report the results of the decoupling variable Gap_over and Gap_under, and the coefficients on control variables are omitted.

Table 4 reports the regression results based on four network centrality variables. The dependent variables in columns (1) to (8) are the over-decoupling variable Gap_over. The coefficients on centrality variables degree, closeness, betweenness and eigenvector are mostly positive (except for eigenvector) but not significant in the pre-adoption period, meanwhile, three of four coefficients are significantly negative in the post-adoption period (except for betweenness). Columns (9) to (16) show the results for Gap_under. The coefficients on degree, closeness, betweenness and eigenvector are all negative in the pre-adoption period and positive in the post-adoption period. The regression results above are similar to our main analysis results.

Heckman Approach

Among the 24,000 more original observations in the research period from 2009 to 2018, only approximately 24% of the

TABLE 3 | Regression results of board network centrality and CSP/CSD/Gap.

Variable	CSP			CSD			Gap_over			Gap_under		
	All	Post=0	Post=1	All	Post=0	Post=1	All	Post=0	Post=1	All	Post=0	Post=1
	(2009–2018)	(2009–2014)	(2015–2018)	(2009–2018)	(2009–2014)	(2015–2018)	(2009–2018)	(2009–2014)	(2015–2018)	(2009–2018)	(2009–2014)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Centrality	.0325** (2.0707)	.0307 (1.3087)	.0296** (2.2038)	.1389** (2.5653)	.1127 (1.5747)	.1854*** (3.6060)	-.0014 (-1.3923)	.0023** (2.1132)	-.0026** (-2.4718)	-.0002 (-.1793)	-.0007 (-.6720)	.0020* (1.8577)
CASH	.0786 (1.4183)	.1006 (1.3535)	.0289 (.5948)	.2811 (1.5184)	.2172 (.9801)	.2438 (1.2389)	.0018 (.7387)	.0027 (.3775)	.0021 (.7158)	.0026 (.8251)	.0017 (.4309)	.0062** (2.1120)
ROA	-1.6256* (-1.9465)	-3.1231*** (-3.7324)	-.5692 (-.8249)	-.7074 (-2.839)	-3.0923 (-1.0783)	.1460 (.0566)	-.0844* (-1.7729)	-.1678*** (-2.7163)	-.0414 (-.7735)	.0967** (2.1558)	.1490*** (3.0915)	.0120 (.3293)
BTM	-.9321*** (-4.0178)	-.9322*** (-3.0648)	-1.0363*** (-3.9455)	-2.3657*** (-3.0211)	-2.6502*** (-2.6552)	-2.6169*** (-2.9372)	-.0069 (-.6555)	-.0107 (-.7212)	.0032 (.2375)	.0031 (.3987)	.0038 (.2992)	.0111 (.6912)
LEV	-.7394** (-2.4698)	-1.0488*** (-2.9267)	-.4459* (-1.7813)	-2.0850** (-2.2736)	-2.3149** (-2.0905)	-1.7441* (-1.7998)	-.0065 (-.4223)	-.0183 (-.6682)	.0035 (.1921)	.0228 (1.5502)	.0374** (2.2407)	-.0033 (-.2697)
SIZE	.5592*** (6.9301)	.5919*** (5.7687)	.5878*** (8.4169)	1.9497*** (7.7247)	1.9197*** (6.4835)	2.1747*** (8.5415)	-.0067 (-1.4266)	.0002 (.0406)	-.0120*** (-2.5943)	.0021 (.5839)	.0024 (.4942)	-.0024 (-.6729)
AGE	-.2840*** (-3.9662)	-.2945*** (-3.0448)	-.2667*** (-4.2588)	-.9411*** (-3.8022)	-1.0584*** (-3.6343)	-.9276*** (-3.4387)	-.0001 (-.0328)	.0009 (.1103)	.0023 (.5505)	-.0059 (-1.5799)	-.0074 (-1.6101)	-.0028*** (-3.9459)
TOP1	.0018 (.6158)	.0017 (.4560)	.0016 (.5791)	.0185* (1.7803)	.0141 (1.2649)	.0232** (2.1008)	-.0003* (-1.8667)	-.0001 (-.3941)	-.0003 (-1.5915)	.0001 (.6621)	.0001 (.9277)	.0001 (.4107)
MSH	.5605 (1.4724)	.6771 (1.2804)	.4685 (1.1261)	.0613 (.0484)	.1142 (.0708)	.0472 (.0303)	-.0246 (-1.3245)	-.0051 (-.0947)	-.0323 (-1.5063)	-.0570** (-2.4249)	-.0604*** (-2.5910)	-.0346 (-.6153)
IB	.6465 (.8608)	-.0903 (-1.067)	1.0953 (1.5108)	.7474 (.3093)	.3735 (.1491)	1.1776 (.3526)	.0876* (1.9284)	.0699 (1.3908)	.0677 (1.1298)	.0056 (.1355)	.0250 (.6194)	-.0170 (-.2108)
BSIZE	.4477** (2.0214)	.4573 (1.4536)	.3795* (1.9351)	2.0570*** (2.6623)	2.2619*** (2.5776)	1.7481* (1.9348)	.0116 (.8553)	.0257 (1.2741)	.0100 (.5367)	.0322*** (3.1221)	.0388*** (3.0136)	.0159 (1.2512)
DUAL	-.1682** (-2.1223)	-.1445 (-1.3356)	-.1655* (-1.7789)	-.4316 (-1.3001)	-.1147 (-.2629)	-.7484** (-2.0043)	-.0025 (-.5144)	.0042 (.2937)	-.0039 (-.8124)	.0010 (.1428)	.0021 (.2421)	-.0024 (-.2767)
Constant	-8.2256*** (-6.3981)	-8.5891*** (-5.4065)	-6.8855*** (-5.4962)	-36.3719*** (-8.5858)	-36.2787*** (-7.6539)	-41.8466*** (-10.0731)	.1455 (1.5762)	-.0811 (-.8968)	.3323*** (3.9220)	-.0892 (-1.5054)	-.1043 (-1.5979)	-.0270 (-.3755)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5,729	3,026	2,703	5,729	3,026	2,703	2045	455	1,590	3,684	2,571	1,113
R ²	.4075	.2645	.3333	.2934	.2954	.3163	.1794	.1961	.1656	.1640	.1480	.1842

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

TABLE 4 | Alternative measurements of board network centrality.

Variable	Gap_ over	Gap_ over	Gap_ over	Gap_ over	Gap_ over	Gap_ over	Gap_ over	Gap_ over	Gap_ under	Gap_ under	Gap_ under	Gap_ under	Gap_ under	Gap_ under	Gap_ under	Gap_ under
	Post=0	Post=0	Post=0	Post=0	Post=1	Post=1	Post=1	Post=1	Post=0	Post=0	Post=0	Post=0	Post=1	Post=1	Post=1	Post=1
	(2009–2014)	(2009–2014)	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)	(2009–2014)	(2009–2014)	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Degree	.0023 (1.5497)				-.0012** (-2.5744)				-.0004 (-.7464)				.0008 (1.3153)			
Closeness		.0557 (1.4171)						-.1647*** (-4.8710)				-.0116 (-.2141)			.0701 (1.4805)	
Betweenness			2.4563 (1.4812)					-.5721 (-.7008)					-1.1878** (-2.0294)			1.6874 (.8730)
Eigen vector				-3.3313 (-.7523)				-7.7697*** (-4.3980)					-.6048 (-.2854)			3.6448 (.8003)
Constant	-.0691 (-.9544)	-.0915 (-1.1838)	-.0663 (-.9009)	-.0944 (-1.2118)	.3324*** (4.2523)	.3493*** (4.3461)	.3485*** (4.5838)	.3485*** (4.4711)	-.1014 (-1.5289)	-.0953 (-1.4795)	-.1120* (-1.6969)	-.0950 (-1.4467)	-.0064 (-.0668)	-.0194 (-.1893)	-.0023 (-.0250)	-.0155 (-.1539)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	455	455	455	455	1,590	1,590	1,590	1,590	2,571	2,571	2,571	2,571	1,113	1,113	1,113	1,113
R ²	.1996	.1913	.1978	.1909	.1647	.1665	.1625	.1647	.1479	.1477	.1486	.1477	.1832	.1827	.1830	.1827

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

observations with CSD are included in our main analysis, which may cause sample selection bias. For this problem, we use the Heckman method (Heckman, 1979). In the first step, we design the probit model as follows:

$$\text{probit}(\text{CSD_dummy}_{i,t}) = \alpha_0 + \sum \beta_j \text{CSD Determinates}_{i,t} + \sum \text{Year \& Indu effects} + \varepsilon_{i,t} \quad (2)$$

where CSD_dummy is a dummy variable. If the firm discloses CSR information, the value is 1; otherwise, it is 0. Following Li et al. (2013), the influential variables of CSD are as follows: (1) ROA, the return on firm equity; (2) SOE, is a dummy variable, if firm is state-owned, the value is 1, otherwise 0; (3) SIZE, is measured as the natural logarithm of total assets; (4) AGE, is measured as the natural logarithm of firm listing period; (5) LEV, is measured as asset-to-liability ratio; (6) TOP1, is measured as the percentage of stockholdings by the largest shareholder; (7) Herfindahl 5, is measured as the degree of ownership dispersion, calculated as Herfindahl–Hirschman Index of stockholdings by top five shareholders; (8) MSH, is measured as the percentage of stockholdings by top management team; (9) Year and Industry effects. Column (1) of **Table 5** reports the result from estimating model (2).

Second, we regress based on model (1); meanwhile, the control variables also include the inverse Mills ratio calculated in the first step. Columns (2) to (9) of **Table 5** show the results of model (1). The dependent variables in columns (2) to (3), columns (4) to (5), columns (6) to (7) and columns (8) to (9) are CSP, CSD Gap_over and Gap_under, respectively. For brevity, we only report the coefficients on Centrality, respectively, in the pre-adoption and post-adoption period. The results are similar to our main analysis results.

Endogeneity Test

The relationship between board network centrality and CSR practices investigated in this paper may be affected by other unobservable factors, which may lead to endogeneity problems. Therefore, the two-stage least squares (2SLS) approach is adopted to solve the problem of endogeneity. In the 2SLS estimations, the instrumental variable Centrality_IV is used, which defined as the centrality level in year $t+1$.⁵ For brevity, we do not report the results in the whole periods, and the coefficients on control variables are omitted.

Table 6 shows the results of instrumental regression. Columns (1) to (4), columns (5) to (8), columns (9) to (12) and columns (13) to (16) report the results of CSP, CSD, Gap_over and Gap_under, respectively. The coefficients of CSP, CSD, Gap_over and Gap_under in the 2SLS approach are basically consistent with the main analysis.

⁵We use Centrality in year $t + 1$ as instrumental variable, so some firm-years with missing data are excluded in the regression, resulting in the decrease of sample size decreases in **Table 6**.

Alternative Explanation of Political Connection

Existing research argues that CSR practices are significantly affected by political connections in the Chinese market (Li et al., 2015; Lin et al., 2015; Wang et al., 2020). Therefore, for the results in the main analysis, another alternative explanation is that the relationship between board centrality and CSR practices may be caused by political connections. To testing of this argument, we design the following exclusion tests:

First, we add the control variable politically connections (PC) into regression model (1), which equals 1 if a firm's CEO or chairman who is a former government official (served in government agencies at or above the county level, the municipal people's congress, or the army), and 0 otherwise. If we add the control variable of PC into the regression and the coefficients on Centrality lost significance, these should support the political explanation. Second, we design an alternative sample excluding political-related firms and only use non-political-related firms for regression. If we find that the coefficients on Centrality lost significance in the test with the alternative sample, the political explanation should hold. For brevity, we only report the results in post-adoption period.

The regression results are shown in **Table 7**. The results of adding the PC variable are reported in columns (1) to (4), and results of the alternative sample design are reported in column (5) to (8), the coefficients on Centrality are basically consistent with the main analysis. The alternative explanation of political connection does not hold.

ADDITIONAL TEST

Heterogeneity Test of Regional Environment Regulation

In the hypotheses development, we argue that one of the paths for the influence of board network centrality on CSR decoupling is through circumventing the public opinion supervision. Existing literature suggests that there is a strong relationship between public opinion supervision and regional environment regulation (Ruiqian and Ramakrishnan, 2018; Sun et al., 2019). Firms face stronger supervision in regions with higher degree of environmental regulation, resulting in lower over-decoupling and higher under-decoupling level. If higher board centrality can circumvent the influence of public opinion supervision, then the negative (positive) relationship between regulation and over-decoupling (under-decoupling) should be mitigated.

Referring to Xie et al. (2017) and Ruiqian and Ramakrishnan (2018), we use the number of environmental administrative penalty cases as the proxy of the level of regional environment regulation. We define variable Regulation, measured as the logarithm of the number of province environmental administrative penalty cases.⁶ We design an interaction model as follows:

⁶In the China Environmental Almanac, the data of environmental penalty were only updated to 2015, so the values after 2015 are replaced by those of 2015.

TABLE 5 | Results of Heckman's approach.

Variable	Probit regression		Heckman two-stage estimation: second stage						
	CSD_dummy	CSP	CSP	CSD	CSD	Gap_over	Gap_over	Gap_under	Gap_under
	Original samples	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1
	(2009–2018)	(2009–2014)	(2015–2018)	(2009–2014)	(2015–2018)	(2009–2014)	(2015–2018)	(2009–2014)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Centrality		.1239* (1.6951)	.1841*** (3.6719)	.0386 (1.6421)	.0291** (2.2096)	.0024** (2.4094)	-.0026** (-2.3441)	-.0008 (-.7809)	.0020 (1.5307)
ROA	1.3655*** (6.7186)	1.3836 (.4578)	3.5636 (1.4141)	-.2893 (-.3312)	1.0833 (1.4102)	-.0911 (-1.3417)	-.0471 (-.8528)	.1095** (2.0163)	.0366 (.5868)
SOE	.2599*** (10.2821)								
SIZE	.5827*** (51.0688)	3.3142*** (4.8488)	3.2436*** (5.0575)	1.4273*** (6.2442)	1.0832*** (5.4154)	.0314* (1.8528)	-.0152 (-.9471)	-.0067 (-.7267)	.0070 (.5935)
AGE	.2585*** (15.7031)	-.2320 (-.5248)	-.3476 (-.8058)	.2097 (1.5464)	.0306 (.2642)	.0181 (1.3092)	.0012 (.1442)	-.0135* (-1.9497)	.0019 (.2247)
LEV	-.7854*** (-11.7523)	-4.0045*** (-3.2138)	-2.9890** (-2.2851)	-2.0485*** (-4.8080)	-1.0289*** (-3.2725)	-.0619 (-1.4815)	.0074 (.2532)	.0480** (2.4920)	-.0134 (-.5552)
TOP1	-.0033 (-1.3303)	.0167 (1.4894)	.0274** (2.4687)	.0028 (.7507)	.0032 (1.0271)	-.0001 (-.3502)	-.0003* (-1.6476)	.0001 (.9099)	.0001 (.3982)
Herfindahl_5	.3142 (.9883)								
MSH	-.2266** (-2.2565)	-2.0322 (-1.2531)	-1.1292 (-.6923)	-.5986 (-1.1595)	-.0656 (-.1303)	-.0378 (-.5916)	-.0286 (-1.1255)	-.0429** (-2.1332)	-.0507 (-1.2815)
CASH	.1983 (.9626)	.2191 (1.1700)	.2191 (1.3045)	.0918 (1.3045)	.0266 (.5304)	.0002 (.0302)	.0023 (.7445)	.0015 (.3634)	.0064 (1.4798)
BTM		-2.3543** (-2.4511)	-2.2693** (-2.5658)	-.7458** (-2.5049)	-.8997*** (-3.6013)	-.0017 (-.1176)	.0029 (.2249)	.0001 (.0084)	.0101 (.5678)
IB	.6117 (.2375)	1.6767 (.4908)	1.6767 (.4908)	-.0428 (-.0491)	1.2212 (1.6077)	.0787 (1.6451)	.0657 (1.0900)	.0270 (.6832)	-.0191 (-.3012)
BSIZE		2.5491*** (2.9248)	1.9460** (2.1235)	.6269** (2.0316)	.4708** (2.2514)	.0303 (1.5297)	.0095 (.5313)	.0366*** (2.7406)	.0164 (1.0867)
DUAL		-.1496 (-.3348)	-.8089** (-2.1764)	-.1597 (-1.4547)	-.1908** (-2.1394)	.0043 (.3166)	-.0036 (-.7335)	.0021 (.2483)	-.0022 (-.2536)
Lambda		3.9883** (2.2448)	2.9016* (1.9502)	2.4108*** (4.5965)	1.4003*** (2.9445)	.0771* (1.9414)	-.0071 (-.1948)	-.0284 (-1.3773)	.0260 (.8430)
Constant	-13.8257*** (-53.3399)	-70.8220*** (-3.9268)	-70.2524*** (-4.4697)	-31.1217*** (-5.5885)	-20.2923*** (-3.9402)	-.8546** (-2.2338)	.4091 (1.0494)	.1478 (.6601)	-.2771 (-.9183)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	24,608	3,026	2,703	3,026	2,703	455	1,590	2,571	1,113
F ²		.2911	.3080	.2686	.3262	.2064	.1656	.1489	.1851
Pseudo R ²	.2447								

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

$$\begin{aligned}
 \text{Gap_over}_{i,t} / \text{Gap_under}_{i,t} = & \alpha_0 + \beta_1 \text{Centrality}_{i,t-1} \\
 & \times \text{Regulation}_{i,t-1} \\
 & + \beta_2 \text{Centrality}_{i,t-1} \\
 & + \beta_3 \text{Regulation}_{i,t-1} \\
 & + \sum \text{Control variables}_{i,t} \\
 & + \sum \text{Year \& Indu effects} + \varepsilon_{i,t} \quad (3)
 \end{aligned}$$

where the dependent variables Gap_over/Gap_under represent over-decoupling and under-decoupling, respectively. Regulation

is a proxy for the level of regional environment regulation. Centrality×Regulation is the interaction term between the regulation variable and the centrality variable, which is our main interest. Control variables, year and industry effects are consistent with those of model (1).

Table 8 shows the regression results. For brevity, the coefficients on control variables are omitted. First, we use variable Regulation as the dependent variable. To be specific, columns (1), (3), and (5) report the regression results for over-decoupling variable Gap_over, and column (7), (9), and (11) shows the results for the under-decoupling variable Gap_under

TABLE 6 | Results of 2SLS approach.

Variable	Centrality		CSP		Centrality		CSD		Centrality		Gap_over		Centrality		Gap_under		Centrality		Gap_over		Centrality		Gap_under		
	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	Post=0	Post=1	
	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	(2009-2014)	(2015-2018)	
	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)									
Centrality_IV	.595*** (39.09)	.495*** (18.91)	.495*** (18.91)	.495*** (18.91)	.595*** (39.09)	.638*** (16.84)	.495*** (18.91)	.495*** (18.91)	.638*** (16.84)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	
Centrality	.258*** (4.02)	.258*** (4.02)	.258*** (4.02)	.256* (1.84)	.595*** (39.09)	.057*** (2.70)	.495*** (18.91)	.495*** (18.91)	.057*** (2.70)	.638*** (16.84)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	.584*** (34.97)	.493*** (13.36)	.493*** (13.36)	
Constant	-4.359*** (-5.50)	-28.034*** (-13.67)	-4.945*** (-3.29)	-31.512*** (-7.73)	-4.359*** (-5.50)	-7.372*** (-1.99)	-4.945*** (-3.29)	-6.801*** (-6.67)	-1.960 (-.99)	-0.02 (1.01)	-4.187* (-1.93)	.102 (1.14)	-4.282*** (-4.86)	-0.02 (1.49)	-5.555*** (-2.60)	-0.038 (-.43)	.008*** (2.63)								
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
N	3,023	3,023	1,267	1,267	3,023	3,023	1,267	1,267	453	453	659	659	2,570	2,570	608	608	608	608	608	608	608	608	608	608	
R ²	.442	.244	.323	.216	.442	.217	.323	.263	.498	.050	.334	.047	.430	.092	.319	.010									

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

based on different periods. As shown in column (3) and (9), we find that the variable Regulation is significantly and negatively related (positively correlated) to Gap_over (Gap_under) in the pre-adoption period, but this relationship disappear in the post-adoption period. Before the implementation of the new environmental law, firms in regions with stronger environmental regulations face more stringent CSR supervision, resulting in a decrease of over-decoupling and an increase of under-decoupling. However, after the implementation of the new environmental law, all firms face stronger supervision, and the sensitivity of CSR to environmental regulations disappears. Moreover, we use the interaction effect model (3) for regression, and the regression results for variables Gap_over and Gap_under based on different periods are reported in columns (2), (4), (6) and columns (8), (10), (12), respectively. Specifically, the coefficients between Centrality×Regulation and Gap_over are positive but not significant. Then, the coefficients between Centrality×Regulation and Gap_under are negative, and are both significant at the 1% level. The evidence above suggests that board network centrality helps firms circumvent the influence of public opinion supervision, which is consistent with our theoretical expectations.

Heterogeneity Test of Peer CSR Practices

In the hypothesis development, another path for the relationship between board centrality and CSR decoupling is that firms learn the successful experience from their peers. Historical research based on network theory argues that firms with higher board network centrality gain an advantage in information from other firms, and learning from experience of others more quickly and efficiently (Larcker et al., 2013; Harjoto and Wang, 2020). For this explanation, we investigate whether board network centrality affects the firm's learning on CSR practices from their peers.

We define variables CSP_peer and CSD_peer as the industry average of CSP or CSD in the last year, excluding the firm itself,⁷ and then design an interaction model as follows:

$$\begin{aligned}
 \text{CSP}_{i,t} / \text{CSD}_{i,t} = & \alpha_0 + \beta_1 \text{Centrality}_{i,t-1} \\
 & \times \text{CSP_peer}_{i,t-1} (\text{CSD_peer}_{i,t-1}) \\
 & + \beta_2 \text{Centrality}_{i,t-1} \\
 & + \beta_3 \text{CSP_peer}_{i,t-1} (\text{CSD_peer}_{i,t-1}) \\
 & + \sum \text{Control variables}_{i,t} \\
 & + \sum \text{Year \& Indu effects} + \varepsilon_{i,t}
 \end{aligned} \tag{4}$$

where the dependent variables are CSP and CSD, respectively. CSP_peer (CSD_peer) represents the historical industry average level of CSP (CSD). Centrality×CSP_peer (CSD_peer) is the interaction term between the centrality variable and the industry average variable, which is our main interest. Control variables and year and industry effects are consistent with model (1).

⁷Since the peer learning effect can only exist in industries with a certain number of firms, we exclude sample industries with less than 10 firms.

TABLE 7 | Alternative explanation of political connections.

Variable	CSP	CSD	Gap_over	Gap_under	CSP	CSD	Gap_over	Gap_under
	Post=1	Post=1	Post=1	Post=1	Post=1 & PC=0	Post=1 & PC=0	Post=1 & PC=0	Post=1 & PC=0
	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Centrality	.1853*** (3.6172)	.0293** (2.1840)	-.0026** (-2.4152)	.0020* (1.8485)	.2481*** (4.0316)	.0322* (1.8684)	-.0022 (-1.5696)	.0040** (2.4329)
PC	-.0208 (-.0686)	-.0711 (-.7922)	-.0099** (-2.0494)	-.0032 (-.5563)				
CASH	.2433 (1.2427)	.0271 (.5672)	.0020 (.6892)	.0061** (2.1453)	.3165 (1.1570)	.0662 (.9777)	.0024 (.4167)	.0022 (.2251)
ROA	.1536 (.0592)	-.5430 (-.8025)	-.0367 (-.6901)	.0119 (.3173)	4.3343 (1.2617)	.0355 (.0531)	-.0803 (-1.2576)	-.0051 (-.0961)
BTM	-2.6216*** (-2.9680)	-1.0523*** (-3.9835)	.0010 (.0755)	.0102 (.6453)	-2.0148* (-1.7667)	-.7500*** (-3.3446)	-.0011 (-.0636)	-.0222 (-.8396)
LEV	-1.7455* (-1.8038)	-.4507* (-1.8096)	.0036 (.2048)	-.0039 (-.3290)	-1.2507 (-.9840)	-.4082 (-1.3602)	.0060 (.2673)	.0034 (.2410)
SIZE	2.1763*** (8.6106)	.5933*** (8.5014)	-.0116** (-2.4865)	-.0019 (-.6098)	1.8985*** (5.3382)	.5251*** (5.4497)	-.0098** (-2.3340)	.0034 (.3137)
AGE	-.9279*** (-3.4320)	-.2676*** (-4.2854)	.0024 (.5997)	-.0030*** (-4.4153)	-.6254* (-1.6970)	-.2157** (-2.5102)	-.0022 (-.3742)	-.0062 (-1.3339)
TOP1	.0232** (2.0922)	.0015 (.5309)	-.0003 (-1.6453)	.0001 (.3264)	.0351** (2.1232)	-.0001 (-.0376)	-.0008*** (-2.8476)	.0002 (.8836)
MSH	.0559 (.0355)	.4982 (1.2128)	-.0274 (-1.3638)	-.0330 (-.5834)	.6007 (.2986)	.4113 (.8245)	-.0891* (-1.7910)	-.0671 (-.8912)
IB	1.1858 (.3541)	1.1234 (1.5447)	.0713 (1.1836)	-.0156 (-.1922)	.9493 (.2163)	.9438 (.9310)	.1356 (1.5465)	.0832 (.8955)
BSIZE	1.7502* (1.9321)	.3867** (1.9706)	.0109 (.5805)	.0164 (1.3408)	1.8646* (1.9239)	.4752* (1.8299)	.0105 (.7351)	.0201 (1.3305)
DUAL	-.7484** (-2.0042)	-.1653* (-1.7802)	-.0036 (-.7807)	-.0025 (-.2850)	-1.0671** (-2.2496)	-.1320 (-1.2741)	.0142* (1.7958)	.0061 (.5155)
Constant	-41.8661*** (-10.0107)	-6.9523*** (-5.4801)	.3272*** (3.7680)	-.0330 (-.4649)	-39.7202*** (-7.9281)	-6.0534*** (-4.4579)	.2853*** (4.7605)	-.1306 (-1.4525)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,703	2,703	1,590	1,113	1,581	1,581	952	629
F ²	.3163	.3336	.1682	.1844	.3219	.3432	.2036	.2084

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

Regression results are presented in Table 9. For brevity, we do not report the result for the whole period. Similar to section Heterogeneity Test of Regional Environment Regulation, first, we use variables CSP_peer and CSD_peer as the independent variables to regress, and investigate relationships between them and CSP/CSD. The regression results for the pre-adoption and post-adoption periods are reported in column (1), (3) and column (5), (7), respectively, indicating that lagged CSP_peer and CSD_peer have a significant positive effect on current CSP and CSD, which are consistent with the results of previous studies (Yang et al., 2017). Moreover, we use model (4) for regression. As shown in columns (2), (4), (6), and (8), the coefficients on the interaction terms Centrality×CSP_peer (CSD_peer) are both positive and more significant in the post-adoption period. Consistent with our theoretical expectation, board centrality improves firms' learning of CSR practices from their peers, and this improvement effect is more pronounced in the period of the supervision strengthening.

Mechanism Test of Foreign Investor

Previous research suggests that foreign investors promote CSR engagement in emerging markets (Khan et al., 2013; Ali et al., 2017; Hao et al., 2018; Wang and Zhang, 2020). For example, Li et al. (2021) and McGuinness et al. (2017) find that firms invested by foreigners have better CSP in emerging markets. Hu et al. (2018) argue that foreign investors lead to a greater likelihood for CSR reporting in emerging markets. Thus, it is necessary to take into consideration the influence of foreign investors on the relationship between centrality and decoupling.

The influence of foreign investors on the relationship between centrality and CSR decoupling may be complex. The existing literature suggests that mature capital markets punish firms which adopt symbolic management in CSR practices (Marquis et al., 2016; García-Sánchez et al., 2020). However, in the market of investee firms, it is difficult for participants in the foreign market to supervise the CSR practices of investee firms due to the information limitations (Tashman et al., 2019). As

TABLE 8 | Heterogeneity test of environmental regulation.

Variable	Gap_over	Gap_over	Gap_over	Gap_over	Gap_over	Gap_over	Gap_under	Gap_under	Gap_under	Gap_under	Gap_under	Gap_under
	All	All	Post=0	Post=0	Post=1	Post=1	All	All	Post=0	Post=0	Post=1	Post=1
	(2009–2018)	(2009–2018)	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)	(2009–2018)	(2009–2018)	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Centrality × Regulation		.0003 (.5817)		.0011 (1.0708)		.0002 (.1599)		–.0017*** (–2.6265)		–.0019*** (–2.5918)		–.0019*** (–2.9657)
Centrality		–.0038 (–.7849)		–.0062 (–.8326)		–.0035 (–.4042)		.0139** (2.3696)		.0148** (2.2426)		.0182*** (3.2068)
Regulation	–.0023 (–.7798)	–.0042 (–1.4012)	–.0068** (–2.4807)	–.0128*** (–4.9043)	–.0005 (–.1197)	–.0012 (–.1833)	.0018 (.7923)	.0122*** (3.1373)	.0037* (1.6778)	.0147*** (3.7230)	–.0033 (–.6968)	.0098** (1.9810)
Constant	.1720* (1.7799)	.1804** (1.9696)	–.0595 (–.7003)	.0159 (.1427)	.3377*** (3.5679)	.3290*** (3.8011)	–.0947 (–1.5312)	–.1821*** (–2.6454)	–.1206* (–1.9202)	–.2191*** (–3.1814)	.0103 (.0790)	–.0892 (–.7921)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,989	1,989	454	454	1,535	1,535	3,643	3,643	2,561	2,561	1,082	1,082
R ²	.1806	.1814	.2031	.2119	.1647	.1674	.1637	.1662	.1499	.1537	.1856	.1893

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicate significance at the levels of 1%.

a result, the investee firms easily respond to CSR pressure from overseas markets through symbolic practices (Jamali et al., 2015). The information strength brought by boards with high centrality helps their firms to better notice and to take advantage of the information disadvantage of the overseas participants, thus strengthening the use of symbolic strategy. In terms of under-decoupling, the influence of foreign investors is ambiguous, and the pressure from the overseas participants may stimulate under-decoupling firms with high board centrality to increase CSD and CSP at the same time, or only one of them, or even maintain the original strategy.

For the above argument, we design an interaction effect model as follows:

$$\begin{aligned} \text{Gap_over}_{i,t} / \text{Gap_under}_{i,t} = & \alpha_0 + \beta_1 \text{Centrality}_{i,t-1} \\ & \times \text{Foreign}_{i,t-1} \\ & + \beta_2 \text{Centrality}_{i,t-1} \\ & + \beta_3 \text{Foreign}_{i,t-1} \\ & + \sum \text{Control variables}_{i,t} \\ & + \sum \text{Year \& Indu effects} + \varepsilon_{i,t} \end{aligned} \quad (5)$$

where the dependent variables are CSP, CSD, Gap_over and Gap_under, respectively. Foreign is a dummy variable that equals 1 if there is a foreign investor in a firm; otherwise, it equals 0. Centrality×Foreign is the interaction term between the foreign investor variable and the centrality variable, which is our main interest. Control variables and year and industry effects are consistent with those of model (1).

Table 10 reports the results of model (5). Columns (1) and (2) show the coefficients on Centrality×Foreign in the pre-adoption period, which are not significant with the dependent variables of both decoupling. Columns (3) and (4) show the coefficients on Centrality×Foreign in the post-adoption period. The coefficient on Centrality×Foreign is significantly positive ($p < .05$) when the dependent variable is Gap_over. The above results indicate that, after regulation strengthening, foreign investors weaken the negative relationship between centrality and over-decoupling.⁸

Influence of Institutional Regulation Strengthening

The Chinese government began to implement mandatory CSR reporting policy since 2009. However, due to the lack of corresponding substantive guidance and supervision system, Chinese firms do not face high pressure on CSR legitimacy, and many firms only need to deal with it through symbolic strategies. For example, Kuo et al. (2012) find that up to 41% of 711 social reports released in 2010 (the 2nd year after the policy was adopted) provided little useful additional information, and only 17% of them reported quantification indicators on the firms' CSR practices. Liao et al. (2018) find that the total ratio of CSR assurance for Chinese listed firms from 2008 to 2012 was only 4.04%, compared to the international level for

sustainability reports from large firms assured by a third party of 40% (Kolk and Perego, 2010).

The new environmental law was adopted in 2015, which significantly enhanced the regulation strength (Zhang et al., 2017). The strengthening of CSR regulatory system causes more legitimacy pressure for firms. Especially when firms disclose more CSR information, they will attract more attention from stakeholders. Meanwhile, stricter legal basis enables the public to carry out rights protection litigation against firms and supervise enforcers. Based on 45 countries, Marquis et al. (2016) find that, in countries and regions with greater external supervision and institutional pressures, firms in the environmental sensitive industries disclose less selective CSR information. Based on polluting industries in the United States, Berrone et al. (2017) finds that the positive relationship between symbolic environmental practices and corporate legitimacy can be weakened when firms are strictly supervised by non-governmental organizations (NGOs). Yu et al. (2020) find that, based on transnational samples, higher scrutiny of independent directors and institutional investors can weaken the tendency of symbolic environmental practices. Therefore, after the strengthening of CSR regulatory system, firms with high board centrality have to be more careful about selective CSD and choose a more conservative reporting strategy, which weakens the positive relationship between centrality and over-decoupling, and makes centrality has a positive impact on under-decoupling.

For this concern, we employ a Differences-in-Differences design. The variable Post is defined as same as before, which equals 0 if the firm-years belong to 2009 to 2014, or 1 during 2015 to 2018. Specifically, the following estimation model was used:

$$\begin{aligned} \text{Gap_over}_{i,t} / \text{Gap_under}_{i,t} = & \alpha_0 + \beta_1 \text{Centrality}_{i,t-1} \\ & \times \text{Post}_{i,t} \\ & + \beta_2 \text{Centrality}_{i,t-1} (\beta_3 \text{Post}_{i,t}) \\ & + \sum \text{Control variables}_{i,t} \\ & + \sum \text{Year \& Indu effects} + \varepsilon_{i,t} \end{aligned} \quad (6)$$

where the dependent variables Gap_over/Gap_under represent over-decoupling and under-decoupling, respectively. Centrality × Post is an interaction term between the period variable Post and the centrality variable Centrality, which is our main interest. Control variables and year and industry effects are consistent with those of model (1). In addition, due to the multicollinearity between the period variable Post and the year effect variable, the period variable Post is removed in the regression when the year dummies are included (Chen et al., 2017).

Table 11 reports the results from estimating model (6). The dependent variables in columns (1) to (2) and (3) to (4) are the over-decoupling variable Gap_over and the under-decoupling variable Gap_under, respectively. Columns (1) and (3) involve the variable Post, the variable Centrality and their interaction term but not year dummies, because of the multicollinearity problem. Columns (2) and (4) involve all control variables and effects. Columns (1) and (2) show that the coefficients of Centrality × Post are -0.0056 and -0.0058 , both significant at the 1% level, which suggests that the

⁸As shown in column (9) of **Table 3**, the coefficient on Centrality is -0.0026 and significant at 5% level.

TABLE 9 | Heterogeneity test of peer CSR practices.

Variable	CSP	CSP	CSD	CSD	CSP	CSP	CSD	CSD
	Post=0	Post=0	Post=0	Post=0	Post=1	Post=1	Post=1	Post=1
	(2009–2014)	(2009–2014)	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)	(2015–2018)	(2015–2018)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Centrality×CSP_peer		.0524 (1.3288)				.0635* (1.7167)		
CSP_peer	.6253*** (4.6547)	.3233 (1.1724)			.4861*** (3.2172)	.0522 (1.777)		
Centrality×CSD_peer				.0054 (.1583)				.0514** (2.1016)
CSD_peer			.4658*** (3.6339)	.4371** (2.2041)			.3189** (2.0769)	-.0341 (-.2713)
Centrality		-.9077 (-1.3645)		-.0331 (-.1663)			-1.0458* (-1.6646)	-.3231* (-1.7277)
CASH	-.1938 (-.6408)	-.1784 (-.5618)	.1021 (.6508)	.1022 (.6418)	.3424 (.7401)	.3068 (.6646)	-.0755 (-.7612)	-.0926 (-.9527)
ROA	1.6132 (2866)	1.0670 (1883)	-2.1678 (-1.5614)	-2.1740 (-1.5605)	-.3544 (-.0565)	.2786 (.0459)	-.4583 (-.3431)	-.4251 (-.3338)
BTM	-.3731 (-.2601)	-.5492 (-.3891)	-.2093 (-.5621)	-.2102 (-.5533)	-1.9649 (-1.1665)	-1.9269 (-1.1600)	-.2368 (-.6607)	-.1720 (-.5008)
LEV	.6024 (.2811)	.6332 (.2860)	.1911 (.3768)	.1926 (.3775)	1.4681 (.7209)	1.2853 (.6454)	-.1830 (-.3112)	-.2613 (-.4476)
SIZE	1.8334*** (3.8000)	1.8391*** (3.8037)	.3903** (2.2420)	.3902** (2.2231)	1.7589*** (3.2972)	1.7815*** (3.2779)	.6121*** (4.6979)	.6098*** (4.6723)
AGE	-1.7267*** (-2.5892)	-1.7185** (-2.5601)	-.4707*** (-3.0513)	-4.695*** (-3.0702)	-1.1756* (-1.7005)	-1.1714* (-1.6900)	-.6352*** (-3.8831)	-.6591*** (-4.1198)
TOP1	.0357 (1.4392)	.0354 (1.4038)	.0083 (1.2482)	.0084 (1.2251)	.0027 (.0920)	-.0006 (-.0210)	.0033 (.4820)	.0028 (.4051)
MSH	-2.6310 (-4.721)	-2.6847 (-4.796)	.5942 (.3785)	.5873 (.3755)	-1.0012 (-4.495)	-1.0020 (-4.411)	1.0200 (.9685)	.9815 (.9697)
IB	-2.5635 (-3.484)	-2.3022 (-.3127)	.4344 (.1761)	.4482 (.1834)	-1.4543 (-2.533)	-1.7068 (-3.000)	.4268 (.3158)	.3029 (.2304)
BSIZE	3.6262 (1.2838)	3.9337 (1.3313)	.7932 (1.1640)	.8029 (1.1354)	1.4048 (.7868)	1.3665 (.6668)	.5124 (.9948)	.3718 (.7098)
DUAL	.5063 (.6464)	.5446 (.7100)	-.0512 (-.1749)	-.0488 (-.1695)	-.7233 (-1.3083)	-.7880 (-1.4199)	-.2978** (-2.5156)	-.3080*** (-2.6485)
Constant	-36.3616*** (-3.4830)	-32.2100*** (-2.8693)	-7.3216*** (-2.9910)	-7.1764** (-2.2899)	-29.1723*** (-2.9235)	-21.6652** (-2.5258)	-2.6817 (-.9055)	.3390 (.1411)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	411	411	411	411	584	584	584	584
F ²	.4666	.4699	.4531	.4532	.3835	.3872	.4187	.4264

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

institutional regulation strengthening mitigates the positive relationship between centrality and over-decoupling. Columns (3) and (4) show that the coefficients of Centrality × Post are .0032 ($p < .05$) and .0020 (insignificantly). The results indicate that, after the institutional regulation strengthening, the relationship between centrality and under-decoupling tends to be negative in some kind. The above evidence suggests that the new environmental law brings significantly exogenous shock to the relationship between board centrality and CSR decoupling.

DISCUSSION

In this paper, we examine the impact of board network centrality on CSR decoupling. To test this relationship, we use a sample

based to the Chinese capital market between 2009 and 2018. We reveal the complex role of the board network in CSR practices in China: (1) when the CSR institutional regulation is weak, board network centrality is positively related to over-decoupling but not related to under-decoupling and (2) when the regulation get strengthening, board network centrality is negatively (positively) related to over-decoupling (under-decoupling).

Theoretical Contributions

First, our study extends the extant firm-related studies based on network theory. While the existing literature has demonstrated the relationship between board network centrality and CSP, the relationship between board network centrality and CSR decoupling is not examined further. Based on evidence from the Chinese market, we suggest that due to the information

TABLE 10 | Mechanism effect of foreign investors.

Variable	Gap_over	Gap_under	Gap_over	Gap_under
	Post=0	Post=0	Post=1	Post=1
	(2009–2014)	(2009–2014)	(2015–2018)	(2015–2018)
	(1)	(2)	(3)	(4)
Centrality×Foreign	-.0027 (-.8293)	.0001 (.0414)	.0035** (2.1461)	.0025 (.6041)
Centrality	.0029* (1.7942)	-.0007 (-.6445)	-.0035*** (-2.7247)	.0010 (.4449)
Foreign	.0132 (.9687)	.0076 (.7464)	-.0247* (-1.7887)	-.0155 (-.5195)
CASH	.0025 (.3378)	.0018 (.4587)	.0021 (.7185)	.0063** (2.0199)
ROA	-.1659*** (-2.7573)	.1494*** (3.0925)	-.0386 (-.7016)	.0120 (.3718)
BTM	-.0107 (-.6955)	.0059 (.4761)	.0021 (.1228)	.0134 (.8383)
LEV	-.0164 (-1.5822)	.0397** (2.3070)	.0030 (.1847)	-.0025 (-.1897)
SIZE	.0002 (.0241)	.0011 (.2035)	-.0119*** (-3.2608)	-.0029 (-.7742)
AGE	.0013 (.1573)	-.0075 (-1.6437)	.0024 (.5713)	-.0029*** (-3.0991)
TOP1	-.0001 (-.3963)	.0001 (.9619)	-.0003 (-1.4911)	.0000 (.2675)
MSH	-.0012 (-.0221)	-.0587** (-2.5500)	-.0361* (-1.7465)	-.0337 (-.5992)
IB	.0722 (1.4211)	.0276 (.6724)	.0588 (.9422)	-.0186 (-.2253)
BSIZE	.0269 (1.2704)	.0388*** (2.9798)	.0092 (.4596)	.0152 (1.0602)
DUAL	.0042 (.2929)	.0021 (.2527)	-.0034 (-.6799)	-.0030 (-.3777)
Constant	-.0845 (-.9666)	-.0799 (-1.1698)	.3410*** (4.2373)	-.0081 (-.0812)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	455	2,571	1,590	1,113
R ²	.1977	.1492	.1672	.1850

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicates significance at the levels of 1%.

advantages of firms with high board centrality, it may enhance the symbolic management of CSR when CSR institutional regulation system is weak.

Second, our results support that the new environmental law plays an important role in strengthening CSR regulation in China. The law brings an incremental pressure on firms with high board centrality, making them to take more careful consideration about decision of CSD. Thus, the relationship between board centrality and over-decoupling (under-decoupling) turns to be negative (positive) after the adoption of the law.

Managerial Contributions

Our results show that the influence of board network centrality on CSR practices is complex in the Chinese market. Firms with higher board centrality gain stronger advantages, including social capital and so on, and are more likely to have higher

TABLE 11 | DID approach.

Variable	Gap_over	Gap_over	Gap_under	Gap_under
	All	All	All	All
	(2009–2018)	(2009–2018)	(2009–2018)	(2009–2018)
	(1)	(2)	(3)	(4)
Centrality×Post	-.0056*** (-4.3926)	-.0058*** (-4.5889)	.0032** (2.4766)	.0020 (1.4344)
Centrality	.0011 (1.1507)	.0028** (2.1437)	.0001 (.0756)	-.0007 (-.6997)
Post	.0866*** (5.7804)		-.0701*** (-3.4085)	
CASH		.0014 (.5499)		.0025 (.7920)
ROA		-.0792* (-1.7157)		.0958** (2.1542)
BTM		-.0062 (-.5832)		.0022 (.2905)
LEV		-.0063 (-1.4093)		.0227 (1.5438)
SIZE		-.0065 (-1.3818)		.0024 (.6580)
AGE		.0002 (.0676)		-.0060 (-1.6031)
TOP1		-.0003* (-1.8959)	.0000	.0001 (.6909)
MSH		-.0250 (-1.3283)		-.0579** (-2.4849)
IB		.0901** (1.9617)		.0049 (.1179)
BSIZE		.0126 (.9294)		.0322*** (3.1388)
DUAL		-.0023 (-.4665)		.0011 (.1608)
Constant	.0705*** (4.3989)	.1261 (1.4161)	.1461*** (5.7160)	-.0885 (-1.4643)
Year	No	Yes	No	Yes
Industry	Yes	Yes	Yes	Yes
N	2,045	2,045	3,684	3,684
R ²	.1206	.1844	.0828	.1645

*Indicates significance at the levels of 10%; **Indicates significance at the levels of 5%; ***Indicate significance at the levels of 1%.

CSR over-decoupling when CSR institutional regulation system is weak, but the relationship switches to negative when the system is strong. This paper reminds CSD users such as SRIs that it is necessary to pay attention to the relationship between board network centrality and symbolic management when the CSR regulation is under developed.

Limitation and Future Research

Firstly, limited by the availability of data, this paper only covers the cross-employment of directors and fails to include other types of networks, such as online networks when considering the calculation of board networks (Jing and Zhang, 2021). The solution to this problem needs the improvement of the availability of relevant data.

Moreover, our evidence is based only on the Chinese market, a special emerging market, which has a low level of legalization and public opinion supervision. These market characteristics

may affect the CSR decoupling of Chinese firms to some extent. Therefore, whether the evidence of the relationship between board network centrality and CSR decoupling is established in other markets, especially mature capital markets, requires further investigation.

Conclusion

This research examines the role of board network centrality in CSR decoupling based on network theory. Using the data of Chinese-listed firms between 2009 and 2018, it provides evidence that firms with higher board centrality may be more likely to implement symbolic strategies when the CSR regulation system is under developed, resulting in over-decoupling; but when the system get strengthening, the symbolic problem caused by higher centrality could be mitigated, meanwhile, higher pressure from regulation also makes firms with higher centrality increase under-decoupling. However, when regulatory pressure increases, they weaken the negative relationship between centrality and over-decoupling. We hope this paper could help SRIs and regulators better understand the complex impact of board networks on CSR practice. Furthermore, we suggest that the future research provide cross-country evidence about board network centrality and CSR decoupling.

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, and further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

MZ and WZ contributed to the conception and design of the study, performed the statistical analysis, and wrote the first draft of the manuscript. XL, CY, and DD organized the database and wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by National Natural Science Foundation of China (NSFC), Foundation number: 71902090 and China Postdoctoral Foundation, Foundation number: 2019M651843.

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Does the “Tian-Ren-He-Yi” Belief System Promote Corporate Environmental Performance?

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OPEN ACCESS

Edited by:

Rui Xue,
Macquarie University, Australia

Reviewed by:

Bin Li,
Beijing University of Chemical
Technology, China
Yunjing Wang,
Shandong University of Finance and
Economics, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 28 February 2022

Accepted: 28 March 2022

Published: 18 April 2022

Citation:

Lai J, Liu B and Wang H (2022) Does
the “Tian-Ren-He-Yi” Belief System
Promote Corporate Environmental
Performance?
Front. Psychol. 13:886114.
doi: 10.3389/fpsyg.2022.886114

Buddhism and Taoism are among two of the major religions in China. Their “Tian-ren-he-yi” belief system promotes a conception of harmony between man and nature, which is an important guide for the construction of ecological civilization in China. Using data from Chinese listed manufacturing companies, this paper explores the impact and mechanism of Chinese local religious beliefs on corporate environmental governance. The results indicate that this belief system can improve corporate environmental performance. Furthermore, mechanism tests show that the “Tian-ren-he-yi” belief system promotes corporate environmental practices by reducing the pressure on management to achieve economic performance goals and increasing investment in environmental protection. Finally, the impact of the belief system on corporate environmental performance is more efficacious when the enterprises are under weak external supervision. Our results imply that the traditional religious culture is an important factor that influences corporate environmental performance in Chinese business practices.

Keywords: Tian-ren-he-yi, belief system, corporate environmental performance, corporate sustainable development, local pollution prevention

INTRODUCTION

The rapid development of global industry brings a significant increase in economic growth, but it also generates lots of environmental problems, such as air pollution and water pollution. In the early stage of a country’s development, pursuing economic goals at the expense of the environment seems inevitable. A working group led by the Asian Development Bank released a report (Towards an Environmentally Sustainable Future: A National Environmental Analysis of the People’s Republic of China) noting that a large number of motor vehicles and the rapid expansion of industry have all led to a serious environmental pollution problem in China. Environmental pollution harms not only the health and wellbeing of residents, but also the sustainable development of ecology. Fortunately, the Chinese government attached great importance to this problem and actively takes corresponding measures to protect the environment. Especially after the 18th National Congress of the Communist Party of China, which occurred in 2012, the following provisions were issued in clear text, such as improving processes related to the cadre-performance appraisal system, considering the environmental impact assessments of economic development, and incorporating ecological benefits into strategic planning. We can also see that to implement these measures, enterprises at all levels as participants must strive

to meet the requirements of national economic development while emphasizing environmental protection. Corporate environmental performance has become an important indicator for evaluating ecological policy and environmental protection, and it is a critical component of constructing an ecological civilization world-wide.

The International Organization for Standardization (ISO) provides a useful tool to evaluate corporate environmental practices (e.g., ISO14031). It acknowledges differences in geographical, environmental, and technical conditions of various organizations and constructs an "environmental performance standard database" which subdivides environmental performance indicators into environmental status-indicators and environmental performance indicators. The corporate environmental performance evaluation system in China is based on it. According to our review, scholars hold a unanimous view that the relationship between corporate environmental performance and financial performance is positive. There is a temporary reduction in financial performance after a company fulfills its environmental obligations, but in the long run, environmental performance becomes a source of competitive advantage for corporations and improves their financial performance (Gallego-Alvarez et al., 2011; Paul et al., 2011; Trump and Guenther, 2017; Alexopoulos et al., 2018). Currently, scholars are increasingly focused on variables that affect corporate environmental performance, which are classified into internal and external factors. Internal factors relate to the existential characteristics of the firm such as its financial position and profitability (Angelia and Surya, 2015; Pavlos et al., 2019), and internal corporate governance factors (Williams, 2003; Deckop and Merriman, 2006; Bear et al., 2010; Barnard, 2011; Walls et al., 2012; Khan et al., 2021). External factors typically come from the government and market, such as external institutional pressure (Bradford and Fraser, 2008; Bye and Klemetsen, 2018; Ruiqian and Ramakrishnan, 2018), government regulations and subsidies (Karine and Kjetil, 2006; Christmann and Taylor, 2011; Cemoglu and Aghion, 2012; Hong et al., 2021), public opinion pressure (Yamaguchi, 2008), and the degree of competition in the product market (Zhu and Sarkis, 2007). These studies reveal factors that influence corporate environmental performance to a degree that is measurable and predictable, which implies that the environmental regulations play a role in restraining and regulating corporate actions and thus improving their environmental performance. However, researchers should note that informal systems such as religion and their cultural effects work in tandem with formal institutions to promote the progress of society. Especially considering China's current transitional context of emphasizing economic development while protecting the environment, informal institutions such as religious culture occupy an increasingly important position. As analysts, it is not being sufficient to confine ourselves to accepting, assimilating, and improving formal systems while ignoring the informal systems that have slowly developed over thousands of years of history and have had a profound impact (Allen et al., 2005). Therefore, we consider the religious and cultural dimension to corporate activities and advocates that ecological concepts (such as an ecological moral consciousness in informal systems) can be an entry point to explore the

intrinsic link between religious culture and corporate environmental performance. We expand the research on the drivers of corporate environmental performance and provide insights on how to win the battle against pollution while still promoting the construction of a prosperous ecological civilization in practice.

The empirical results demonstrate that (1) The "Tian-ren-he-yi" belief system can promote corporate environmental performance, compared with firms that do not operate on these principles. (2) The belief system promotes corporate environmental practices by reducing the pressure on management to achieve economic performance goals and increasing investment in environmental protection. (3) The belief system can serve as an informal, but beneficial, complement to existing institutions. (4) The impact of the belief system on corporate environmental performance is more efficacious when the enterprises are under weak external supervision.

Our study contributes to both theory and practice in several ways. First, we complement the literature on the influence of religion and its cultural effects on corporate business practices. Prior studies mainly focused on the relationship between religion and business ethics (Weaver and Agle, 2002; Conroy and Emerson, 2004), equity pricing (Ghoul et al., 2012), financial reporting (Dyregren et al., 2012; McGuire et al., 2012), earnings management (Callen et al., 2011), and corporate social responsibility (Zeng et al., 2016). Although some researchers have paid attention to the connection between religion, culture, and environment in the corporate sphere (Arbuckle and Konisky, 2015; Wei et al., 2017), they focus on corporate environmental investment, rather than corporate environmental performance. Our study addresses this gap and documents systematic evidence on how religious culture affects corporate environmental performance.

Second, by focusing on how the domains of cultural transmission and environmental protection intersect, we shed light on issues related to cultural and environmental protection. We also demonstrate that since religion plays an important role in human affairs, it can be used as a complementary schema to corporate governance mechanisms to regulate corporate behavior.

Third, our findings have policy implications. Punishment is not the only way to protect the environment: incorporating religious beliefs to foster and promote an environmentally friendly corporate culture is also an option.

THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

The Meaning of "Tian-Ren-He-Yi"

Chinese civilization originated from the practice of farming, which in its early days had primitive approaches and low productivity; in particular, the harvest of crops depended entirely on natural conditions such as geography and climate. Therefore, the relationship between humans and the natural environment was necessarily closer than it is in the modern era, and the early wise men were concerned with the concept of ecology nonetheless. After being developed gradually through Taoism

and Buddhism, the "Tian-ren-he-yi" belief system was integrated into the daily life of Chinese people. The understanding and advocacy of this sensitive relationship between human beings and nature constitute ecological ethics in traditional Chinese religion and culture. The basic meaning of "Tian-ren-he-yi" is summarized as follows: First, human beings and other life-forms are a part of nature (i.e., all life in the natural system has its inherent value and has the right to live). Therefore, all forms of life are equal, and human beings cannot destroy the natural habitat without considering a moral limitation. Furthermore, moral principles are consistent with the laws of nature; therefore, human beings can properly and readily resolve the relationship between their interests and the interests and development of other life-forms in the world. There is no dilemma (or dichotomy) between ecology and ethics: human beings are able to develop their interests in harmony with nature, and they ought to do so. In a phrase, it means "the nature and mankind combined as one" or "nature-human harmony" (Peng et al., 2016).

The "Tian-Ren-He-Yi" Belief System and Corporate Environmental Performance

Religious culture is the product of social norms that lead to the construction of informal systems. As such, religious culture has a measurable impact on human behavior, and it plays a macro-role in regulating society, economy, and life-processes (Williamson, 2000). Religion provides guidance and clarity for the goals and activities pursued by humankind, which shapes the mindset and behavior of the faithful (Ip, 2009). At the same time, the institutional attribute of religion fills in the behavior of humans with more specific details and regulations, thus forming an implicit and informal constraint on human behavior (and also exercising "soft power" invisibly but comprehensively; Du et al., 2015). We believe that the "Tian-ren-he-yi" belief system can influence the corporate environmental performance in the following ways:

First, the "Tian-ren-he-yi" belief system exerts the "soft power" that restrains and regulates human behavior.

The Taoist concept of "Tian-ren-he-yi" considers that man and nature are a unified "whole." Pursuit of harmonious coexistence is not a matter of applying rational thinking, but rather a matter of the way, humans experience their existence. Furthermore, human beings benefit from a commitment to harmony and charity if they wish to maintain harmony between the whole of nature and its life-forms. Taoism promotes the practice of respecting and revering nature, thus inspiring people to respect and protect nature from over-exploitation. Taoism likewise believes that all life-forms are equal so human beings should respect other life-forms and make use of them with limitation, which is a typical embodiment of ecological thought and practice. Those who kills the goose that lays the golden eggs will sink themselves and others into a boundless desire for material enjoyment that will bring them nothing but danger. Taoism firmly advocates that people take action to protect nature: The Taoist classics warn their readers that burning mountains and polluting land lead to the destruction of

vegetation. Furthermore, the classics also stipulate on how to protect land and water resources, such as not destroying mountains and rivers without restrictions; Taoism prohibits its followers from throwing any contaminants in the water. This is the fundamental idea of environmental protection.

The Buddhist concept of "Tian-ren-he-yi" holds that human beings and other life-forms are closely related, and that the individuals and their surroundings are complementary but inseparable. Furthermore, Buddhism strictly forbids its believers from harming others for their private interests. The Buddhist classics say as: "The earth has the same root of people, and all life-forms are on par with people," which is a typical expression of ecological holism through Buddhism. Buddhist beliefs firmly hold to cause-and-effect transmigration, which means that if someone treats nature recklessly and abuses natural resources, then this person will reap the consequences of their actions. The doctrine of "Tian-ren-he-yi" encourages its followers to show mercy to sentient life and to not pollute the environment, instead, humans should do more to protect the natural ecology. Buddhism is mindful of self-restraint and the reduction of material needs on the part of its followers; it is excessive greed that has led to man's unlimited desire to exploit nature.

Social norms that are formed by religion's interaction with human culture can be considered factors that affect the behavior of individuals within each religious or cultural domain (Conroy and Emerson, 2004; Ghoul et al., 2012). As a part of religious culture, the belief system has deep impact on its believers. Such an eco-ethical notion can promote environmental values within corporations and increase the importance of environmental issues to decision makers. We believe that increased environmental awareness will motivate companies to propose protections that are beneficial to the environment and ultimately improve their environmental performance. Based on the "social identity theory," the social norms originated and conducted by religions can lead to group-level common behaviors (Tajfel, 1986), that is to say, the norms in the groups greatly shape individual characteristics. McGuire et al. (2012) also argued that, regardless of whether the executives believe in religion, religion has influence on their attitudes, judgments, and decisions. Even if they were not religious believers in the enterprise, the "Tian-ren-he-yi" belief system can put external pressure on companies by fostering public advocacy campaigns and creating a regional cultural environment that is conducive to ecological thinking. Companies are bound to adopt environmental values to gain social acceptance, which affects their environmental performance.

Second, the "Tian-ren-he-yi" belief system exerts a "better vision," which demonstrates the excitation power of religious culture.

Both Buddhism and Taoism describe an ideal notion for their believers to advocate. The ideal as described by Buddhism is that the follower will find nirvana and achieve paradise after the end of life: the paradise is orderly, beautiful, and peaceful. The ideal as described by Taoism is that the followers of Taoism enter an immortal world after practicing their discipline: a world in which there are no worries but only happiness and ecological

balance. The religious culture encourages the believers to act conscientiously and work hard during their life in order to cultivate themselves to attain righteousness and enter the Elysian Fields. At the same time, the believers are encouraged to commit to the vision of "an earthly paradise" and build a better world through their efforts when they are in this life on Earth (Cooper and James, 2017). We believe that the concepts of environmental protection and restoration of damaged ecosystems (which are promoted by Buddhism and Taoism) will motivate companies to increase their environmental protection efforts and increase their investment in green technology. These actions ultimately promote the environmental performance of companies.

Based on the above exposition, we formulate the following hypothesis 1:

H1: Ceteris paribus, the "Tian-ren-he-yi" belief system promotes better corporate environmental performance.

RESEARCH DESIGN

Variables

Corporate Environmental Performance

Corporate environmental performance (CEP) refers to the effects and accomplishments of business activities on account of environmental protection and controls of pollution. In the existing literature, the measurement of corporate environmental performance is done through a series of approaches called the evaluation-system method, the pollution emission method, the environmental capital expenditure method, and the eco-efficiency method. The latter three measurement approaches are comparatively limited and cannot provide a complete evaluation of corporate environmental performance, so this paper utilizes the evaluation-system method. Specifically, this paper comprehensively measures corporate environmental performance in the following eight aspects: (1) whether the company has developed or applied innovative products, equipment, or technologies that are beneficial to the environment. (2) Whether the company has policies, measures, or technologies to reduce emissions of waste gas, wastewater, waste residue, and greenhouse gases. (3) Whether the company uses renewable energy or adopts policies or measures for a circular economy. (4) Whether the company has energy-saving policies or technologies. (5) Whether the company has green office policies or measures. (6) Whether the company's environmental management system has passed ISO 14001 certification. (7) Whether the company has received environmental recognition or other positive evaluation. (8) Whether the company has other advantages in environmental aspects that are not covered in the above indicators. If a condition is satisfied for the items above, the item is assigned a value of 1 or otherwise a value of 0. All scores are summed, and the higher the score, the better the CEP.

Measurement of Religious Culture ("Tian-Ren-He-Yi" Belief System)

There are several ways to measure religiosity according to the existing literature: first, the percentage of the religious population in the region (Dyreg et al., 2012); second, the number of

religious places *per capita* (Ghoul et al., 2012); third, regional religious participation as based on questionnaires (McGuire et al., 2012); and fourth, the number of worship places around the company (Du, 2013). On the other hand, there is often a lack of open and uniform information on the characteristics, distribution, and religious participation of populations within administrative regions in China (Du, 2013). Therefore, we use the number of worship places (Buddhist and Taoist monasteries) in the same city as listed companies in order to quantify religiosity at the firm-level (i.e., as to overcome the lack of available statistics). Specifically, the locations of key Buddhist and Taoist temples were manually collected and matched with the registered locations of listed companies based on the "Report on the Identification of Key Buddhist and Taoist Temples in Han Areas Nationwide" issued by the People's Republic of China on April 9, 1983. On this basis, a firm-level religious impact index was calculated.

Other control variables include Growth rate, Lnsiz, return on assets (RoA), enterprise value (Tbq), tangible asset ratio (Tang), and other factors that affect corporate environmental performance. Specific variables were defined as shown in Table 1.

Data and Sample Selection

We used a research sample that includes all Chinese A-share listed manufacturing companies whose information was printed from 2008 to 2018. We used the following parameters to screen the sample: (1) we excluded companies from firm-year observations that have transaction statuses of special treatment (ST), suspension from trading (*ST), or particular transfer (PT). (2) We removed companies from firm-year observations if any variables in the main regression model are missing. The final sample consists of 6,346 firm-year observations. The financial data used in this paper were obtained from the CSMAR database, and the religious data were collected manually based on the Report on the Identification of National Key Buddhist and Taoist Temples in Han Areas that was issued by the People's Republic of China on April 9, 1983. All of the continuous variables listed are winsorized at the 1% level.

TABLE 1 | Variable definitions.

Variables	Definitions
CEP	The natural logarithm of the total scores calculated based on the evaluation of the firm's environmental protection behavior and effectiveness
REC	The natural logarithm of the number of Taoist and Buddhist temples in the city where the listed companies are registered
Lnsiz	The natural logarithm of company's total assets
Tbq	(Current market value + non-current market value + book value of liabilities)/book value of assets
RoA	The ratio of earnings before interest and tax (EBIT) to total assets
Lev	The ratio of total liabilities to total assets
Growth	$(t\text{-stage Total assets} - t\text{-1stage Total assets}) / (t\text{-1stage Total assets})$
Tang	(net fixed assets + sum of inventories)/total assets
Top1	The shareholding ratio of the largest shareholder in year t
Esu	The natural logarithm of analysts who analyze the company in the current year
Reg	The score of urban pollution regulatory information disclosure index

Empirical Models

To test hypothesis H1, we construct the following model by referring to Clarkson et al. (2008) and Walls et al. (2012):

$$\begin{aligned} CEP_{i,t} = & \alpha_0 + \alpha_1 REC_{i,t} + \alpha_2 Lnsiz_{i,t-1} + \\ & \alpha_3 Tbq_{i,t-1} + \alpha_4 Roa_{i,t-1} + \alpha_5 Lev_{i,t-1} + \\ & \alpha_6 Growth_{i,t-1} + \alpha_7 Tang_{i,t-1} + \\ & \alpha_8 Top1_{i,t-1} + \alpha_9 Esu_{i,t-1} + \\ & \alpha_{10} Reg_{i,t-1} + \sum Ind + \sum Year + \varepsilon_{i,t} \end{aligned} \quad (1)$$

In the above model, the dependent variable CEP is a proxy variable for the level of corporate environmental performance, the independent variable REC is a proxy variable for the degree of religious and cultural influence. In this model, industry and year-effects are controlled and ε is the residual. The regression coefficient α_1 indicates the degree of influence of religious culture on corporate environmental performance. If α_1 is positive and statistically significant, it indicates that the "Tian-ren-he-yi" belief system promotes better corporate environmental performance.

EMPIRICAL RESULT

Descriptive Statistics

Table 2 reports the descriptive statistics for all variables that were used in this study. As shown in Table 2, the average of CEP is 1.292, which contains a minimum value of 0 and a maximum value of 2.079, thus indicating that corporate

environmental performance can be improved. REC had an average value of 2.935, a minimum of 0, a standard deviation of 0.925, and a maximum of 4.771. The relatively large SD of REC indicates that there is a wide variation in the distribution of religious culture, which forms the basis for our study. The remaining variables are not further described.

Pearson Correlation

Table 3 lists the Pearson correlation coefficients of major variables. The results show that the correlation coefficients between CEP and REC are positive such that they are statistically significant at the 5% level.

Hypotheses Test

The previous hypothesis predicted that a religious culture that promotes "Tian-ren-he-yi" will improve corporate environmental performance. Table 4 reports the OLS regression results. To address a concern about potential serial correlation problems associated with unbalanced panel data, we computed and reported all t -values using robust SEs adjusted for clustering at the firm-level.

As shown in column (1), the coefficient of REC is positive such that it is statistically significant at the 5% level. When a series of relevant control variables are added, the regression coefficient of REC remains positive and statistically significant at the 1% confidence level (column 2). This indicates that religious culture improves corporate environmental performance and that the more Buddhist and Taoist monasteries in where the firm is registered, the better environmental performance there will be, verifying Hypothesis 1.

TABLE 2 | Sample selection and sample distribution.

Variables	Mean	SD	Min	Median	P75	Max
CEP	1.292	0.475	0	1.386	1.609	2.079
REC	2.935	0.925	1.091	3.045	3.638	4.771
Lnsiz	23.043	1.462	13.786	22.875	23.932	26.229
Tbq	2.011	1.439	0.851	1.565	2.290	31.122
Roa	0.043	0.062	-0.618	0.037	0.068	0.429
Lev	0.492	0.200	0.101	0.504	0.640	0.996
Growth	0.179	0.387	-0.362	0.107	0.229	3.072
Tang	0.244	0.188	-0.206	0.202	0.362	0.621
Top1	0.392	9.913	0.124	0.375	0.442	1
Esu	2.328	0.791	0.693	2.397	2.891	4.159
Reg	3.940	0.315	2.398	4.011	4.174	4.396

TABLE 3 | Pearson correlation.

Variables	CEP	REC	Lnsiz	Tbq	Roa	Lev	Growth	Tang	Top1
CEP	1.000								
REC	0.062***	1.000							
Lnsiz	0.299***	-0.037***	1.000						
Tbq	-0.169***	0.006	-0.264***	1.000					
Roa	0.010	-0.008	0.031***	0.076***	1.000				
Lev	0.142***	-0.016***	0.223***	-0.125***	-0.385***	1.000			
Growth	-0.034***	-0.002	0.123***	0.004	0.188***	-0.021***	1.000		
Tang	0.127**	0.013***	0.098***	-0.010**	-0.053***	0.052**	-0.091***	1.000	
Top1	-0.030**	0.012**	0.122***	0.111***	0.056***	-0.019***	0.041***	-0.060***	1.000

, * represent significant at the 5%, and 1% significance level, respectively.

TABLE 4 | The linear model regression results.

Variables	CEP (1)	CEP (2)
REC	0.013** (2.08)	0.018*** (2.85)
Lnsizes		0.112*** (20.79)
Tbq		-0.005 (-1.17)
Roa		0.017** (2.29)
Lev		-0.003 (-0.09)
Growth		-0.003*** (-4.31)
Tang		0.052 (1.18)
Top1		0.033 (0.84)
Esu		0.007 (0.87)
Reg		0.070*** (3.22)
_Cons	0.663*** (4.46)	-1.969*** (-9.69)
Year FE	Yes	Yes
Ind FE	Yes	Yes
N	6,346	6,346
Adj_R2	0.14	0.21

** and *** represent significant at the 5 and 1% significance level, respectively. *t* values are provided in parentheses.

Endogenous Discussion

During the Qing Dynasty, the Confucian classics became the official textbook for the imperial examinations, and the scholars naturally became the propagators of "Tian-ren-he-yi" belief system. In the Qing Dynasty, the printing and publication of books were basically carried out by the official printing bureaus. Due to the imbalance of the geographical distribution of the official printing bureaus and the inconvenient transportation, there were differences in the circulation of books in different regions, and thus, there were differences in the dissemination of the "Tian-ren-he-yi" belief system. After entering modern society, these printing bureaus were closed down due to the impact of advanced Western publishing technologies. Therefore, there is no direct relationship between these printing bureaus and the corporate environmental performance, satisfying the conditions of correlation and exogeneity. So we add the official printing bureaus (OPB) of the Qing Dynasty as the instrumental variable. According to the test results in **Table 5**, there is a positive correlation between instrumental variables and explanatory variables, at the 1% confidence level, predictive explanatory variables and explained variables are also significantly and positively correlated, which indicates that religious culture can promote corporate environmental performance.

Robustness Test

The model was regressed by staggering control variables at stages to exclude control variables from playing a determinant role in the regression results. To further ensure the reliability of the main findings and to avoid conclusions formed by pure chance, we performed the following robustness tests.

Constructing the Differential Model (DID)

The impact of religious culture on corporate environmental performance can be inflected by capturing the changes in the environmental performance after a firm's registration place migrates from an area of low religiosity to an area of high religiosity. Since the migration of firms' registration place occurs in multi-batch and multi-year instances, this paper will utilize the dummy

TABLE 5 | Regression results of instrumental variables.

Models\Variables	1st stage	2nd stage
	REC	CEP
REC		0.066*** (5.21)
OPB	0.930*** (52.39)	
Lnsizes	-0.034*** (-3.42)	0.115*** (21.16)
Tbq	-0.017** (-2.23)	-0.003 (-0.75)
Roa	0.032*** (2.43)	0.013* (1.90)
Lev	0.178*** (2.72)	-0.009 (-0.26)
Growth	0.004 (0.52)	-0.003*** (-4.07)
Tang	-0.015 (-0.20)	0.053 (1.22)
Top1	-0.002*** (-3.19)	0.056 (1.42)
Esu	0.074*** (5.58)	0.004 (0.06)
Reg	-1.152*** (-28.19)	0.110*** (4.62)
_Cons	7.243*** (22.44)	-2.283*** (-10.30)
Year FE	Yes	Yes
Ind FE	Yes	Yes
N	6,346	6,346
Adj_R2	0.35	0.28
Shea's partial R2	0.16	
F		623.26

t values are provided in parentheses.

*represents significant at the 10% significance level.

**represents significant at the 5% significance level.

***represents significant at the 1% significance level.

variable Migration so as to highlight the migrated companies. Specifically, regions are divided into two groups that are based on the level of religiosity: if a firm's place of incorporation has migrated from a location of low religiosity to a location of high religiosity previously or in the current year, its dummy variable Migration is then marked with a value of 1, otherwise its Migration is marked 0. According to the premise of the difference-in-differences (DID) method, the dummy variable Migration can effectively capture the net-change in corporate environmental performance after the place of registration changes from a location with low religiosity to a location with high religiosity. The regression results of the DID model are reported in **Table 6**. As shown in column (1), the regression coefficient of Migration is positive and significant at the 5% confidence level. This further demonstrates that religious culture contributes to the improvement of corporate environmental performance.

Replacing the Regression Method (Tobit)

Since some of the explanatory variables in the sample have zero values, we use the Tobit regression model to retest the effect of religious culture on corporate environmental performance. The results are reported in **Table 6**. As shown in column (2), we find that the regression coefficient of REC is still positive such as to be statistically significant after replacing the regression method. The conclusion that religious culture improves corporate environmental performance is still valid.

FURTHER ANALYSIS

Possible Mechanisms

We have demonstrated the positive effect of religious culture on corporate environmental performance. In this section,

TABLE 6 | Robustness test results.

Models/Variables	DID	Tobit
	CEP (1)	CEP (2)
REC		0.096*** (4.21)
Migration	0.222** (1.98)	
Lnszize	0.087*** (17.67)	0.362*** (19.74)
Tbq	-0.015*** (-3.29)	-0.056*** (-3.87)
Roa	0.033*** (4.34)	0.141*** (4.86)
Lev	-0.027 (-0.79)	-0.193 (-1.64)
Growth	-0.003*** (-2.99)	-0.008* (-1.79)
Tang	0.252*** (7.87)	0.734*** (6.48)
Top1	-0.001 (-0.46)	-0.001 (-0.90)
Esu	0.030*** (3.90)	0.108*** (4.14)
Reg	0.029 (1.37)	0.227*** (3.43)
_Cons	-1.263*** (-6.97)	-6.48*** (-14.30)
Year FE	Yes	
Ind FE	Yes	
Firm FE	Yes	
N	6,346	6,346
Adj_R2/Pseudo R2	0.13	0.05

t values/*z* values are provided in parentheses.

*represents significant at the 10% significance level.

**represents significant at the 5% significance level.

***represents significant at the 1% significance level.

we discuss the underlying mechanisms by which religion improves corporate environmental performance.

The rising global competition demands corporates to be more economically competitive. Meanwhile, the natural environment seems to deteriorate around the world and protecting the environment demands more attention. Obviously, both economic performance and environmental performance are important (Porter and Kramer, 2011). The dilemma is as: How do firms reconcile these different performance dimensions? If the corporations have only embraced an economically oriented strategy, in their pursuit for economic performance, they end up significantly polluting the environment. In existing studies, scholars have confirmed that corporate executives will overinvest in their companies under the pressure of meeting economic performance indicators (Kuusela and Maula, 2016). The long-term consequence of overinvestment is to ensure competition for natural resources and bring pollution and destruction to the environment. The "Tian-ren-he-yi" belief system insists that believers ought to understand the laws of nature and master moral limits when using natural resources. It avoids the polarization of dangerous extremes, such as too much emphasis on human needs or too little emphasis on the environment. This "ecological ethical connotation" will inevitably guide the behavior of believers and alleviate the utilitarian pursuit of economic benefits by the shareholders of companies (i.e., at the expense of the environment), thus relieving management of pressure to meet environmental performance indicators. At the same time, the "Tian-ren-he-yi" belief system shapes a corporate culture that promotes environmental protection and reduces the disagreement and friction among stakeholder parties in protecting the environment. In this way, corporations will respond more positively to ecological protection and make decisions that are friendly to the environment, such as by

TABLE 7 | Mechanism test results.

Variables	Management performance pressure		Corporate environmental investment	
	High	Low	Less	More
	CEP (1)	CEP (2)	CEP (3)	CEP (4)
REC	0.021** (2.47)	0.014 (1.52)	0.016* (1.94)	0.019 (1.32)
Lnszize	0.111*** (15.70)	0.112*** (13.13)	0.107*** (14.83)	0.118*** (13.96)
Tbq	-0.003 (-0.57)	-0.003 (-0.45)	-0.003 (-0.41)	-0.006 (-1.02)
Roa	0.194 (1.20)	0.014 (1.11)	0.013 (1.21)	0.154 (0.82)
Lev	0.027 (0.57)	-0.018 (-0.32)	-0.002 (-0.05)	0.008 (0.16)
Growth	-0.003*** (-5.48)	-0.009 (-1.42)	-0.002*** (-4.17)	-0.007 (-1.63)
Tang	0.113* (1.93)	-0.010 (-0.15)	-0.021 (-0.38)	0.156** (2.20)
Top1	0.001 (0.45)	0.000 (0.77)	0.001 (1.09)	-0.001 (-1.10)
Esu	0.009 (0.86)	0.002 (0.15)	0.010 (0.96)	0.006 (0.49)
Reg	0.100*** (3.37)	0.035 (1.11)	0.051* (1.87)	0.100*** (2.77)
_Cons	-2.102*** (-7.07)	-1.759*** (-6.17)	-1.817*** (-7.85)	-2.089*** (-5.39)
Year FE	Yes	Yes	Yes	Yes
Ind FE	Yes	Yes	Yes	Yes
N	3,680	2,666	3,776	2,570
Adj_R2	0.22	0.21	0.22	0.27

t values are provided in parentheses.

*represents significant at the 10% significance level.

**represents significant at the 5% significance level.

***represents significant at the 1% significance level.

increasing investment in environmental protection in order to improve their environmental performance.

To verify the mechanisms, we follow Ma et al. (2019) to classify firms into two groups according to management economic performance pressure and regress them separately. A firm is defined as being in the group with high pressure if the firm's average price-to-earnings ratio predicted by analysts is greater than the predicted annual industry median. The regression results are listed in **Table 7**. As shown in columns (1) and (2), the regression coefficient of REC is significantly positive only in the group with high pressure. It indicates that the impact of the belief system on corporate environmental performance is partly channeled by alleviating the pressure of management performance. Moreover, we also classify firms into two groups according to corporate environmental investment and regress them separately. The regression results are listed in **Table 7**. As shown in columns (3) and (4), the regression coefficient of REC is significantly positive only in the group with less corporate environmental investment. It indicates that the impact of the belief system on corporate environmental performance is partly channeled by increasing corporate environmental investment. To sum up, the "ecological ethics" contained within the traditional Chinese religions of Buddhism and Taoism alleviates the pressure of performance on the part of executives to reduce degradation to the environment through external regulation. At the same time, ecological ethics also help to increase the firms' environmental investment in order to repair the natural environment (i.e., through internal regulation). The two channels work together to improve the corporate environmental performance.

The "Tian-Ren-He-Yi" Belief System and Corporate Environmental Performance: An Analysis Based on the Intensity of Regulations and External Supervision

Williamson (2000) documents four levels of "Social Analysis," in which religion lies in the first and embedded level, the governance structures with transactions in third. Generally speaking, religion complements market governance mechanism. The introduction of external supervision can act as a restraint on management behavior through reputation maintenance and pressure mechanisms. When the intensity of external supervision increases, when a company has environmental problems, they can be easily detected and quickly transmitted to the outside world, thus damaging the company's image and social reputation. To save corporations reputations, executives are bound to pay attention to environmental protection and make moves to improve corporate environmental performance. That is, external monitoring can weaken the role of religious culture in improving corporate environmental performance. Du et al. (2015) also show that religiosity can curtail unethical behaviors of managers, while this relationship is attenuated for firms with better external monitoring mechanisms. As an important information intermediary in the capital market, analysts play an important role in external supervision, and analysts' attention to companies is an important supervisory force. Therefore, this paper classifies firms into two groups according to analysts' concerns as being subject to strong and weak external monitoring, and we regress them separately. A company is defined as being in the group with stronger external oversight if the number of analysts it follows is greater than the median industry-annual number of analysts who follow it. The regression results are listed in **Table 8**. As shown in columns (1) and (2), the regression coefficient of REC is significantly positive only in the group with weak external oversight. It indicates that the impact of the belief system on corporate environmental performance is more efficacious when the enterprises are under weak external supervision.

Both formal and informal systems are fundamental parts of the disciplinary approach in management, which plays an important role in the behavior and decision making of senior staff. Their decisions may be complementary or alternative to the goal of environmental preservation. In reality, the reasons for why companies improve their environmental performance are complex. They may choose to follow their ethical values or implement policies passively under the pressure of the institutional environment or because of social norms. In areas with strong environmental regulations, the formal legal system will force executives to take effective actions to improve corporate environmental performance. In this case, the role of religious culture in improving corporate environmental performance may be weakened. Therefore, we complete a further analysis to investigate the differences between the two types of regulatory environments. The Urban Pollution Regulatory Information Disclosure Index (PITI) is jointly developed by the Institute of Public and Environmental Affairs (IPE) and the Natural Resources Defense Council (NRDC). The index can effectively reflect the institutional

TABLE 8 | Heterogeneity analysis results.

Variables	External supervision		Environmental regulation	
	Weakly	Strongly	Weakly	Strongly
	CEP (1)	CEP (2)	CEP (3)	CEP (4)
REC	0.020** (2.10)	0.014 (1.64)	0.027*** (2.93)	0.014 (1.50)
Lnsizes	0.099*** (10.29)	0.115*** (15.99)	0.118*** (15.72)	0.106*** (13.34)
Tbq	-0.001 (-0.11)	-0.011* (-1.66)	-0.002 (-0.36)	0.001 (0.14)
Roa	0.008 (0.90)	0.159 (1.06)	0.012 (1.15)	0.303* (1.67)
Lev	-0.038 (-0.64)	0.062 (1.37)	0.038 (0.82)	-0.014 (-0.26)
Growth	-0.003*** (-4.12)	-0.011 (-1.21)	-0.003*** (-4.57)	-0.004 (-0.99)
Tang	0.080 (1.15)	0.012 (0.20)	0.034 (0.50)	0.053 (0.90)
Top1	0.001 (0.52)	0.001 (1.09)	-0.001 (-0.62)	0.001 (1.52)
Esu			0.006 (0.58)	-0.002 (-0.18)
Reg	0.098*** (2.88)	0.047* (1.66)		
_Cons	-1.698*** (-5.78)	-2.032*** (-7.22)	-1.625*** (-6.94)	-1.388*** (-7.48)
Year FE	Yes	Yes	Yes	Yes
Ind FE	Yes	Yes	Yes	Yes
N	2,995	3,351	3,249	3,097
Adj_R2	0.17	0.26	0.26	0.18

t values are provided in parentheses.

*represents significant at the 10% significance level.

**represents significant at the 5% significance level.

***represents significant at the 1% significance level.

constraints represented by the central government's environmental surveillance, including its supervision by the Ministry of Ecology and Environment. We divided the firms into strongly and weakly regulated groups and conducted regression analyses on each group. The regression results are listed in **Table 8**. As shown in columns (3) and (4), the regression coefficient of REC is positive and statistically significant only in areas with weak regulation, which indicates that the effect of religious culture on improving corporate environmental performance is stronger in areas with weak regulation. The conclusion from this observation implies that religious culture serves as an important and implicit alternative governance mechanism that compensates for formal institutions when they are inadequate.

The "Tian-Ren-He-Yi" Belief System and Corporate Environmental Performance: An Analysis Based on CEO's Heterogeneity Characteristics

The upper echelon theory shows that age, educational background, and other characteristics effectively reflect people's values and cognitive basis, and these values and cognitive basis will further affect people's decision-making behavior (Hambrick and Mason, 1984). The spread and penetration of religious culture are a slow process, and it takes time to influence believers. So as CEOs get older, religious culture influences them more. The rich life experiences of older CEOs enable them to have a deeper understanding of "Tian-ren-he-yi" belief system, which makes them more willing to

TABLE 9 | Heterogeneity analysis results of corporate executives.

Variables	Age of CEO		Educational background of CEO	
	Old	Young	Poor-educated	Well-educated
	CEP (1)	CEP (2)	CEP (3)	CEP (4)
REC	0.031*** (3.31)	0.011 (1.26)	0.032*** (3.56)	0.001 (0.16)
Lnsiz	0.118*** (15.24)	0.101*** (12.26)	0.130*** (16.42)	0.094*** (11.53)
Tbq	0.001 (0.17)	-0.007 (-1.21)	-0.005 (-0.61)	-0.007 (-1.33)
Roa	0.007 (0.54)	0.338** (2.12)	0.018 (1.39)	0.515*** (3.34)
Lev	-0.025 (-0.45)	0.020 (0.41)	0.067 (1.36)	-0.013 (-0.23)
Growth	-0.002*** (-4.19)	-0.003 (-0.69)	-0.002*** (-3.78)	-0.011* (-1.66)
Tang	0.041 (0.68)	0.071 (1.07)	0.008 (0.11)	0.162*** (2.75)
Top1	0.001 (0.89)	0.001 (0.71)	0.001*** (2.61)	-0.001* (-1.76)
Esu	-0.004 (-0.36)	0.015 (1.35)	-0.011 (-0.98)	0.021* (1.92)
Reg	0.086*** (2.85)	0.033 (1.03)	0.074** (2.34)	0.064** (2.16)
_Cons	-2.092*** (-7.99)	-2.032*** (-7.22)	-2.442*** (-8.73)	-1.352*** (-4.08)
Year FE	Yes	Yes	Yes	Yes
Ind FE	Yes	Yes	Yes	Yes
N	3,145	3,201	3,163	3,183
Adj_R2	0.23	0.22	0.24	0.22

t values are provided in parentheses.

*represents significant at the 10% significance level.

**represents significant at the 5% significance level.

***represents significant at the 1% significance level.

invest in corporate environmental governance. Being well-educated means that CEOs generally have a more complete body of knowledge that can shape better values and guide them to fulfill their corporate social responsibility in a more active way (Slater and Dixon-Fowler, 2010). And environmental protection is part of corporate social responsibility. Therefore, we believe that well-educated CEOs will spontaneously improve corporate environmental performance. That is, the educational background will weaken the role of religious culture in improving corporate environmental performance. We complete a further analysis to investigate how the different ages and education work in the relationship between religious culture and corporate environmental performance. We divided the firms into old age, Young age, Poor-educated, and well-educated four groups, and conducted regression analyses on each group. The regression results are listed in **Table 9**. As shown in columns (1) and (2), the regression coefficient of REC is positive and statistically significant only in the group with old ages, which indicates that the effect of religious culture on improving corporate environmental performance is stronger when the CEO with old age. As shown in columns (3) and (4), the regression coefficient of REC is significantly positive only in the group with poor-educated. It indicates that the educational background will weaken the role of religious culture in improving corporate environmental performance.

SUMMARY AND CONCLUSION

This paper explores the effects and mechanisms of religious culture (namely: "Tian-ren-he-yi" in Buddhism and Taoism) on corporate environmental performance in China. The empirical

results indicate that the "Tian-ren-he-yi" belief system can improve corporate environmental performance. Furthermore, the "Tian-ren-he-yi" belief system promotes corporate environmental practices by reducing the pressure of management on achieving economic performance goals and increasing investment in environmental protection. We also find that the belief system can serve as an informal, but beneficial, complement to existing institutions. Finally, the impact of belief system on corporate environmental performance is more efficacious when the enterprises are under weak external supervision. By focusing on how the domains of cultural transmission and environmental protection intersect, we expand the research on the drivers of corporate environmental performance and provide insights on how to win the battle against pollution while still promoting the construction of a prosperous ecological civilization in practice. We also demonstrate that religion plays an important role in human affairs.

The findings of this paper suggest that the traditional religious culture of China improves the corporate environmental performance in Chinese business practices. Therefore, scholars and researchers should evaluate religious culture more comprehensively, rationally, and objectively when they are promoting sensible environmental policy that is specific to a region or nation. As an effective supplement to formal organizations and institutions, soft "restraining" forces such as religious culture plays an important governance and regulatory role; this indicates that it is feasible to draw wisdom from a traditional religious culture in order to solve environmental problems in contemporary times. While actively creating a legal environment that supports sensible environmental planning, the government should also consider the role of supervision that traditional religious culture plays in environmental performance. It is necessary for corporations to actively organize

environmental activities and transform a rich ecological theory into a part of lived-corporate culture. Human beings ought to take multiple measures—and to make the necessary efforts—to create a comfortable living space for ourselves and our offspring.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found at: <https://cn.gtadata.com/>.

AUTHOR CONTRIBUTIONS

BL and HW contributed to conception and design of the study and reviewed and revised the draft critically for important

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intellectual content. JL organized the database, performed the statistical analysis, and wrote the first draft of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This research is supported by the Natural Science Foundation of Zhejiang Province (LQ20G020006).

ACKNOWLEDGMENTS

We are very thankful to the respected editor and reviewers for their insightful comments and suggestions which helped us to improve the overall impression of this study.

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Green Credit Policy and Corporate Stock Price Crash Risk: Evidence From China

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Using the promulgation of *Green Credit Guidelines* in China as the research setting, this paper exploits a quasi-natural experiment to examine the impact of green credit policy on the stock price crash risk of heavy-polluting firms. The results show that green credit policy significantly increases the risk of stock price crash of heavy-polluting firms. Such impact is transmitted through increased financial constraints and reduced information transparency. In addition, we find that the impact of green credit policy on the stock price crash risk is more pronounced in firms with weak external governance and a small size. Our findings provide policy implications for mitigating corporate risks and promoting corporate sustainability.

OPEN ACCESS

Edited by:

Shiyang Hu,
Chongqing University, China

Reviewed by:

Di Bu,
Macquarie University, Australia
Chao Zhong,
Beijing Normal University, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 07 March 2022

Accepted: 28 March 2022

Published: 25 April 2022

Citation:

Zhang W, Liu Y, Zhang F and
Dou H (2022) Green Credit Policy
and Corporate Stock Price Crash
Risk: Evidence From China.
Front. Psychol. 13:891284.
doi: 10.3389/fpsyg.2022.891284

Keywords: green credit policy, stock price crash risk, financial constraints, information transparency, corporate sustainability

INTRODUCTION

The global sustainable development goals emphasize the urgency of environmental governance (Clark, 2018; Sun et al., 2019). Environmental regulation has become a common means for balancing economic and environmental development. As a vital aspect of environmental regulation, green credit policy (GCP) has a greater influence than other green financial policies such as green bonds, green insurance, and green crowdfunding policy (Wu and Yin, 2021). The definition of “green credit” is based on the Equator Principles established in 2002 by the International Finance Corporation (IFC) and ABN AMRO Bank, which, although not legally binding, has become a new standard in international project financing. Green credit is gaining popularity as a tool for environmental protection and corporate development. By 2020, 113 financial institutions across 37 countries have recognized the Equator Principles. In China, the green credit policy has also been refined: in 2007, the *Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks* included green credit policies for the first time, and in 2012, the *Green Credit Guidelines* laid out more specific and detailed requirements (Zhang et al., 2011; Wang et al., 2019). By 2021, China’s balance of green credit has grown to RMB159,000 yuan, according to the People’s Bank of China. GCP involves a set of policies and institutional arrangements aimed at restricting the flow of credit to heavy-polluting firms while increasing the flow of credit to non-heavy-polluting firms that participate in environmental and

energy-saving projects through loan products, loan terms, loan interest rates and loan limits, which ultimately influences firms' environmental behaviors (Nandy and Lodh, 2012; Wen et al., 2021). Prior research shows that GCP incentivizes heavy-polluting firms to innovate and reform (Wang and Wang, 2021), as well as improve productivity (Zhang, 2021) and resource allocation (Zhou et al., 2021). From the perspective of corporate behavior, Liu et al. (2021) find that "green" commitment lowers a firm's stock price crash risk. In terms of green credit regulation, Fan et al. (2021) discover that GCP has a significantly positive impact on the loan interest rates, loan size and financing costs of non-heavy-polluting firms, but a significantly negative impact on heavy-polluting firms. However, there is no systematic analysis on the relationship between GCP and stock price crash risk in the existing literature. Research on this issue has important implications for mitigating the financial risks of capital markets and maintaining stock market stability.

Stock price crashes damage a firm's value and cause loss of wealth for investors. Corporate sustainability and stock market stability will also be jeopardized. Since the outbreak of the global financial crisis in 2008, "stock price crash risk" has been one of the focal points of academic discussions (Zhang et al., 2021; Kang et al., 2022; Tian et al., 2022a). On the one hand, principal-agent and information asymmetry theories suggest that stock price crashes occur as a result of managers concealing bad news about the firm. This behavior leads to information asymmetry between investors and the firm. On the other hand, with the implementation of the GCP, the risk of loan default of heavy-polluting firms has increased, forcing banks and other financial institutions to cut loan sizes and tighten financing constraints for these firms to mitigate the risk. The tightened financing constraints thus increases the stock price crash risks of heavy-polluting firms. Therefore, we believe that GCP influences stock price crash risk through two channels: corporate financial constraints, which can be measured by corporate loan size, corporate loan cost, and the SA index (Hadlock and Pierce, 2010; Yao et al., 2021), and information transparency, which can be measured by common financial reporting quality indicators like earnings quality (DD), corporate disclosure score (DSCORE), number of analysts following (ANALYST) and analysts' earnings forecast accuracy (ACCURACY) (Graham et al., 2005; Huddart et al., 2009).

Information asymmetry or opacity is one of the main causes of stock price crashes (Gaspar et al., 2005; Piotroski et al., 2015). The key factors influencing corporate information transparency include conflicts of interest between managers and shareholders (Jin and Myers, 2006; Kim et al., 2011a,b), media coverage quality (Fang and Peress, 2009; Zou et al., 2019), and audit quality (Bleck and Liu, 2007). For self-serving purposes, managers may selectively disclose information about the firm and conceal bad news, limiting information transparency and making it harder for outside investors to assess genuine corporate performance in a timely manner. When bad news builds up to a particular point before being revealed to the market, it can be a fatal blow to the firm's stock performance and potentially lead to a stock price crash (Jin and Myers, 2006; Hutton et al., 2009; Kim and Zhang, 2016). Meanwhile,

GCP has a negative impact on the information transparency of heavy-polluting firms, which in turn increases their risk of price crashes. As GCP severely restricts the flow of credit to heavy-polluting firms, these firms are more prone to conceal bad news or obfuscate information in order to circumvent the policy restrictions (Eiler et al., 2015; Wang et al., 2015; He et al., 2019).

China provides the ideal research setting for exploring the impact of GCP on stock price crash risk (Su et al., 2020; Wan et al., 2021). On the one hand, it is the world's largest carbon emitter, and environmental issues have become a major concern for both the government and the general public (Xue et al., 2021; Liu et al., 2022; Tian et al., 2022b; Zhai et al., 2022). In recent years, China has taken a number of environmental initiatives, including a target to peak CO₂ emissions by 2030 and achieve carbon neutrality by 2060, which was declared during the 75th UN General Assembly in 2020. On the other hand, the introduction of *Green Credit Guidelines* in 2012 is an exogenous and firm-independent event for Chinese firms, which provide an ideal context for a quasi-natural experiment. Using China as the research setting is consistent with our research hypotheses. Finally, the escalating environmental issues in China resulting from its rapid economic development catalyzed the promulgation of green credit policy. Therefore, the policy aims to reform the high energy-consuming, high-polluting economic structure, making it highly relevant to our research.

Using Chinese A-share listed firms¹ as the research setting, this paper empirically examines the impact of GCP on stock price crash risk by employing the difference-in-differences (DID) model to measure stock price volatility before and after the adoption of GCP. The results show that, first, GCP increases the risk of heavy-polluting firms experiencing price crashes, and this finding is robust. Second, the heterogeneity analysis suggests that GCP has a more pronounced impact on the stock price crash risk of heavy-polluting firms with poor external governance and a small size. Finally, the mediating analysis reveals that corporate financial constraints and information transparency play a substantial role in mediating the relationship between GCP and the stock price crash risk of heavy-polluting firms. By examining whether and how GCP affects stock price crash risk, our paper provides a reference for mitigating corporate risks, improving corporate sustainability, and developing a cohesive macro-financial policy framework.

The remainder of this paper is organized as follows: section "Theoretical Background and Hypotheses Development" provides the theoretical background and hypothesis development; section "Research Design" introduces the research design; section "The Impact of Green Credit Policy on Stock Price Crash Risk" explains the baseline results; section "Robustness Checks" presents the robustness checks; section "Heterogeneity Analysis" is the heterogeneity analysis; section

¹According to the document "Key Performance Indicators for Implementing Green Credit," Class A industries include: nuclear power generation; hydro power generation; water conservancy and inland river port construction; coal mining and washing; oil and gas extraction; ferrous metal mining and processing; non-ferrous metal mining and processing; non-metallic mining and processing; other mining industries.

“Mediating Analysis” provides the mediating analysis; section “Conclusions and Policy Implications” concludes the paper.

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

Institutional Background

To address environmental challenges, the Chinese government has prioritized environmental governance and implemented a number of initiatives and policies.² However, the lack of an effective monitoring and regulatory mechanism has resulted in a limited effect of these policies on raising environmental awareness among businesses and a significant gap between intended and achieved goals (Tian et al., 2020; Yang et al., 2020). According to the *2019 Bulletin of Ecology and Environment Status of China*, 53.4% of Chinese cities exceeded ambient air quality standards in 2019, with 337 cities experiencing 452 days of severe pollution, an increase of 88 days from 2018.³ As a result, “market” mechanism is still needed in addressing environmental problems. Green credit policy (GCP) incorporates environmental governance in corporate development through a differentiated loan granting policy (Zhong et al., 2021; Shi et al., 2022). In 2007, the Environmental Protection Administration, People’s Bank of China, and China Banking Regulatory Commission (CBRC) jointly issued the *Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks* to curb the blind expansion of high energy-consuming and polluting industries. It requires commercial banks to undertake credit control over firms and projects that do not comply with industrial policies and environmental objectives and make environmental performance a condition for loan granting. In 2012, the CBRC issued the *Green Credit Guidelines*, which supplemented the *Opinions* and improved the GCP’s operability. According to the People’s Bank of China, the green credit balance in China’s domestic and foreign currencies was 5.20 trillion yuan in 2013 and would expand to 15.9 trillion yuan in 2021, with an average annual growth rate of 15%.⁴ Since the inception of the GCP, the

scale of green credit has been on the rise year by year (as shown in **Figure 1**).

Hypotheses Development

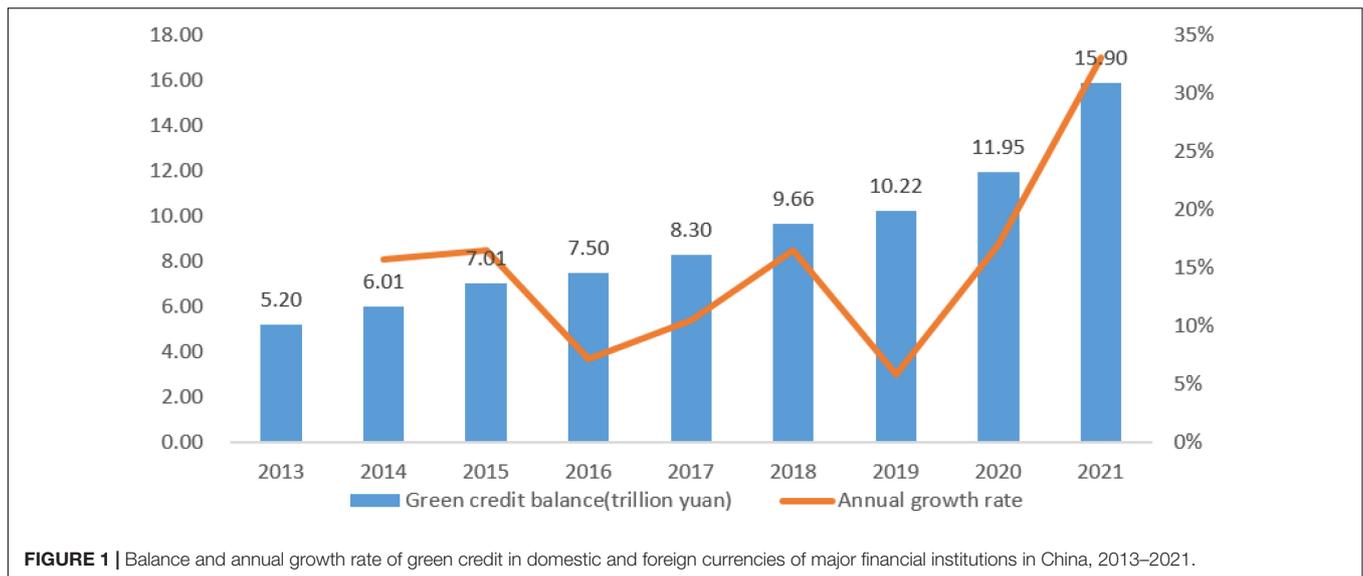
Stock price crash risk refers to the probability of stock prices falling swiftly and sharply as a result of a large number of investors selling stocks for a specific reason (Hong et al., 2017). Stocks are notoriously volatile, with price crashes occurring more frequently than price surges (Bekaert and Wu, 2000). In terms of the impact sphere, stock price crashes can be divided into market-level and firm-level stock price crashes. The 2007 U.S. financial crisis and the 2015–2016 China stock market crash are two well-known examples of the market-level stock price crash. Meanwhile, typical examples of the firm-level crashes include (1) the “D’long incident” in 2004, in which the D’long International Strategic Investment Company blindly expanded in the absence of funding, eventually leading to the collapse of its share price; and (2) the stock price crash of Huishan Dairy in 2018, which occurred in less than half an hour owing to the exaggerated profits and profitability being exposed. The stock price crash severely infringes on the interests of stakeholders and has serious economic ramifications.

Research on stock price crash risk primarily focuses on its formation mechanism, measurement method, and influencing factors. The most prominent topic among them is influencing factors, and most of the existing literature on this topic concentrates on internal and external corporate governance. From the perspective of internal corporate governance, separation of corporate ownership and management led by refinement of social division of labor has resulted in a principal-agent problem. The principal-agent theory suggests that business owners expect managers to maximize resource allocation and economic benefits while maintaining strong environmental performance and a positive firm image to be able to obtain green credit and government subsidies. Simultaneously, corporate managers seek to avoid negative evaluations led by the exposure of environmental problems such as severe pollution by focusing on green innovation and resource conservation. However, managers may act short-sightedly in pursuit of self-serving interests. They tend to conceal or delay the disclosure of bad news owing to various concerns related to career prospect (Kothari et al., 2009), colleague respect (Ball, 2009), promotion (Piotroski et al., 2015), and equity (Kim et al., 2011b). Information asymmetry theory suggests that managers may use their information advantage to engage in short-sighted conduct that damages environmental causes, corporate development, and the interests of the information disadvantaged parties such as investors. Graham et al. (2005) find that managers are more likely to delay or conceal bad news when confronted with it. The concealing of substantial amounts of unfavorable news results in low business transparency and significant degrees of information asymmetry. The exposure of such news could lead to a stock price crash (Benmelech et al., 2010). Thus, the more transparent a firm’s information disclosure, the lower its stock price crash risk (Chen et al., 2001; Kim and Zhang, 2016). Therefore, information transparency helps to reduce information asymmetry and a firm’s risk of price crashes.

²In 1973, the State Council held the first National Working Conference on Ecological and Environmental Protection; in 1983, the second National Working Conference on Ecological and Environmental Protection established environmental protection as a basic state policy; in 1984, the *Decision on Environmental Protection* was issued; in 1988, the State Environmental Protection Administration was established; in 1979, the *Environmental Protection Law of the People’s Republic of China* was trialed and went into law in 1989; in 1992, *China’s Ten Strategic Policies on Environment and Development* was announced; in 1996, the *Decision on Several Issues of Environmental Protection* was issued; in 1994, *China’s Agenda 21* was promulgated; in 2019, the government work report states that it will continue to promote pollution prevention and control, and consolidate and expand the achievements of the Blue Sky Defense War, while specifying that SO₂ and NO_x emissions will fall by 3% and PM_{2.5} concentrations will continue to fall in key areas; in February 2021, the State Council issued the *Guiding Opinions on Accelerating the Establishment and Improvement of a Green and Low-Carbon Circular Development Economic System*, which states that “establishing and improving a green and low-carbon circular development economic system and promoting a comprehensive green transformation of economic and social development are the basic policies for solving China’s resource, environmental, and ecological problems.”

³The data was retrieved from the *2019 Bulletin of Ecology and Environment Status of China* <http://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/>.

⁴<http://www.pbc.gov.cn>



With the adoption of the GCP, heavy polluters may face huge environmental liability as a result of pollution control, and financial institutions will lower their loan size to hedge the risks. Some studies have shown that when firms have information asymmetry with investors, low information transparency, and high default risk, they are unable to obtain long-term debt financing (Goss and Roberts, 2011; Ge and Liu, 2015). In addition, the regulatory constraints increase the risk of heavy-polluting firms defaulting on their loans owing to corporate infractions (Cai et al., 2019). Moreover, once negative news of heavy-polluting firms like major environmental pollution was exposed, banks are likely to reduce their loan size and increase their financing constraints under public pressure.

Under the GCP, heavy-polluting firms are reluctant to disclose environmental information in order to circumvent the policy restrictions, while firms with good environmental performance are more willing to disclose environmental information (Peters and Romi, 2013). This is because, in order to minimize debt costs, financial institutions seek to subsidize firms that provide more environmental information (Eliwa et al., 2021). According to Chen et al. (2014), the more transparent a firm's corporate disclosure is, the more detailed the environmental information it discloses. Both the financing ability and information transparency of heavy-polluting firms are closely related to their share price crash risk. Therefore, we propose the first hypothesis.

Hypothesis 1: Green credit policy increases the stock price crash risk of heavy-polluting firms.

As an important mechanism affecting the cost of corporate financing and information transparency, external corporate governance significantly affects the risk of stock price crash. External corporate governance refers to the mechanism through which outsiders, such as auditors, institutional investors, media, and securities analysts, monitor and supervise the acts of a firm's controlling shareholders and decision-makers such as managers

and boards of directors (Bradshaw, 2011; Mayew et al., 2013; Solomon and Soltes, 2015; Gao et al., 2017). First, reputation theory suggests that external regulators, such as auditors and securities analysts, have the ability and motivation to detect and disclose corporate violations in a timely manner. Their in-depth knowledge of a firm's overall performance allows them to uncover corporate infractions sooner than ordinary investors. Also, it is one of their responsibilities to protect investors from investment losses in firms with irregularities, and the prompt disclosure of corporate irregularities enhances their reputation and career prospects (Yuan and Zhu, 2022).

Second, in firms with poor external corporate governance, management may override corporate governance mechanisms, which would increase the occurrence of managers' self-interested behavior. Adams et al. (2005) and Cheng (2008) find that the greater the power of managers, the more volatile corporate performance becomes. Also, Quan et al. (2010) find that when managers have more power, they are more likely to engage in earnings management for higher pay, which would directly damage the firm's value. In China's institutional setting, the level of corporate information transparency has a strong correlation with managerial conduct. Kothari et al. (2009) find that managers tend to conceal or delay the disclosure of bad news when it happens, leading to information opacity. This is especially true for heavy-polluting firms since the implementation of the GCP, as their information transparency has significantly decreased (Wang et al., 2015). However, a more transparent information disclosure can reduce the stock price crash risk and enhance market liquidity (Bloomfield and Wilks, 2000; Patel and Dallas, 2003). Hence, we propose the second hypothesis.

Hypothesis 2: Green credit policy has a more significant impact on the stock price crash risk of firms with poor external corporate governance.

Prior research shows that the extent of financial constraints imposed by banks on a firm is proportional to the size of

the firm. First, the loan repayment capacity and business risks of borrowing firms are important factors for banks and other financial institutions to consider. Banks are more inclined to lend money to large firms because their assets can be used to repay the debt even if they go bankrupt and liquidate. Tong (2011) argues that larger firms own more capital, social influence, and resource integration capabilities than smaller firms. They also have a larger pool of potential collateral assets, a better reputation and business credit, and fewer financial constraints. Moreover, larger firms are better at risk-diversification, especially in the event of an exogenous occurrence, such as the introduction of GCP. Furthermore, large firms have a broader and more diverse group of stakeholders (Branco and Rodrigues, 2008), comprising trading partners like shareholders, creditors, employees, consumers, and suppliers, as well as supervisory bodies like the government and the media (Li and Zhang, 2020; Dumitrescu and Zakriya, 2021). These stakeholders have direct or indirect influence with the production and operation activities of firms. They share certain business risks with the firms while monitoring and controlling their production and operation activities. On the one hand, stakeholders require firms to actively disclose information in order to understand the real condition of firm operation and reduce information asymmetry. On the other hand, stakeholders increase their monitoring and supervision of firms to avoid economic losses potentially caused by the self-serving conduct of firm managers. As such, large firms have a higher level of information transparency. Therefore, after the introduction of GCP, heavy-polluting firms with a large size will have lower financing constraints, higher information transparency, and lower risk of stock price crash than heavy-polluting firms with a smaller size. Hence, we propose the third hypothesis.

Hypothesis 3: Green credit policy has a greater influence on the stock price crash risk of small firms than that of large firms.

RESEARCH DESIGN

Model Specification

Based on the difference-in-difference (DID) model, we construct Model (1) to examine the impact of green credit policy (GCP) on stock price crash risk.

$$Crashrisk_{it+1} = \alpha + \beta_1 Policy_t \times treat_i + \beta_2 treat_i + \beta_3 Policy_t + \gamma' x_{it} + \varepsilon_{it} \quad (1)$$

Following (Kim et al., 2011a,b), we use the skewness of negative stock return (*NCSKEW*) and the fluctuations in stock return (*DUVOL*) to measure stock price crash risk. In Model (1), *Crashrisk* is the stock price crash risk as measured by *NCSKEW* and *DUVOL*. *Policy* indicates the implementation of GCP; following (Hu et al., 2021; Yao et al., 2021), it is set to the value of 1 for the years after 2012 when the *Green Credit Guidelines* was issued, and 0 otherwise. *Treat* denotes whether the firm is in a heavy-polluting industry or whether it is subject to financial constraints imposed by the GCP; it is set to the value of 1 when the firm belongs to Category A industry or is a heavy-polluting firm (treatment group), and 0 when the firm is non-heavy-polluting firm (control group). *Policy* × *treat* is the interaction term of GCP and heavy-non-heavy-polluting firms; it measures the impact of the GCP on the stock price crash risk of heavy-polluting and non-heavy-polluting firms. β_1 reflects the impact of GCP on the stock price crash risk of heavy-polluting and non-heavy-polluting firms before and after its implementation. If β_1 is significantly greater than 0, it means that GCP significantly contributes to the stock price crash risk of heavy-polluting firms; otherwise, there is no significant contribution.

Based on prior studies (Chen et al., 2001; Kim et al., 2014), we also control for the following factors to eliminate their impacts on stock price crash risk: leverage ratio (*Lev_t*), profitability (*ROE_t*), net operating cash flow (*Cashflow_t*), equity balance (*Balance_t*), monthly stock turnover rate (*Dturn_t*), firm age (*age_t*), firm size (*lnsize_t*), *TobinQ_t*, the standard deviation of weekly

TABLE 1 | Summary statistics.

Variable	N	Mean	Std.err	5%	25%	Median	75%	95%
<i>NCSKEW_{t+1}</i>	6,594	-0.2417	0.9144	-1.7369	-0.7812	-0.2517	0.3137	1.2474
<i>DUVOL_{t+1}</i>	6,594	-0.1834	0.7435	-1.4152	-0.6580	-0.2076	0.2743	1.1257
<i>Lev_t</i>	6,594	0.5213	0.1825	0.2051	0.3871	0.5259	0.6622	0.8084
<i>ROE_t</i>	6,594	0.0757	0.1040	-0.0796	0.0287	0.0731	0.1240	0.2376
<i>Cashflow_t</i>	6,594	0.0428	0.0710	-0.0789	0.0044	0.0427	0.0841	0.1608
<i>Balance_t</i>	6,594	0.5332	0.5163	0.0414	0.1354	0.3683	0.7675	1.6258
<i>Dturn_t</i>	6,594	0.0413	0.3147	-0.4772	-0.1254	0.0227	0.2078	0.6001
<i>age_t</i>	6,594	2,001	5.3144	1,993	1,996	2,000	2,004	2,010
<i>lnsize_t</i>	6,594	3.1065	0.0540	3.0268	3.0691	3.0994	3.1397	3.2067
<i>Sigma_t</i>	6,594	0.0500	0.0182	0.0253	0.0373	0.0474	0.0593	0.0865
<i>Ret_t</i>	6,594	0.0474	4.2081	-6.4174	-2.1556	-0.4336	1.9267	7.9269
<i>TobinQ_t</i>	6,594	1.9621	1.2212	1.0026	1.2294	1.5896	2.2502	4.1938
<i>policy_t</i>	6,594	0.6794	0.4667	0	0	1	1	1
<i>treat_t</i>	6,594	0.0855	0.2797	0	0	0	0	1
<i>treat_t × policy_t</i>	6,594	0.0604	0.2382	0	0	0	0	1

TABLE 2 | Baseline regression results.

Variable	(1)	(2)	(3)	(4)
	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t</i> × <i>policy_t</i>	0.1277** (2.0719)	0.1639*** (3.2871)	0.1534** (2.4195)	0.1929*** (4.1010)
<i>policy_t</i>	0.0130 (0.2406)	0.1129** (2.2964)	-0.0589 (-0.9586)	0.0320 (0.5701)
<i>treat_t</i>	-0.1256*** (-3.0729)	-0.1199*** (-3.5462)	-0.1354*** (-3.0248)	-0.1162*** (-3.8209)
<i>Lev_t</i>			-0.0834 (-0.9741)	-0.1564** (-2.6433)
<i>ROE_t</i>			0.3794*** (2.8683)	0.1501 (1.5753)
<i>Cashflow_t</i>			-0.3159 (-1.4731)	-0.2403 (-1.4092)
<i>Balance_t</i>			0.0090 (0.4332)	-0.0001 (-0.0071)
<i>Dturn_t</i>			-0.0845 (-1.5419)	-0.0943** (-2.0683)
<i>age_t</i>			0.0005 (0.1482)	0.0014 (0.5554)
<i>Insize_t</i>			-0.4172 (-1.0958)	0.1978 (0.7600)
<i>NCSKEW_t</i>			0.0230* (1.8378)	
<i>Sigma_t</i>			3.9500*** (3.9328)	3.2817*** (4.0922)
<i>Ret_t</i>			-0.0047 (-1.3990)	-0.0019 (-0.6987)
<i>TobinQ_t</i>			0.0111 (0.8625)	0.0157* (1.7315)
<i>DUVOL_t</i>				-0.0190 (-1.4163)
Constant	-0.1984*** (-3.3725)	-0.2969*** (-5.3161)	-0.0699 (-0.0106)	-3.7714 (-0.7907)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	6,680	6,680	6,594	6,594
R-squared	0.0861	0.1112	0.0938	0.1182

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

TABLE 3 | Placebo test.

Variable	(1)	(2)	(3)	(4)
	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t</i> × <i>beforepolicy1_t</i>	0.1813 (1.5374)	0.1824* (1.9223)		
<i>beforepolicy1_t</i>	-0.0598 (-0.9632)	0.0348 (0.6068)		
<i>treat_t</i> × <i>beforepolicy2_t</i>			0.3394 (1.3337)	0.2316 (0.9524)
<i>beforepolicy2_t</i>			-0.0718 (-1.0925)	0.0317 (0.5136)
<i>treat_t</i>	-0.1726* (-1.7004)	-0.1250 (-1.5792)	-0.3360 (-1.3978)	-0.1877 (-0.8262)
<i>Lev_t</i>	-0.0834 (-0.9729)	-0.1564** (-2.6409)	-0.0823 (-0.9612)	-0.1557** (-2.6322)
<i>ROE_t</i>	0.3786*** (2.8896)	0.1495 (1.5976)	0.3819*** (2.9279)	0.1525 (1.6427)
<i>Cashflow_t</i>	-0.3158 (-1.4626)	-0.2423 (-1.4081)	-0.3184 (-1.4715)	-0.2468 (-1.4290)
<i>Balance_t</i>	0.0090 (0.4388)	0.0001 (0.0087)	0.0092 (0.4466)	0.0005 (0.0326)
<i>Dturn_t</i>	-0.0863 (-1.5896)	-0.0963*** (-2.1275)	-0.0866 (-1.5700)	-0.0960** (-2.0937)
<i>age_t</i>	0.0004 (0.1322)	0.0013 (0.5062)	0.0004 (0.1317)	0.0012 (0.4799)
<i>Insize_t</i>	-0.4202 (-1.1015)	0.1924 (0.7334)	-0.4201 (-1.1019)	0.1896 (0.7228)
<i>NCSKEW_t</i>	0.0226* (1.8208)		0.0233* (1.8647)	
<i>Sigma_t</i>	3.9296*** (3.9156)	3.2494*** (4.0463)	3.9554*** (3.9458)	3.2542*** (4.0562)
<i>Ret_t</i>	-0.0046 (-1.3901)	-0.0019 (-0.6784)	-0.0045 (-1.3699)	-0.0018 (-0.6527)
<i>TobinQ_t</i>	0.0109 (0.8433)	0.0153* (1.6798)	0.0107 (0.8314)	0.0151 (1.6528)
<i>DUVOL_t</i>		-0.0193 (-1.4442)		-0.0188 (-1.3976)
Constant	0.0484 (0.0073)	-3.5159 (-0.7324)	0.0645 (0.0098)	-3.3678 (-0.7027)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	6,594	6,594	6,594	6,594
R-squared	0.0948	0.1179	0.0942	0.1178

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

stock return (*Sigma_t*), mean weekly stock return (*Ret_t*). These control variables are denoted by *x_{it}*. Detailed descriptions of all variables are provided in **Appendix Table 1**. To eliminate the effects of unobservable factors and heteroscedasticity, we adopt the dual-cluster model that controls for time fixed effects and industry fixed effects, and robust standard errors are clustered at the industry level.

Table 1 provides the summary statistics. The variables of *NCSKEW* and *DUVOL* have a mean value of -0.2417 and -0.1834 and a standard deviation of 0.9144 and 0.7435, respectively. This indicates that the two variables differ

significantly among the sample firms, and the statistical results are similar to those of Chen et al. (2001) and Xu et al. (2012).

Sample and Data Source

In 2012, the China Banking Regulatory Commission (CBRC) established the *Green Credit Guidelines*, dividing industries into categories A, B, and C based on environmental and social risk as defined in the *Key Performance Indicators for Implementing Green Credit*. Category A includes industries whose construction, production, and operation activities are likely to seriously change the original ecology and produce adverse environmental and

TABLE 4 | Matching results.

Variable	Unmatched		Mean		% reduct		t-test		V(T)/V(C)
	Matched	Treated	Control	% bias	bias	t	p > t		
Lev_t	U	0.55	0.51	19.40		4.54	0.00	0.90	
	M	0.55	0.55	2.20	88.60	0.40	0.69	0.94	
ROE_t	U	0.09	0.07	13.70		3.26	0.00	0.97	
	M	0.09	0.08	4.10	69.80	0.71	0.48	0.87	
$Cashflow_t$	U	0.08	0.05	50.90		11.87	0.00	0.88	
	M	0.08	0.07	6.60	87.10	1.12	0.26	0.79*	
$Balance_t$	U	0.52	0.54	-4.30		-1.09	0.28	1.28*	
	M	0.52	0.53	-2.70	38.00	-0.47	0.64	1.29*	
$Dturn_t$	U	0.04	0.04	-0.20		-0.05	0.96	0.92	
	M	0.04	0.04	-0.20	9.40	-0.04	0.97	1.25*	
age_t	U	2000	2001	-18.80		-4.15	0.00	0.66*	
	M	2000	2000	-0.20	98.70	-0.04	0.96	0.74*	
$lnsize_t$	U	3.14	3.10	59.50		14.99	0.00	1.27*	
	M	3.14	3.13	8.90	85.00	1.48	0.14	0.99	
$Sigma_t$	U	0.04	0.05	-37.90		-8.88	0.00	0.91	
	M	0.04	0.04	-5.80	84.60	-1.07	0.29	1.05	
Ret_t	U	-0.10	0.08	-4.20		-0.99	0.32	0.90	
	M	-0.10	-0.09	-0.20	94.60	-0.04	0.97	1.00	

(1) If variance ratio outside (0.85; 1.17) for U and (0.85; 1.17) for M; (2) * represents significant at the 10% significance level.

social consequences.⁵ Category B includes industries whose construction, production and operation activities may produce adverse environmental and social consequences but can be easily mitigated; Category C includes industries that do not have an adverse impact on the environment. Using Chinese A-share listed firms as the research setting, we set the sample interval as the 3 years before and after 2012 (the year of the adoption of the *Green Credit Guidelines*), namely, 2009–2015. The sample was screened according to the following criteria: (1) excluding firms in the financial and insurance industries; (2) excluding ST, ST*, and PT firms; (3) excluding firms with asset-liability ratios less than 0 and greater than 1; (4) excluding firms with missing values; (5) excluding extreme values after all continuous variables are winsorized at the 1 and 99% levels. Eventually, 6,594 observations were obtained. The data on institutional investors' holdings used in this paper comes from the Wind database,⁶ and other data comes from the *China Stock Market Accounting Research* (CSMAR).⁷

THE IMPACT OF GREEN CREDIT POLICY ON STOCK PRICE CRASH RISK

Baseline Results

Table 2 reports the baseline results. Columns (1) and (2) show the regression results without control variables, whereas columns

⁵Category A includes: nuclear power generation; hydro power generation; water conservancy and inland river port construction; coal mining and washing; oil and gas extraction; ferrous metal mining and processing; non-ferrous metal mining and processing; non-metallic mining and processing; other mining industries.

⁶<https://www.wind.com.cn/>

⁷<https://www.gtarsc.com/>

(3) and (4) show the regression results with control variables. As shown in columns (1) and (2), the coefficients of $treat_i \times policy_t$ are 0.1277 and 0.1639 and significantly positive at the 5 and 1% level, respectively. This indicates that the stock price crash risk of heavy-polluting firms has increased significantly after the implementation of the green credit policy (GCP). The results in columns (3) and (4) show that after controlling for other factors that may affect stock price crash risk, the coefficients of $treat_i \times policy_t$ increase to 0.1534 and 0.1929 and are significantly positive at the 5 and 1% level, indicating that the implementation of the GCP makes the stock price crash risk significantly higher for heavy-polluting firms. The findings prove Hypothesis 1.

ROBUSTNESS CHECKS

In this section, we will conduct a battery of robustness checks on the empirical results, including placebo tests, PSM-DID, alternative measures of dependent variables, expanding the heavy-polluting firm sample group, and adding CEO-level control variables.

Placebo Test

To eliminate the influence of other factors on the stock price crash risk of heavy-polluting firms other than the green credit policy (GCP), we advance the implementation date of GCP by 1 year and 2 years, assuming that the policy was implemented in 2011 and 2010, respectively. We then re-estimate the baseline regression using the updated time, and the results are shown in Table 3. The results reveal that the coefficients of $treat_i \times beforepolicy1_t$ and $treat_i \times beforepolicy2_t$ are not significant, indicating that GCP has

TABLE 5 | Robustness checks.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	NCSKEW _{t+1}	DUVOL _{t+1}	CRASH	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t × policy_t</i>	0.1433** (2.4518)	0.1896*** (4.1240)	0.0614*** (2.8790)	0.1534** (2.4195)	0.1929*** (4.1010)	0.1467** (2.2803)	0.1889*** (4.0020)
<i>policy_t</i>	-0.0665 (-1.0876)	0.0256 (0.4444)	0.1654*** (5.8762)	-0.0589 (-0.9586)	0.0320 (0.5701)	-0.0571 (-0.9043)	0.0328 (0.5728)
<i>treat_t</i>	-0.1410*** (-3.3808)	-0.1325*** (-4.3101)	-0.0258 (-1.5450)	-0.5380*** (-18.4063)	-0.3244*** (-14.0536)	-0.0978** (-2.1577)	-0.0929*** (-2.9720)
<i>Lev_t</i>	-0.0590 (-0.7007)	-0.1459** (-2.5744)	0.0210 (0.9326)	-0.0834 (-0.9741)	-0.1564** (-2.6433)	-0.0924 (-1.0788)	-0.1628*** (-2.7262)
<i>ROE_t</i>	0.3659*** (2.7268)	0.1269 (1.2695)	-0.0685* (-1.9009)	0.3794*** (2.8683)	0.1501 (1.5753)	0.3632** (2.5464)	0.1291 (1.3005)
<i>Cashflow_t</i>	-0.3848 (-1.5608)	-0.2863 (-1.5361)	0.0422 (0.8969)	-0.3159 (-1.4731)	-0.2403 (-1.4092)	-0.2811 (-1.2828)	-0.2083 (-1.2161)
<i>Balance_t</i>	0.0076 (0.3689)	-0.0010 (-0.0594)	0.0106* (1.7249)	0.0090 (0.4332)	-0.0001 (-0.0071)	0.0072 (0.3575)	-0.0024 (-0.1496)
<i>Dturn_t</i>	-0.0627 (-1.0818)	-0.0692 (-1.4479)	-0.0246* (-1.8995)	-0.0845 (-1.5419)	-0.0943** (-2.0683)	-0.0939* (-1.6724)	-0.1042** (-2.2716)
<i>age_t</i>	0.0007 (0.2294)	0.0015 (0.6186)	-0.0006 (-0.8303)	0.0005 (0.1482)	0.0014 (0.5554)	0.0013 (0.3715)	0.0020 (0.7530)
<i>Insize_t</i>	-0.4125 (-1.0660)	0.2028 (0.7562)	-0.2039** (-2.5719)	-0.4172 (-1.0958)	0.1978 (0.7600)	-0.4060 (-1.0559)	0.2037 (0.7636)
<i>NCSKEW</i>	0.0249* (1.9062)			0.0230* (1.8378)		0.0213* (1.7319)	
<i>Sigma</i>	4.2814*** (3.7712)	3.3970*** (3.7425)	0.0142 (0.0534)	3.9500*** (3.9328)	3.2817*** (4.0922)	3.8400*** (3.8795)	3.1249*** (3.8981)
<i>Ret_t</i>	-0.0045 (-1.3109)	-0.0018 (-0.6384)	-0.0004 (-0.4834)	-0.0047 (-1.3990)	-0.0019 (-0.6987)	-0.0049 (-1.4375)	-0.0023 (-0.8288)
<i>TobinQ_t</i>	0.0307** (2.1301)	0.0311*** (2.8990)	-0.0041 (-1.1685)	0.0111 (0.8625)	0.0157* (1.7315)	0.0141 (1.0461)	0.0182** (2.0096)
<i>IsDuality_i</i>						-0.0320 (-1.0032)	-0.0133 (-0.6091)
<i>gender_i</i>						0.0152 (0.3484)	-0.0083 (-0.2608)
<i>oveseaback_i</i>						-0.0092 (-0.1843)	-0.0131 (-0.3153)
<i>DUVOL_t</i>		-0.0184 (-1.3955)			-0.0190 (-1.4163)		-0.0219 (-1.6228)
<i>Constant</i>	-0.6285 (-0.0982)	-4.1160 (-0.8716)	16.5471 (1.0131)	-0.0699 (-0.0106)	-3.7714 (-0.7907)	-1.7359 (-0.2496)	-4.9795 (-0.9787)
<i>Industry fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Observations</i>	6,340	6,340	7,503	6,594	6,594	6,402	6,402
<i>R-squared</i>	0.0966	0.1200	0.0480	0.0938	0.1182	0.0948	0.1204

(1) Robust standard errors are clustered by industry and *t*-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

no effect on the stock price crash risk of heavy-polluting firms. This proves that the risk of a price crash for heavy-polluting firms is indeed influenced by the GCP rather than other factors.

Propensity Score Matching-Difference-in-Differences

To mitigate potential endogeneity problems caused by sample selection bias, we adopt the propensity score matching (PSM) method for robustness check. In this paper, we use the kernel matching method with *Lev_t*, *ROE_t*, *Cashflow_t*, *Balance_t*, *Dturn_t*, *age_t*, *Insize_t*, *Sigma_t*, *Ret_t* as covariates to match the treatment group, and the differences of covariates before and after matching

are shown in **Table 4**. The propensity scores are estimated using a logit model. The matched sample size is 6,340. As shown in **Table 4**, the standardized bias (% bias) of all variables after matching is less than 10%, and none of the *t*-test results rejects the null hypothesis that there is no systematic difference between the treatment and control groups. The regression results remain robust as shown in columns (1) and (2) in **Table 5**.

Short-Term and Long-Term Effect

We divide the post-policy period into three segments: (1) 1 year after the implementation of GCP; (2) 2 years after the implementation of GCP; and (3) 3 years after the implementation

TABLE 6 | Short-term and long-term effect.

Variable	One year after the implementation of GCP		Two years after the implementation of GCP		Three years after the implementation of GCP	
	(1)	(2)	(3)	(4)	(5)	(6)
	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t × policy_t</i>	0.5216*** (2.9640)	0.4981*** (2.7430)	0.1447 (1.6638)	0.1970** (2.3529)	0.1612** (2.1766)	0.2073*** (3.4412)
<i>policy_t</i>	-0.3121*** (-3.6748)	-0.1396* (-1.9776)	0.3945*** (4.0380)	0.4751*** (4.8468)	-0.1765** (-2.2878)	-0.1280** (-2.0353)
<i>treat_t</i>	0.2880*** (3.1160)	0.2042** (2.1967)	0.0591 (1.0278)	0.0318 (0.5737)	-0.0868 (-1.6214)	-0.0891** (-2.1215)
<i>Lev_t</i>	-0.0842 (-0.6874)	-0.1480 (-1.6607)	-0.2162* (-1.8917)	-0.2454*** (-2.8368)	-0.1344 (-1.3597)	-0.2079*** (-2.7404)
<i>ROE_t</i>	0.3088 (1.5886)	-0.0874 (-0.5291)	0.5983*** (3.0610)	0.2066 (1.4252)	0.4487*** (2.6802)	0.1567 (1.2984)
<i>Cashflow_t</i>	-0.4322 (-1.3715)	-0.3291 (-1.1346)	-0.3561 (-1.2328)	-0.2485 (-1.0532)	-0.3931* (-1.6791)	-0.2946 (-1.4522)
<i>Balance_t</i>	0.0244 (0.5554)	0.0034 (0.1129)	-0.0027 (-0.0804)	-0.0090 (-0.3510)	0.0027 (0.1041)	-0.0023 (-0.1038)
<i>Dturn_t</i>	-0.1695** (-2.5429)	-0.1809*** (-3.0765)	-0.1485** (-2.1205)	-0.1436** (-2.3971)	-0.0778 (-1.2257)	-0.0982* (-1.8077)
<i>age_t</i>	0.0053 (0.9759)	0.0043 (1.0675)	0.0091* (1.9339)	0.0073** (2.0239)	0.0029 (0.7789)	0.0028 (0.9420)
<i>Insize_t</i>	1.5854*** (4.4829)	1.8335*** (5.5284)	-0.2904 (-0.6948)	0.2512 (0.9118)	-0.2670 (-0.7137)	0.3631 (1.4654)
<i>NCSKEW_t</i>	0.0439** (2.1977)		0.0374* (1.9394)		0.0259* (1.7213)	
<i>Sigma_t</i>	6.8395*** (3.4901)	5.0624*** (2.9162)	6.5047*** (4.4123)	4.9866*** (3.8358)	5.1500*** (3.6963)	3.8657*** (3.4086)
<i>Ret</i>	0.0004 (0.1087)	0.0028 (0.7960)	0.0014 (0.3295)	0.0031 (0.8490)	-0.0038 (-0.9966)	-0.0014 (-0.4118)
<i>TobinQ</i>	0.0804*** (2.8670)	0.0651*** (2.8433)	0.0476** (2.2367)	0.0427*** (2.6810)	0.0442** (2.5672)	0.0396*** (3.0346)
<i>DUVOL</i>		0.0021 (0.1132)		-0.0098 (-0.5175)		-0.0210 (-1.4018)
Constant	-16.3681 (-1.5067)	-15.1529* (-1.8207)	-17.9883* (-1.9084)	-16.0087** (-2.2900)	-5.5492 (-0.7389)	-7.1647 (-1.2477)
<i>Industry fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Observations</i>	3,188	3,188	4,399	4,399	5,515	5,515
<i>R-squared</i>	0.1076	0.1171	0.1225	0.1343	0.1100	0.1327

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

of GCP. In this way, we estimate the short-term and long-term impact of GCP on stock price crash risk. The regression results in **Table 6** shows that the policy has the most pronounced impact on the stock price crash risk of heavy-polluting firms 1 year after its implementation than 2 and 3 years after, that is, GCP has a more pronounced impact on stock price crash risk in the short term. First, the implementation of the GCP is an exogenous event that firms cannot control, leaving them unprepared with specialized risk mitigation measures. So, the short-term policy impact is stronger than the long-term one. Second, firms will

gradually engage in green innovation, increase environmental expenditures, and seek to transform into an energy-saving, green, and low-carbon production model in the long run, so as to mitigate the policy impacts (Goetz, 2019; He et al., 2019).

Alternative Measures

Following Kim et al. (2016), we use a dummy variable *CRASH* as an alternative measure of stock price crash risk to re-estimate the baseline regression, and the results are presented in column (3) of **Table 5**. The results show that the coefficient of *treat_i ×*

TABLE 7 | Impact of external corporate governance.

Variable	Low-quality external governance		High-quality external governance	
	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t × policy_t</i>	0.2355** (2.4950)	0.2853*** (3.8107)	0.0700 (0.9392)	0.1063 (1.6002)
<i>policy_t</i>	-0.0540 (-0.6470)	0.0357 (0.4558)	-0.0503 (-0.5394)	0.0423 (0.5420)
<i>treat_t</i>	-0.1833*** (-2.6642)	-0.3231*** (-5.9630)	-0.0588 (-1.0895)	0.0105 (0.2287)
<i>Lev_t</i>	-0.1664 (-1.4321)	-0.1915** (-2.2901)	0.0314 (0.3311)	-0.1004 (-1.4938)
<i>ROE_t</i>	0.2520 (1.4424)	0.0517 (0.3906)	0.4970*** (2.9833)	0.2476* (1.9922)
<i>Cashflow_t</i>	-0.5588** (-2.5895)	-0.3828** (-2.0663)	-0.1395 (-0.4329)	-0.1274 (-0.5000)
<i>Balance_t</i>	-0.0076 (-0.2999)	-0.0147 (-0.6445)	0.0294 (0.7779)	0.0165 (0.5785)
<i>Dturn_t</i>	-0.1658** (-2.6011)	-0.1702*** (-3.1893)	0.0111 (0.1188)	-0.0148 (-0.1922)
<i>age_t</i>	-0.0019 (-0.4425)	0.0009 (0.2836)	0.0027 (0.6645)	0.0016 (0.5751)
<i>Insize_t</i>	-0.1388 (-0.2960)	0.4646 (1.3039)	-0.6694* (-1.7123)	0.0116 (0.0400)
<i>NCSKEW_t</i>	0.0170 (1.0546)		0.0185 (1.0933)	
<i>Sigma_t</i>	4.6793** (2.5419)	4.2238*** (2.8033)	3.7981*** (3.5156)	2.9188*** (3.1974)
<i>Ret_t</i>	0.0021 (0.4007)	0.0046 (1.0775)	-0.0108*** (-3.9416)	-0.0075*** (-2.9180)
<i>TobinQ_t</i>	0.0021 (0.1267)	0.0086 (0.6414)	0.0157 (0.7906)	0.0216 (1.4845)
<i>DUVOL_t</i>		-0.0129 (-0.6433)		-0.0285* (-1.8271)
<i>Constant</i>	3.8904 (0.4528)	-3.5619 (-0.5439)	-3.7304 (-0.4656)	-3.8573 (-0.6839)
<i>Industry fixed effects</i>	Yes	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	3,118	3,118	3,459	3,459
<i>R-squared</i>	0.1188	0.1556	0.1010	0.1123

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

policy_t is significantly positive at the 1% significance level and the regression results remain robust.

Other Robustness Checks

According to the *Key Performance Indicators for Implementing Green Credit*, Category B industries may also have adverse environmental and social consequences in addition to Category A industries. Following Wang and Wang (2021), we include firms in the Category B industries⁸ in the treatment group. As seen

⁸According to the *Key Performance Indicators for Implementing Green Credit*, Category B includes 25 types of industries, including cotton dyeing, printing, and finishing; wool dyeing and finishing; hemp dyeing and finishing; silk dyeing, printing, and finishing; chemical fiber dyeing, printing, and finishing; knitting or crochet dyeing, printing, and finishing; leather tanning and finishing; fur tanning and finishing; pulp manufacturing; paper making; petroleum refining,

TABLE 8 | Impact of firm size.

Variable	Small-sized firm		Large-sized firm	
	NCSKEW _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	DUVOL _{t+1}
<i>treat_t × policy_t</i>	0.2449*** (2.7448)	0.2772*** (3.6809)	0.2103 (0.9233)	0.2218 (1.2842)
<i>policy_t</i>	-0.1000 (-1.5017)	0.0277 (0.4643)	-0.1170 (-0.7422)	-0.1410 (-0.8593)
<i>treat_t</i>	-0.1091* (-1.7683)	-0.1469*** (-2.7869)	-0.3282* (-1.9248)	-0.0515 (-0.4111)
<i>Lev_t</i>	-0.0578 (-0.6557)	-0.1236* (-1.9416)	-0.2623 (-1.1142)	-0.3174* (-1.9796)
<i>ROE_t</i>	0.3106** (2.4325)	0.1056 (1.2015)	0.5124* (1.7230)	0.2808 (1.2177)
<i>Cashflow_t</i>	-0.3452 (-1.5787)	-0.2576 (-1.4952)	-0.2429 (-0.5834)	-0.1713 (-0.5557)
<i>Balance_t</i>	-0.0020 (-0.0878)	-0.0057 (-0.3089)	0.0352 (0.8628)	0.0148 (0.3980)
<i>Dturn_t</i>	-0.0778 (-1.4947)	-0.0859** (-2.0295)	-0.1166 (-0.9198)	-0.1238 (-1.0435)
<i>age_t</i>	0.0021 (0.6470)	0.0025 (0.9501)	0.0005 (0.0698)	0.0005 (0.1279)
<i>Insize_t</i>	0.0787 (0.1651)	0.5024 (1.4907)	-2.2342* (-1.8828)	-1.6789* (-1.8600)
<i>NCSKEW_t</i>	0.0349*** (2.7688)		-0.0062 (-0.2428)	
<i>Sigma_t</i>	3.8536*** (3.4788)	3.4022*** (3.8216)	5.8495*** (2.8996)	3.9459** (2.3024)
<i>Ret_t</i>	-0.0027 (-0.7468)	-0.0006 (-0.1824)	-0.0159** (-2.3154)	-0.0107 (-1.6044)
<i>TobinQ_t</i>	0.0208 (1.4010)	0.0198* (1.7727)	-0.0266 (-0.9962)	-0.0121 (-0.4847)
<i>DUVOL_t</i>		0.0001 (0.0041)		-0.0421 (-1.2342)
<i>Constant</i>	-4.8440 (-0.7969)	-7.0050 (-1.4005)	5.6454 (0.4168)	3.8478 (0.5357)
<i>Industry fixed effects</i>	Yes	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	5,324	5,324	1,270	1,270
<i>R-squared</i>	0.1182	0.1555	0.1246	0.1225

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

from columns (4) and (5) in **Table 5**, the coefficients of *treat_t × policy_t* are still significantly positive. Considering the important influence of managers on corporate operation, we further control for CEO-level characteristics, such as whether the CEO also serves as the chairman of the board (*IsDuality_i*), CEO gender (*gender_i*), and whether the CEO has an overseas background (*oveseaback_i*). The regression results are presented in columns (6) and (7) of **Table 5**. It shows that the coefficients of *treat_t × policy_t*

coking and nuclear fuel processing; chemical material and product manufacturing; pharmaceutical manufacturing; rubber and plastic products; non-metallic mineral products; ferrous metal smelting and rolling processing; non-ferrous metal smelting and rolling processing; thermal power generation; heat power generation and supply; gas generation and supply; house building; civil engineering construction; railroad transportation; intra-city and inter-city rail-transit; pipeline transport.

remain significant, indicating that GCP can significantly increase the price crash risk of heavy-polluting firms.

Heterogeneity Analysis

External Corporate Governance

Following An and Zhang (2013), we use the shareholding ratio of institutional investors to measure external corporate governance quality in order to investigate if it affects the relationship between GCP and the stock price crash risk of heavy-polluting firms. If a firm's shareholding ratio of institutional investors is higher than the mean value of the sample firms, the firm's external governance

is deemed high-quality, while the opposite is considered low-quality.

As shown in Table 7, the coefficients of $treat_i \times policy_t$ are significant at the 5 and 1% level in the group with low-quality external governance, but not in the group with high-quality external governance. This indicates that GCP increases the stock price crash risk of heavy-polluting firms with weak external governance significantly more than those with adequate external governance, which proves Hypothesis 2.

TABLE 9 | Impact of corporate financial constraints.

Variable	(1)	(2)	(3)
	sa_{t+1}	$NCSKEW_{t+1}$	$DUVOL_{t+1}$
$treat_i \times policy_t$	0.0007** (2.3639)	0.1526** (2.0362)	0.1987*** (3.2803)
sa_{t+1}		11.4387*** (5.8249)	11.5029*** (6.5950)
$policy_t$	0.0013*** (4.9234)	-0.1909** (-2.5165)	-0.1424** (-2.3170)
$treat_i$	-0.0038*** (-16.6890)	-0.0429 (-0.8089)	-0.0449 (-1.0807)
Lev_t	-0.0013*** (-2.6959)	-0.1191 (-1.1957)	-0.1924** (-2.5078)
ROE_t	-0.0074*** (-7.1830)	0.5339*** (3.1298)	0.2425* (1.9405)
$Cashflow_t$	0.0049*** (2.7270)	-0.4491** (-1.9988)	-0.3510* (-1.7925)
$Balance_t$	-0.0001 (-0.9841)	0.0038 (0.1488)	-0.0011 (-0.0499)
$Dturn_t$	0.0002 (0.6878)	-0.0798 (-1.2558)	-0.1002* (-1.8528)
age_t	-0.0001*** (-4.8696)	0.0038 (1.0173)	0.0036 (1.2601)
$Insize_t$	-0.4630*** (-197.3469)	5.0287*** (4.9284)	5.6883*** (6.6290)
$NCSKEW_t$	-0.0001 (-0.4538)	0.0266* (1.8169)	
$DUVOL_t$	0.0000 (0.1160)		-0.0202 (-1.3726)
$Sigma_t$	0.0042 (0.5118)	5.1029*** (3.5860)	3.8162*** (3.3112)
Ret_t	-0.0000 (-0.0939)	-0.0038 (-0.9894)	-0.0013 (-0.4056)
$TobinQ_t$	-0.0007*** (-3.6765)	0.0525*** (3.1271)	0.0480*** (3.8260)
Constant	-0.5971*** (-18.8777)	1.2817 (0.1651)	-0.2970 (-0.0486)
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	5,515	5,515	5,515
R-squared	0.9680	0.1129	0.1370

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

TABLE 10 | Impact of corporate information transparency.

Variable	(1)	(2)	(3)
	$ACCURACY_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$
$treat_i \times policy_t$	-0.0096** (-2.1193)	0.1711** (2.2912)	0.1960*** (3.2310)
$ACCURACY_{t+1}$		-1.2674*** (-4.2371)	-1.4484*** (-5.8661)
$policy_t$	-0.0027 (-0.7345)	-0.1795** (-2.1520)	-0.1238* (-1.8200)
$treat_i$	0.0301*** (10.1236)	-0.0116 (-0.2085)	0.0108 (0.2496)
Lev_t	-0.0170** (-2.2872)	-0.1005 (-0.9057)	-0.1908** (-2.1076)
ROE_t	0.0824*** (5.2669)	0.4626** (2.2249)	0.1957 (1.3375)
$Cashflow_t$	0.0304** (2.3892)	-0.3596 (-1.4913)	-0.2405 (-1.1306)
$Balance_t$	-0.0000 (-0.0219)	0.0040 (0.1477)	-0.0054 (-0.2374)
$Dturn_t$	-0.0013 (-0.4310)	-0.0805 (-1.2155)	-0.0976* (-1.7937)
age_t	-0.0002 (-0.9985)	0.0024 (0.5964)	0.0025 (0.7943)
$Insize_t$	-0.1339*** (-3.7859)	-0.4576 (-1.1251)	0.1370 (0.5081)
$NCSKEW_t$	0.0048** (2.0468)	0.0136 (0.9551)	
$DUVOL_t$	-0.0167*** (-6.2207)		-0.0398*** (-2.7094)
$Sigma_t$	-0.1833** (-2.2680)	5.0573*** (3.1535)	3.3163*** (2.6784)
Ret_t	-0.0001 (-0.7849)	-0.0037 (-0.9424)	-0.0010 (-0.3066)
$TobinQ_t$	0.0025*** (3.4180)	0.0552*** (3.1043)	0.0497*** (3.5267)
Constant	0.7319** (2.1641)	-4.0866 (-0.4820)	-5.9671 (-0.9454)
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	4,986	4,986	4,986
R-squared	0.2154	0.1128	0.1381

(1) Robust standard errors are clustered by industry and t-statistics are reported in parentheses; (2) *, **, *** represent significant at the 10, 5, and 1% significance level, respectively.

Firm Size

To investigate whether the relationship between GCP and the stock price crash risk of heavy-polluting firms is affected by firm size, we divide the sample into subgroups according to the following criteria and regress the subgroups: if a firm's market value⁹ exceeds the sample's mean value (Cui et al., 2021), it is classified as a large-sized firm; otherwise, a small-sized firm.

Table 8 reports the regression results by firm size, which show that the coefficients of $treat_i \times policy_i$ for the small-sized firms are significantly positive at the 1% level, but are insignificant for the large-sized firms. It can be concluded that the impact of GCP on the stock price crash risk of heavy-polluting firms is more pronounced in small-sized firms. This supports Hypothesis 3.

MEDIATING ANALYSIS

The baseline results in section "The Impact of Green Credit Policy on Stock Price Crash Risk" demonstrate that green credit policy (GCP) raises the stock price crash risk of heavy-polluting firms significantly. In this section, we will further examine how corporate information transparency and financial constraints play a role in transferring the impact of GCP on stock price crash risk.

Financial Constraints

Following Hadlock and Pierce (2010), we use sa_{t+1} ¹⁰ to measure corporate financial constraints. **Table 9** reports the results for the mediating effect of financial constraints. As shown in column (1), the impact of GCP on the stock price crash risk of heavy-polluting firms is positively transmitted by the firms' financial constraints, indicating that GCP increases the financial distress of heavy-polluting firms. In addition, the results in columns (2) and (3) indicate that the increased financial constraints caused by GCP on heavy-polluting firms results in significant increase in their price crash risk.

Corporate Information Transparency

Following Lang et al. (2012), we use analysts' earnings forecast accuracy, $ACCURACY_{t+1}$, to measure corporate information transparency; the higher the value of $ACCURACY$, the more information transparency the firm has. **Table 10** reports the results for the mediating effect of corporate information transparency. As shown in column (1), the impact of GCP is negatively related to the information transparency of heavy-polluting firms, indicating that GCP decreases the information transparency of heavy-polluting firms. In addition, the results in columns (2) and (3) show that the negative impact of GCP on the information transparency of heavy-polluting firms can increase their price crash risk.

⁹This data comes from the China Stock Market Accounting Research (CSMAR).

¹⁰According to Hadlock and Pierce (2010), $sa_{t+1} = -0.737 * size_{it+1} + 0.043 * size_{it+1}^2 - 0.04 * age_{it+1}$, where $size_{it+1}$ denotes firm size and age_{it+1} represents firm age.

CONCLUSION AND POLICY IMPLICATIONS

This paper explores the impact of green credit policy (GCP) on stock price crash risk using Chinese A-share listed firms as the research setting in the context of the *Green credit guidelines* issued by the China Banking Regulatory Commission (CBRC) in 2012. The DID results show that the implementation of GCP significantly increases stock price crash risk, and this finding passes a battery of robustness checks. However, the results are influenced by two factors: the quality of external governance and the size of the firm, and GCP has a more significant impact on the stock price crash risk in heavy-polluting firms with weak external governance and a small size. In addition, the mediating analysis shows that corporate information transparency and financial constraints play a mediating role in transferring the impact of GCP on stock price crash risk. The GCP increases the financial constraints of heavy-polluting firms and decreases their information transparency, which in turn affects their risk of a price crash.

The implementation of GCP increases the risk of heavy-polluting firms experiencing price crashes, prompting them to invest in green projects, minimize negative environmental impacts, and enhance corporate sustainability. Based on our findings, we propose the following policy recommendations to strengthen GCP's environmental regulatory effect: First, commercial banks, as the examination and approval department in the execution of GCP, should strictly adhere to GCP regulations when granting loans to firms, and higher authorities should provide proper oversight and inspection. Second, GCP's goal is not to trigger a stock market crash but to rationalize capital allocation. Therefore, in order to reduce the price crash risk, heavy-polluting firms should enhance corporate information transparency and expand corporate financing channels by strengthening corporate compliance, improving external governance, and increasing firm value. Finally, green transformation is the key to corporate sustainability. Heavy-polluting firms should enhance their environmental awareness, expedite green transformation and innovation, and lower corporate risks to achieve corporate sustainable development and fulfill social and environmental responsibility.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: <https://www.gtarsc.com> and <https://www.wind.com.cn>.

AUTHOR CONTRIBUTIONS

WZ, YL, FZ, and HD contributed to conception and design of the study. WZ and YL organized the database and performed the statistical analysis. All authors wrote the first draft of the manuscript, contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This research was supported by the National Social Science Foundation of China (Grant No. 21BTJ064), the National Social

Science Foundation of China (Grant No. 20BTJ030), the National Nature Science Foundation of China (Grant No. 72072070), and the Nature Science Foundation of Guangdong Province (Grant No. 2020A1515010402).

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APPENDIX

Appendix A | Variable definitions.

Variables	Definitions
$NCSKEW_{t+1}$	Skewness of the negative stock return
$DUVOL_{t+1}$	Fluctuation in the stock return.
$treat_i$	An indicator variable takes the value of 1 if firm i belongs to the treatment group (i.e., the firm belongs to heavy-polluting industries), and 0 otherwise.
$policy_t$	A binary variable takes the value of 1 after the green credit policy (2015–2012), and 0 otherwise (2009–2011).
Lev_t	The book value of total debt divided by the book value of total assets.
ROE_t	The net profit divided by the average balance of shareholder equity
$Cashflow_t$	Net cash flow from operating activities divided by total assets
$Balance_t$	The sum of the shareholdings of the second to fifth largest shareholders divided by the shareholding of the first largest shareholder
$Dturn_t$	the average monthly share turnover in year t minus the average monthly share turnover in $t - 1$
age_t	A firm age since listing
$Insize_t$	Natural logarithm of a firm's total assets
$Sigma_t$	Standard deviation of the stock's firm-specific weekly return
Ret_t	Mean of the stock's firm-specific weekly return.
$TobinQ_t$	The net profit divided by the average balance of shareholder equity
$IsDuality_i$	Whether the company's chairman and CEO are the same person
$gender_i$	A dummy variable takes the value of 1 if the CEO is male and 0 if female
$oveseaback_i$	A dummy variable takes the value of 1 if the CEO has overseas background, 0 otherwise



The Impact of eSports Industry Knowledge Alliances on Innovation Performance: A Mediation Model Based on Knowledge Sharing

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This study investigates the associations among member ability, member relationships, knowledge sharing, and innovation performance in eSports industry knowledge alliance. A survey strategy and purposive sampling were applied, and the analysis was conducted on a sample of 311 senior managers from the China eSports Association. The hypotheses were tested using SPSS 24.0 software and AMOS 24.0 software. This study shows that member ability and member relationships have both a direct and indirect effect on innovation performance. Firstly, member ability, member relationships, and member knowledge sharing significantly impact the innovation performance of eSports industry knowledge alliances. Secondly, member knowledge sharing plays a mediating role in the effect of member ability and membership relationship on innovation performance. This pioneering article explores the interaction mechanisms between member ability, member relationships, and innovation performance in eSports industry knowledge alliance. The research results are conducive to the development of the eSports industry toward deep integration and sustainable development and provide a reference for similar knowledge-intensive enterprise alliance behaviors.

Keywords: knowledge sharing, innovation performance, member ability, member relationships, eSports industry, knowledge alliances

OPEN ACCESS

Edited by:

Shiyang Hu,
Chongqing University, China

Reviewed by:

Xiaohong Liu,
Southwest Minzu University, China
Zuoliang Ye,
Southwestern University of Finance
and Economics, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 23 March 2022

Accepted: 08 April 2022

Published: 02 May 2022

Citation:

Yue L, Zheng Y and Ye M (2022)
The Impact of eSports Industry
Knowledge Alliances on Innovation
Performance: A Mediation Model
Based on Knowledge Sharing.
Front. Psychol. 13:902473.
doi: 10.3389/fpsyg.2022.902473

INTRODUCTION

eSports first originated in the 1990s. As an emerging competitive sport, eSports have developed into electronic game competitive sports with the same spirit as that of modern competitive sports (Heere, 2018). It is generally believed that the eSports industry plays a significant role in stimulating economic development and solving the issue of unemployment (Kim et al., 2020). The eSports industry chain attracts multiple parties to participate, and the establishment of strategic alliances is a relatively common form of organization in this industry. With the advent of the knowledge economy, knowledge has replaced traditional resources as a critical hidden asset and is an essential source of sustainable competitive advantage for enterprises (Drucker, 1999; Popkova, 2019). In the context of the rapid development of knowledge management theory, the research on strategic alliance theory has gradually evolved into a new concept—the knowledge alliance (Morrison and Mezentseff, 1997; Schoenmakers and Duysters, 2006). A knowledge alliance is a partnership in which enterprises or other institutions cooperate closely. Its essence is to create new knowledge and carry out knowledge transfer jointly. The knowledge alliance is not a collaborative relationship formed to expand production

and sales but rather one to pay more attention to low-cost knowledge exchange, sharing, and innovation among different organizations within the alliance. Through knowledge alliances, companies can gain knowledge innovation capabilities (Zhang et al., 2019; Zhao et al., 2021). Innovation is an inexhaustible driving force for developing knowledge alliances (Udriyah et al., 2019; Distanont and Khongmalai, 2020).

Choosing the right knowledge partner for an eSports industry knowledge alliance becomes the key to its success. The selection of members, especially core members, is related to realizing all strategic goals and benefits of the union. Member capabilities and relationships have an enormous impact on industry alliances (Todeva and Knoke, 2005; Rezazadeh and Nobari, 2018). Following the characteristics of eSports knowledge innovation, the present research evaluates members' capabilities from two aspects: knowledge specificity and knowledge innovation ability. The closeness of the relationship between alliance members is assessed from two factors: cooperation spirit and trust. Knowledge sharing among members is the basis for knowledge innovation in eSports industry knowledge alliances (Li et al., 2022). Teece (1986) mentioned that it is difficult for any organization to obtain all knowledge resources and that all knowledge resources must be scattered among various organizations. Therefore, acquiring knowledge from other organizations through limited knowledge sharing has become the best choice for enterprises. Hamel (2005) found that the primary purpose and motivation for establishing alliances between enterprises is to share knowledge resources through mutual learning. Knowledge sharing can be understood as the flow of knowledge from one organization to another. However, alliance members need to use their absorptive capacity to digest and absorb the newly acquired knowledge and further integrate it into their knowledge system, transforming it into new knowledge (Arora et al., 2021).

With the construction of knowledge alliances, enterprises can solve the problem of insufficient internal knowledge capital resources, enabling them to form cooperation, mutual assistance, and mutual supplementation to achieve the joint acquisition and effective use of knowledge capital. However, whether the emergence of knowledge alliances among eSports companies can play the role of knowledge innovation and promote the development of new technologies remains to be further studied. Based on this, this article takes knowledge governance as the theoretical basis and examines mainly whether the relationship between members and the ability of members in eSports industry knowledge alliances affects the innovation performance of alliances through knowledge sharing.

THEORETICAL MODEL AND HYPOTHESES

Knowledge Governance Theory

The idea of knowledge governance starts from the vast divergence and continuous debate between transaction cost theory and enterprise knowledge theory. In the past 30 years, the vigorous rise of knowledge movement and knowledge management

indicates that human society is entering the development stage of knowledge society from industrial society. The concept of knowledge governance proposed by Grandori (2001) replaces the original enterprise theory. He believes that its definition should govern knowledge exchange, transfer, and sharing within and outside the organization and the coordination mechanism of knowledge nodes. Foss et al. (2003) propose another definition: knowledge governance is the optimization of knowledge acquisition, construction, sharing, and distribution by selecting or influencing formal organizational mechanisms and structures. Antonelli (2005) believes that knowledge governance is an administrative form of knowledge production and use through institutions, policies, corporate strategies, transaction types, and interactions. From the definitions given by the above scholars, it can be seen that knowledge governance is an activity that optimizes the acquisition, exchange, transfer, sharing, distribution, flow, innovation, and other forms of knowledge in enterprises to achieve the purpose of knowledge utilization and development of new knowledge. The research object of knowledge governance is how different organizational structures, incentive methods, contract methods, other rigid factors, psychological contracts, corporate culture, etc., have different effects on organizational knowledge management activities (Foss, 2007).

The eSports industry is a brand-new industrial form, and its development requires a corresponding management form. The e-sports industry alliance is a common intermediate organization form for e-sports enterprises. The development of eSports enterprises characterized by knowledge production, exchange, and utilization has different requirements from the traditional economy. The cross-border integration between industries is to achieve the extension of the industrial value chain through the mutual integration of existing industrial elements and resources. In this process, knowledge sharing among members is of great significance to the development of the eSports knowledge alliance.

Member Ability and Alliance Innovation Performance

The choice of alliance partners has always been one of the hotspots of industry alliance research. The choice of which members to cooperate with has an enormous impact on industry alliances. In alliance formation, the primary consideration for members is the complementarity of resources between associations (Furlotti and Soda, 2018; O'Dwyer and Gilmore, 2018). Companies that have vital resources that other members do not have are more attractive to those other members. This essential resource can be a specific technology or successful management experience. Harrison et al. (2001) pointed out that if the resources of alliance members are too similar, then the performance of that alliance is far inferior to that of those alliances with different resources that can complement one another. At the same time, when a company is in a highly uncertain environment, identifying companies with complementary resources with which to establish partnerships to reduce the impact of environmental changes on the company

becomes increasingly necessary. The importance of membership capabilities to the success or failure of industry alliances has been confirmed by the extant research. Drawing on the absorptive capacity perspective, Lin et al. (2012) argued that firms with a high level of such capacity seem to benefit more from their alliances than those with a low level of such ability. Argote and Ingram (2000) suggested that corporate learning capabilities affect alliance innovation, while Cummings and Teng (2003) said that companies' alliance experience and qualifications affect alliance innovation. Moreover, Makri and Lane (2010) suggested that corporate organizational structure, partner selection, and similarity between companies affect alliance innovation. Since the innovation activities of the eSports industry require many resources and a great deal of time, once an alliance's knowledge innovation fails, its members may lose valuable development opportunities. Therefore, eSports knowledge alliances must carefully select members to reduce risks as much as possible. Members who are too weak are not conducive to the development of eSports knowledge innovation. In this study, based on previous studies, members' ability is evaluated in terms of knowledge exclusivity and knowledge innovation ability.

The knowledge exclusivity of members refers to the number of standards and patents owned by an organization. The adequate management of the intellectual property is critical to sustaining competitive advantage and managing outbound open innovation, which describes the inside-out flows of knowledge and technology (Grimaldi et al., 2021). Intellectual property and knowledge management practices positively correlate with innovation activities (Law et al., 2021). The results of Roh et al. (2021) revealed that a firm's intellectual property rights and government support significantly affect open, green process, and green product innovation. The innovation of eSports knowledge covers many aspects, the most valuable of which is eSports content and technology, and the most urgently needed is the innovation of eSports industry standards (Kim et al., 2020). In eSports industry knowledge alliances, related intellectual property rights can be divided into core and marginal categories. A core intellectual property right is highly related to the alliance's knowledge innovation direction. Core intellectual property plays a significant role in the knowledge innovation process of partnerships. If the core intellectual property is lacking, then the knowledge innovation of the alliance ends. Members with core intellectual property rights can occupy a dominant position in the alliance and have a vital influence on its development (Wang et al., 2021). The success of an alliance's knowledge innovation further enhances the competitiveness of core members.

The knowledge innovation ability of members examines mainly the organization's knowledge stock, whether the enterprise has carried out knowledge innovation, and the frequency, quantity, and level of such innovation. In the innovation process of eSports industry knowledge alliances, the learning ability of members is crucial. In the highly technical and fast-developing eSports industry, any enterprise can quickly adapt to the development of the situation and absorb and learn knowledge quickly. The research of Gianmario and Davide (2003) confirmed that the innovation ability of members promotes the overall innovation ability of

the alliance. Jin and Yun (2013) studied the mechanism of technological innovation in enterprise management innovation and suggested that management innovation is the guarantee and prerequisite for technological innovation. Suppose a particular enterprise in an alliance has a high level of innovation. It affects its innovation and positively impacts other members, thereby improving overall innovation performance. The research results of Bai et al. (2021) demonstrated that organizational learning capacity positively affects the innovation performance of freight logistics services. From the above analysis, it can be seen that the partner selection of an industry alliance is one of the essential dimensions that affect the performance of eSports industry alliances. Based on this result, combined with the knowledge innovation characteristics of the eSports industry, the paper puts forward the following hypotheses:

H1: *Knowledge exclusivity has a significantly positive impact on alliance innovation performance.*

H2: *Knowledge innovation ability has a significantly positive impact on alliance innovation performance.*

Member Relationship and Alliance Innovation Performance

How the relationship between members affects the performance of industry alliances is also one of the critical areas to which researchers have paid attention. The relationship between knowledge alliance members is divided into many levels, with different researchers conducting research from different perspectives. Robert et al. (1998) proposed that the mutual relationship of alliance members can be described in terms of investment level, return, trust, uncertainty, etc. According to the characteristics of eSports knowledge innovation, from the perspective of the closeness of alliance members, the level of the relationship between eSports industry knowledge alliance members is mainly reflected in two aspects: cooperative spirit and trust level.

Boh et al. (2020) found that corporate investors with broad investment experience strengthen a firm's environmental scanning abilities, enhancing innovation performance by increasing the number of external cooperation activities in which the firm engages. Choi and Choi (2021) found that vertical R&D cooperation positively affected overall industry performance, especially on service and marketing performance.

eSports knowledge comes from different fields, and the eSports industry is constantly absorbing innovations from other areas and applying them to eSports. Suppose a good member cooperative relationship can be formed in an eSports industry knowledge alliance. In that case, the knowledge achievements of different subjects can be used to promote the effective development of eSports knowledge innovation activities. Suppose a good member cooperative relationship can be formed in an eSports industry knowledge alliance. In that case, the knowledge achievements of different subjects can be used to promote the effective development of eSports knowledge innovation activities. The effect of member partnership on the performance of eSports industry knowledge alliances is more manifested as a process

effect. Suppose the spirit of cooperation among members is poor. In that case, the knowledge innovation activities of the eSports industry knowledge alliance are unable to operate, resulting in the alliance's failure. In contrast, if there is a spirit of cooperation among alliance members, the knowledge innovation process between associations is smoother.

The coexistence of competition and cooperation is the primary feature of the membership of an industrial alliance. Although establishing an industrial partnership promotes knowledge sharing, the relationships between industrial alliance members cannot be regarded as only cooperative. Harrigan (1986) suggested that industry alliances need to formulate rules or sign contracts to regulate and constrain members' behavior. When dealing with the relationship between members of a knowledge alliance, trust among members is extremely important. At the same time, Ring and Van de Ven (1994) suggested that establishing a trusting relationship between individuals is the key to alliance success. Later, Birnberg (1998) came to the same conclusion, meaning that trust can have the same effect as a control. In his analysis of alliance trust, he proposed that the analysis results come from two assumptions: first, alliance members believe that default makes them lose more, and second, alliance members hope to form a set of reciprocity standards. Adobor (2005) suggested that the establishment of sufficient trust among alliance partners is the key to alliance success and analyzed the generation mechanism of trust in the context of cooperation. Trust is the basis and premise of collaboration and can also improve the efficiency of communication and collaboration among members and reduce the dependence on formal rules and regulations (Poppo and Zenger, 2002). Le and Lei (2018) found a mediating role of trust in stimulating the relationship between transformational leadership and knowledge sharing processes. The results of Arroyave et al. (2020) showed that firms that value cooperation with universities develop a more comprehensive range of environmental innovations and increase their sales and benefits.

As an informal organization, an eSports industry knowledge alliance cannot establish a power relationship between subordinates as can a single organization. Therefore, effective collaboration is more critical to the coalition. The establishment of mutual trust and cooperation between different subjects can better stimulate members' creativity through information exchange to discover opportunities for innovation and obtain innovative results. Accordingly, the paper proposes the following hypotheses:

H3: Cooperative spirit has a significant positive impact on alliance innovation performance.

H4: Trust level has a significant positive impact on alliance innovation performance.

Knowledge Sharing and Alliance Innovation Performance

The theory of knowledge holds that knowledge is an essential resource for maintaining the competitive advantage of market players (Grant and Baden-Fuller, 1995). Enterprises must

effectively acquire and develop knowledge. In addition to integrating one's internal knowledge, acquiring external knowledge is also essential for an enterprise. Organizational learning theory suggests that learning from other organizations is crucial for enterprises acquiring knowledge. Through practical learning, enterprises can develop new knowledge and expand the depth and breadth of such knowledge (Lane et al., 2001). An important consideration for members in joining a knowledge alliance is to share and exchange knowledge with partners and apply it to their development process to make up for their knowledge deficiencies at a relatively small cost. Obtaining knowledge from other alliance members can enrich the knowledge reserve of members and help them innovate knowledge and seize new market opportunities (Kim et al., 2011). Most scholars have suggested that knowledge sharing positively impacts innovation performance. Using hierarchical multiple regression and moderated multiple regression methods, the results from a survey of 236 firms in China indicated significant positive relationships among collaborative innovation activities, knowledge sharing, collaborative innovation capability, and firm innovation performance (Wang and Hu, 2020). Mardani et al. (2018) found that knowledge creation, integration, and application facilitate innovation and performance. Muhammed and Zaim (2020) found that the extent of employees' engagement in knowledge sharing behavior has a positive impact on organizations' knowledge management success, which, in turn, can positively affect organizations' innovation performance. Tassabehji et al. (2019) investigate knowledge sharing and its contribution to firm innovation performance improvements. Results from a survey of 236 firms in China indicated significant positive relationships between collaborative innovation activities, knowledge sharing, collaborative innovation capability, and a firm's innovation performance. Moreover, knowledge sharing is expected to play a partial mediating role in the relationships between collaborative innovation activities and the firm's innovation performance (Wang and Hu, 2020). Knowledge sharing and innovation strategy fully mediate the relationship between outside-in OI and innovation performance (Bagherzadeh et al., 2019). The result of Hanifah et al. (2021) shows that knowledge sharing significantly impacts firm innovation performance. Based on the above analysis, this paper puts forward the following hypothesis:

H5: Member knowledge sharing has a significant positive impact on alliance innovation performance.

Mediating Effect of Knowledge Sharing

In the era of the knowledge economy, knowledge, especially tacit knowledge, is the key to the core competitiveness of enterprises. Knowledge sharing can effectively integrate mutually complementary resources to rapidly respond to the market and improve competitive advantages (Wang and Noe, 2010; Jiang and Chen, 2021).

Knowledge sharing can be understood as the process of knowledge dissemination among individuals or organizations to further absorb and internalize it into their knowledge and, on this basis, carry out further innovation to realize value creation. The

knowledge management theory shows that only through a wider range of mutual communication, learning and sharing can the utilization and value-added effect of knowledge be better. The research of Singh et al. (2021) suggested that top management knowledge value and knowledge sharing practices influence open innovation, which, in turn, affects organizational performance.

Knowledge-sharing behavior has long been regarded as the most crucial link between knowledge management factors. Knowledge sharing is an indicator of knowledge management and organizational learning effectiveness (Yang and Xu, 2021). Lee (2001) suggested that knowledge sharing at different levels between firms and within firms has different effects on innovation performance. Song et al. (2015) examined servant leadership as a precursor to a knowledge-sharing climate. They demonstrated the mediating role of such a knowledge-sharing climate in the relationship between servant leadership and team performance. Al-Husseini et al. (2021) examined the linkages among transformational leadership, knowledge sharing, and innovation in higher education. A positive direct impact was found in transformational leadership, knowledge sharing, and innovation. Moreover, knowledge sharing was identified as a mediator between transformational leadership and innovation.

Accordingly, the paper proposes the following hypotheses:

H6: *Knowledge sharing mediates the effect of knowledge exclusivity on innovation performance.*

H7: *Knowledge sharing mediates the effect of learning innovation ability on innovation performance.*

A good partnership can promote knowledge sharing among enterprises, and there is also a positive relationship between knowledge sharing and innovation performance. Knowledge collaboration can improve the efficiency of knowledge flow and sharing and is also a meaningful way to generate value-added knowledge (Cheng and Chang, 2020). Knowledge sharing is a mediator between collaborative culture and innovation capability (Yang et al., 2018).

Inkpen (1998) pointed out that members take a cautious attitude toward knowledge sharing, but to achieve the alliance's goals, alliance members can only share knowledge. In addition, member trust helps promote the knowledge transfer of the alliance. Moreover, the above author pointed out that the accessibility of alliance knowledge, including the trust among alliance members, the degree of knowledge protection, the degree of tacit knowledge, and the past development history of alliance members, are the main factors that affect alliance knowledge sharing. Delbufalo (2012) suggested that this kind of trust is extremely important to the willingness to share knowledge among alliance members. The results of the (Ogunmokun et al., 2020) revealed that both knowledge sharing behaviour mediates the positive effect of propensity to trust on service innovation. Accordingly, this paper proposes the following hypotheses:

H8: *Knowledge sharing mediates the effect of cooperative spirit on innovation performance.*

H9: *Knowledge sharing mediates the effect of trust level on innovation performance.*

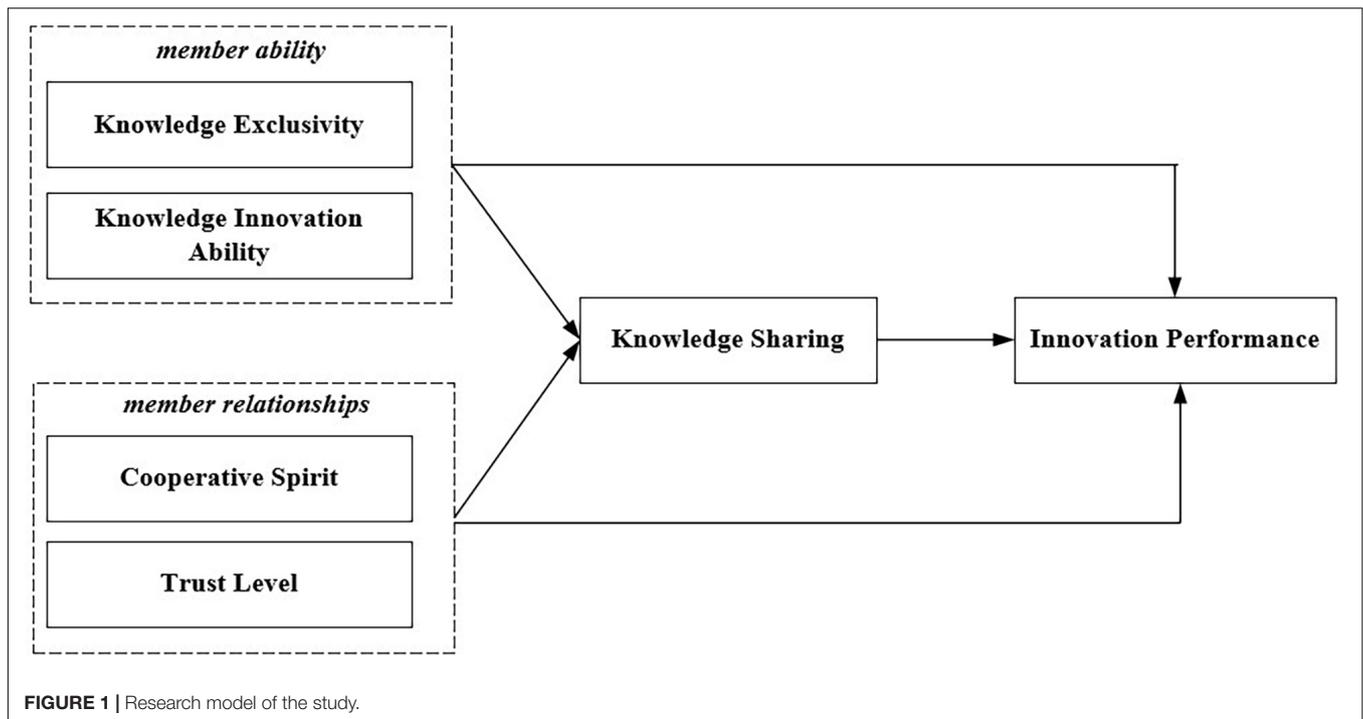
In the process of knowledge alliance innovation, alliance members need to cooperate with different types of subjects to combine different kinds of innovation resources (Steensma and Corley, 2000). The members of eSports industry knowledge alliances must collaborate with other members, gain new knowledge from other members, and jointly invest in eSports knowledge innovation through knowledge sharing. This paper constructs the innovation performance relationship model of eSports industry knowledge alliances from the perspective of the factors of eSports industry member ability, member relationships, and member knowledge sharing, as shown in **Figure 1**.

MATERIALS AND METHODS

This study is cross-sectional, and a structured questionnaire was used to evaluate quantitative data. A total of 23 items were employed to develop a questionnaire for variable analysis. The questionnaire takes the form of a commissioned survey. Participants are senior managers of eSports competition organizers, eSports content producers, eSports operators, eSports media, eSports equipment developers and manufacturers, eSports participants, and eSports management departments. Through the recommendation of the Sichuan eSports Association, an electronic questionnaire is distributed among alliance members in 22 provinces, autonomous regions, and municipalities affiliated with the China eSports Association. A total of 400 electronic questionnaires were distributed, and 346 questionnaires were recovered, for a recovery rate of 86.5%. 35 invalid questionnaires are eliminated, and 311 valid questionnaires are finally obtained for an effective rate of 90%. The reliability and validity tests of the measurement scale and the whole model were tested using SPSS 24.0 software and AMOS 24.0 software. As a result, previous research measurements were used in this study to assess all the constructs of the current model.

Variable Measurement

Researchers can develop measurement scales using deductive methods based on theoretical support and a clear understanding of the connotation and structure of constructs (Hinkin, 1995). This paper refers to the existing literature to design measurement items for each variable. The scale items are revised according to the interviews conducted with managers of eSports enterprises and industry associations in eSports industry knowledge alliances, as well as experts and scholars in related research fields. All variables in the questionnaire are scored using a 5-point Likert scale, with "completely disagree," "partially disagree," "uncertain," "partially agree," and "completely agree" corresponding to scores of 1–5, respectively. The questionnaire is divided into two parts. The first part is the basic information of respondents, including gender, age, working time in the eSports industry, and the type of eSports organization for which they work. The second part is the measurement items of the main



variables involved in this research, namely, alliance member ability (knowledge specificity and knowledge innovation ability), alliance member relationship (cooperative spirit and trust level), alliance member knowledge sharing, and alliance innovation performance, for a total of 6 variables and 23 items.

In this study, the ability of alliance members involves two dimensions: knowledge specificity and learning and innovation ability. According to Hitt et al. (2012), this study sets 4 items for the measurement of knowledge specificity and learning innovation ability. Alliance membership in this study involves two dimensions: cooperative spirit and trust level. According to the research of Chen and Yang (2014), four items are set to measure cooperation spirit and trust level. This paper refers to the study of Ipe (2003) and selects three items to measure the knowledge-sharing behavior of alliance members. Drawing on the views of scholars such as Brouwer and Kleinknecht (1999), combined with in-depth interviews, this paper sets up four items for the measurement of alliance innovation performance and verifies the independence of the above indicators.

Descriptive Analysis

The study sample is 66% male and 34% female. In terms of age, the 20-to-30-year-old age group is the majority, accounting for 45.02% of the sample, followed by the 31-to-40-year-old age group, accounting for 25.72%, the under 20-year-old age group, accounting for 12.54%, the 41-to-50-year-old age group, accounting for 10.93%, and the over-50-year-old age group, accounting for 5.79%. In terms of working time in the eSports industry, the proportion of those working less than 1 year is the largest, accounting for 39.55%; the second is those working 1–3 years, accounting for 38.91%; and the third is

those working more than 6 years, accounting for 12.54%. The lowest is those working 4–6 years, accounting for 9.00%. In terms of the types of eSports organizations, eSports participants and eSports management departments account for the largest proportions, at 18.33% and 15.43%, respectively. The remaining eSports organizations are eSports competition organizers, eSports operators, educational institutions, eSports media, scientific research institutions, eSports content producers, and eSports equipment developers and manufacturers, the proportions of which are 12.86%, 11.58%, 11.58%, 10.61%, 8.36%, 5.79%, and 5.47%, respectively.

Reliability Test

In this study, the average score of the six factors is used as the variable score. The mean, standard deviation, and pairwise Pearson correlation coefficient of the variables are calculated. The results are shown in **Table 1**, in which the Cronbach's α reliability coefficient of the scale is in parentheses on the diagonal.

From **Table 1**, it can be seen that the correlation between the main variables in this study reaches a significant level, which lays the foundation for further hypothesis testing. At the same time, Cronbach's α reliability coefficient values of all scales are more significant than 0.6, meeting the statistical requirements. It should be noted that from the test results, the Cronbach's α value of each scale is shown not to be high, possibly because there are fewer measurement items (3 or 4 items) for each variable in this study. Few items are used for measurement because it is difficult to collect data on the senior managers of enterprises or organizations related to eSports industry knowledge alliances. Using fewer items to measure is

TABLE 1 | Correlation analysis and reliability test results of each variable.

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1 Gender	1.39	0.49										
2 Age	2.52	1.03	-0.035									
3 Working time	1.95	0.99	-0.069	0.157**								
4 Organization type	5.15	2.52	0.019	-0.057	-0.158**							
5 Knowledge exclusivity	4.11	0.73	0.009	-0.044	0.026	0.018	(0.614)					
6 Learning innovation ability	3.84	0.79	-0.083	-0.117*	-0.021	0.026	0.312**	(0.607)				
7 Cooperative spirit	4.00	0.79	-0.029	-0.229**	-0.033	0.013	0.275**	0.458**	(0.630)			
8 Trust level	3.59	0.82	0.008	-0.196**	-0.122*	0.049	0.223**	0.291**	0.334**	(0.709)		
9 Knowledge sharing	3.83	0.95	-0.029	-0.182**	0.02	0.031	0.255**	0.304**	0.336**	0.270**	(0.705)	
10 Innovation performance	3.65	0.88	-0.064	-0.275**	-0.145*	0.014	0.148**	0.401**	0.386**	0.357**	0.402**	(0.714)

** $p < 0.01$, * $p < 0.05$.

convenient to meet the statistical requirements of 5–10 times between the sample size and item size.

RESULTS

Empirical Analysis of the Main Effects Influence of Member Ability on Alliance Innovation Performance

The linear regression method tests the influence of the two dimensions of alliance member ability on innovation performance. **Table 2** presents the test results of linear regression.

From **Table 2**, it can be seen that knowledge specificity and learning innovation ability in M2 and M3 have a significant positive impact on innovation performance ($\beta = 0.141$, $p < 0.05$; $\beta = 0.370$, $p < 0.01$), so research Hypotheses H1 and H2 are verified. When knowledge specificity and learning innovation ability are entered into the regression model together, only learning and innovation ability are positively significant for the impact of knowledge technology innovation ($\beta = 0.361$, $p < 0.01$), but knowledge specificity is not ($\beta = 0.029$, n.s.). This

finding shows that alliance members' learning and innovation ability has a greater impact on the performance of alliance knowledge innovation.

Influence of Member Relationships on Alliance Innovation Performance

A linear regression method is used to test the influence of the two dimensions of alliance membership on innovation performance. **Table 3** presents the regression test results.

Table 3 shows that both the spirit of cooperation and trust in M2 and M3 have a significant positive impact on innovation performance ($\beta = 0.338$, $p < 0.01$; $\beta = 0.308$, $p < 0.01$). Therefore, research Hypotheses H3 and H4 are verified. When the spirit of cooperation and the trust level is entered into the regression model together, the two effects are still significant (M4, $\beta = 0.269$, $p < 0.01$; $\beta = 0.226$, $p < 0.01$).

Impact of Member Knowledge Sharing on Alliance Innovation Performance

The linear regression method is used to test the effect of knowledge sharing among alliance members on alliance innovation performance. **Table 4** presents the test results.

Table 4 shows that knowledge sharing among alliance members in M2 significantly affects innovation performance ($\beta = 0.367$, $p < 0.01$). Therefore, research Hypothesis H5 is validated.

TABLE 2 | Regression analysis of alliance member ability on innovation performance.

Independent variable	Dependent variable: innovation performance			
	M1	M2	M3	M4
Gender	-0.081	-0.082	-0.048	-0.050
Age	-0.261**	-0.254**	-0.217**	-0.217**
Working time	-0.109*	-0.114*	-0.107*	-0.108*
knowledge exclusivity		0.141*		0.029
Learning innovation ability			0.370**	0.361**
R ²	0.093	0.113	0.227	0.477
ΔR ²	0.093	0.020	0.134	0.135
ΔF	10.49**	6.79*	52.95**	26.56**

$N = 311$; ** $p < 0.01$, * $p < 0.05$; two-tailed test.

TABLE 3 | Regression analysis of Member relationship on innovation performance.

Independent variable	Dependent variable: innovation performance			
	M1	M2	M3	M4
Gender	-0.081	-0.068	-0.079	-0.070
Age	-0.261**	-0.183**	-0.205**	-0.158**
Working time	-0.109*	-0.110*	-0.081	-0.088
Cooperative spirit		0.338**		0.269**
Trust level			0.308**	0.226**
R ²	0.093	0.201	0.183	0.246
ΔR ²	0.093	0.108	0.090	0.153
ΔF	10.49**	41.46**	33.89**	30.84**

$N = 311$; ** $p < 0.01$, * $p < 0.05$; two-tailed test.

TABLE 4 | Regression analysis of member knowledge sharing on innovation performance.

Independent variable	Dependent variable: innovation performance	
	M1	M2
Gender	-0.081	-0.069
Age	-0.261**	-0.191**
Working time	-0.109*	-0.127*
Knowledge sharing		0.367**
R ²	0.093	0.223
ΔR ²	0.093	0.130
ΔF	10.489**	51.198**

N = 311; **p < 0.01, *p < 0.05; two-tailed test.

Empirical Analysis of the Mediation Effect

Mediating Role Played by Member Knowledge Sharing in the Effect of Member Ability on Alliance Innovation Performance

Under the control of gender, age, and working time, the macro plug-in PROCESS3.3 in SPSS24.0 was used to test the research hypothesis. A linear regression method is used to test the mediating role of alliance member knowledge sharing in the influence of the two dimensions of alliance member ability on innovation performance. Table 5 presents the test results of linear regression.

Table 5 shows that knowledge specificity and learning innovation ability in M2 have a significant positive effect on the knowledge sharing of alliance members ($\beta = 0.0$, $p < 0.05$; $\beta = 0.0$, $p < 0.01$). In both M3 and M5, knowledge specificity and learning innovation ability have a significant positive effect on innovation performance ($\beta = 0.141$, $p < 0.05$; $\beta = 0.370$, $p < 0.01$). But when the knowledge sharing of alliance members enters the regression model, the influence of knowledge specificity on innovation performance is no longer significant (M4, $\beta = 0.053$, n.s.). However, learning innovation ability still has a significant impact on innovation performance, but it has declined (M6, $\beta = 0.289$, $p < 0.01$);

at the same time, the knowledge sharing of alliance members has a significant impact on innovation performance ($\beta = 0.354$, $p < 0.01$; $\beta = 0.283$, $p < 0.01$). These findings show that knowledge sharing among alliance members plays a complete mediating role in the influence of knowledge exclusivity on knowledge technological innovation and plays a partial mediating role in the impact of learning innovation ability on innovation performance. Therefore, research Hypotheses H6 and H7 are verified.

The structural equation modeling method is used to test further the mediating role of alliance members' knowledge sharing in the effect of member ability on alliance performance. Knowledge specificity and learning and innovation ability are independent variables, knowledge sharing among alliance members is an intermediary variable, and innovation performance is an outcome variable, as shown in Figure 2. ($\chi^2/df = 1.678$; RMSEA = 0.047; IFI = 0.933; CFI = 0.932. N = 311; **p < 0.01, *p < 0.05, †p < 0.10).

Mediating Role of Member Knowledge Sharing in the Effect of Member Relationships on Alliance Innovation Performance

This section uses a linear regression method to test the mediating role of alliance member knowledge sharing in the impact of alliance membership on innovation performance. Table 6 presents the test results of linear regression.

Table 6 shows that the cooperative spirit and trust level in M2 has a significantly positive effect on the knowledge sharing of alliance members ($\beta = 0.0$, $p < 0.05$; $\beta = 0.0$, $p < 0.01$). Both the spirit of cooperation and the level of trust in M3 and M5 significantly affect innovation performance ($\beta = 0.338$, $p < 0.01$; $\beta = 0.308$, $p < 0.01$). When the knowledge sharing of alliance members enter the regression model, the influence of cooperation spirit and trust level on innovation performance is still significant but has declined (M4, $\beta = 0.248$, $p < 0.01$; M6, $\beta = 0.230$, $p < 0.01$). At the same time, knowledge sharing among alliance members has a significant impact on innovation performance ($\beta = 0.292$, $p < 0.01$; $\beta = 0.310$, $p < 0.01$). This finding shows that knowledge sharing among alliance members partially mediates

TABLE 5 | The mediating effect of member knowledge sharing on the impact of member ability on innovation performance.

Independent variable	Dependent variable: knowledge sharing		Dependent variable: innovation performance			
	M1	M2	M3	M4	M5	M6
Gender	-0.033	-0.014	-0.082	-0.070	-0.048	-0.046
Age	-0.190**	-0.154**	-0.254**	-0.191**	-0.217**	-0.173**
Working time	0.047	0.043	-0.114*	-0.128*	-0.107*	-0.121*
Knowledge exclusivity		0.175**	0.141*	0.053		
Learning innovation ability		0.231**			0.370**	0.289**
Knowledge sharing				0.354**		0.283**
R ²	0.036	0.144	0.113	0.226	0.227	0.298
ΔR ²	0.036	0.108	0.020	0.133	0.134	0.205
ΔF	3.87*	19.16**	6.79*	26.13**	52.95**	44.47**

N = 311; **p < 0.01, *p < 0.05; two-tailed test.

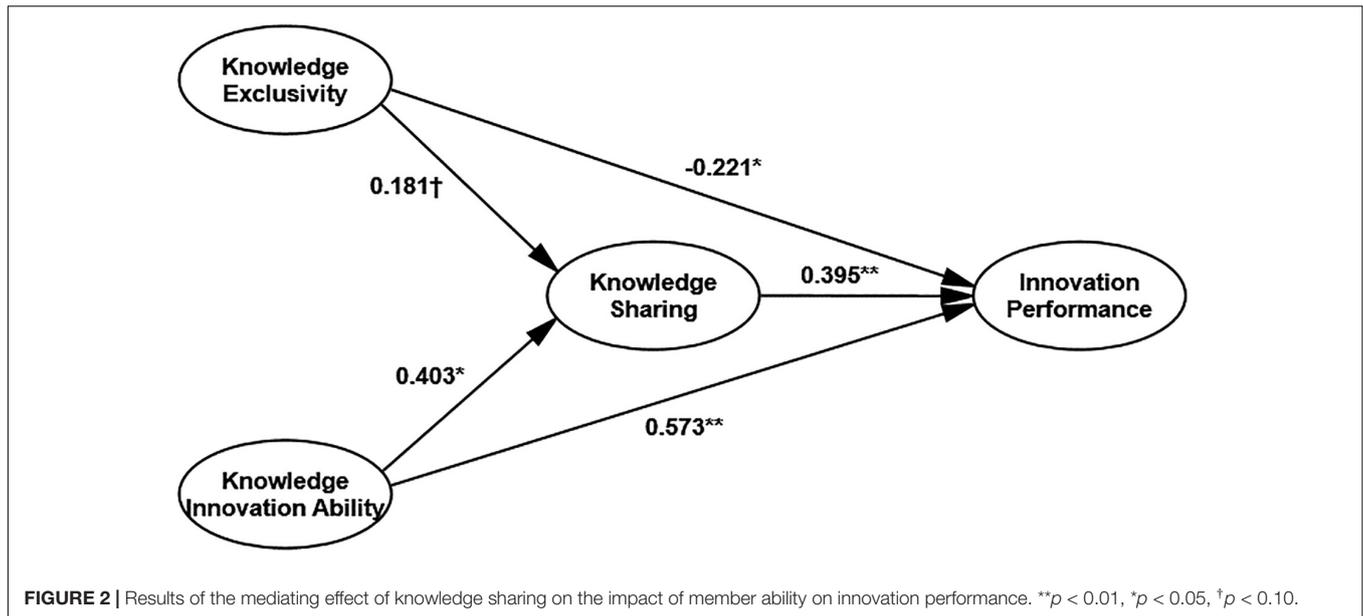
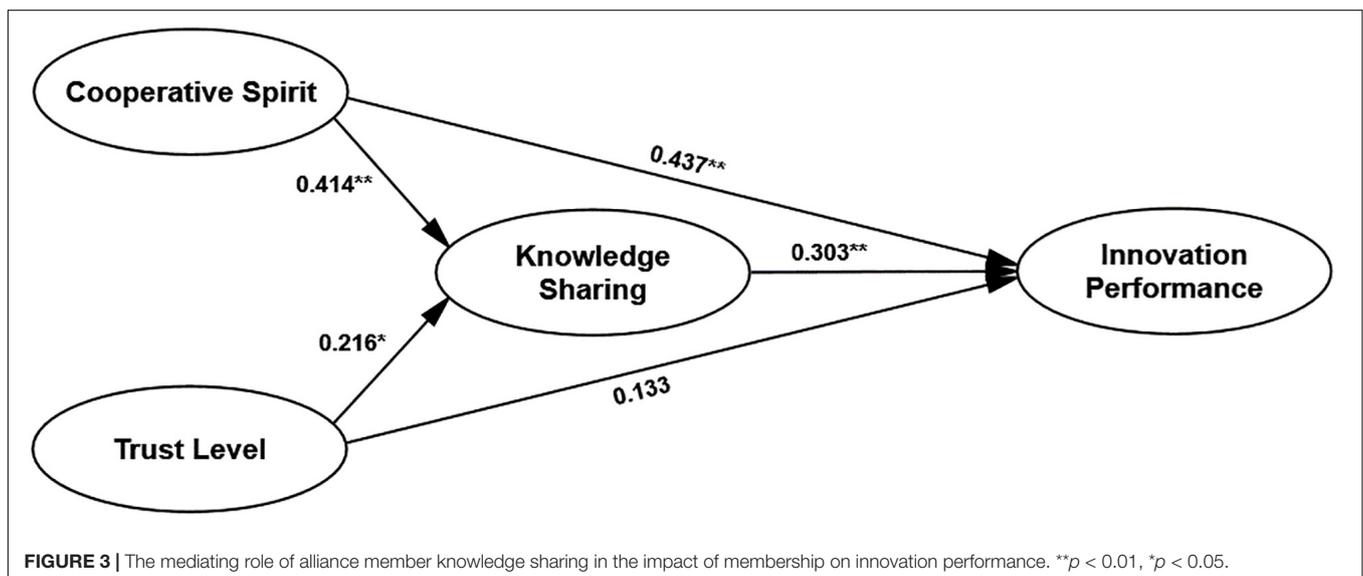


TABLE 6 | The mediating effect of member knowledge sharing on the impact of member relationship on innovation performance.

Independent variable	Dependent variable: knowledge sharing		Dependent variable: innovation performance			
	M1	M2	M3	M4	M5	M6
Gender	-0.033	-0.022	-0.068	-0.062	-0.079	-0.070
Age	-0.190**	-0.100	-0.183**	-0.149**	-0.205**	-0.160**
Working time	0.047	0.063	-0.110*	-0.123*	-0.081	-0.103*
Cooperative spirit		0.257**	0.338**	0.248**		
Trust level		0.172**			0.308**	0.230**
Knowledge sharing				0.292**		0.310**
R ²	0.036	0.153	0.201	0.276	0.183	0.270
ΔR ²	0.036	0.116	0.108	0.183	0.090	0.177
ΔF	3.87*	20.97**	41.46**	38.44**	33.89**	37.09**

$N = 311$; ** $p < 0.01$, * $p < 0.05$; two-tailed test.



cooperation spirit and trust level in innovation performance. Therefore, research Hypotheses H8 and H9 are verified.

The structural equation modeling method is used to test further the mediating role of alliance member knowledge sharing in the effect of membership on alliance performance. Cooperative spirit and trust level are independent variables, knowledge sharing among alliance members is an intermediary variable, and innovation performance is an outcome variable, as shown in **Figure 3**. $\chi^2/df = 2.166$; RMSEA = 0.061; IFI = 0.913; CFI = 0.911. $N = 311$; $**p < 0.01$, $*p < 0.05$).

CONCLUSION AND DISCUSSION

Conclusion

eSports industry knowledge alliances have become the main structural form and source of innovation for eSports enterprises. However, both in practice and theory, these alliances are still a relatively new concept. Based on previous scholars' research on innovation performance, the present research explores the influence of alliance member ability and membership relationship on alliance innovation performance utilizing a questionnaire survey and analyses the mediating role of knowledge sharing. The reliability and validity tests of the measurement scale and the whole model were tested using SPSS 24.0 software and AMOS 24.0 software. Through theoretical analysis and empirical research, the following conclusions are obtained. (1) Member ability, member relationships, and member knowledge sharing significantly impact the innovation performance of eSports industry knowledge alliances. (2) Member knowledge sharing plays a mediating role in the effect of member ability and membership relationship on the innovation performance of eSports industry knowledge alliances.

Theoretical Contributions

Member ability, member relationships, and member knowledge sharing have a significantly positive impact on the innovation performance of eSports industry knowledge alliances. Membership ability is reflected mainly in knowledge specificity and learning ability. When selecting members of the eSports industry knowledge alliance, priority should be given to choosing enterprises or organizations with robust learning and innovation capabilities and existing knowledge that complements other alliance members (Camisón and Villar-López, 2014; Najafi-Tavani et al., 2018). Membership is reflected mainly in the cooperative spirit and trust level of members, which are the basis for cooperation among alliance members (Jones et al., 2018). The theoretical assumptions that motivation induces behavior and that willingness guides action are also applicable from studying individual behavior to organizational behavior. Knowledge sharing is the foundation of promoting eSports knowledge development (Singh et al., 2021). eSports industry knowledge alliances are not enterprise organizations established based on equity but rather loose alliances based on the development of eSports knowledge.

Knowledge sharing among alliance members plays a complete mediating role in the influence of knowledge exclusivity on

technological innovation. It also plays a partial mediating role in the impact of learning innovation ability on innovation performance. Knowledge sharing among alliance members plays a partial mediating role in the influence of cooperation spirit and trust level on innovation performance. Member ability and membership relationships further affect alliance performance by affecting the knowledge sharing of eSports industry knowledge alliances. Knowledge sharing transmits information to the other party and digests and absorbs the shared knowledge, integrates it into its knowledge structure, and develops new knowledge capabilities (Ganguly et al., 2019). eSports industry knowledge alliances are common for eSports companies and organizations to expand eSports knowledge and innovate eSports products and formats.

Practical Contributions

Carefully Select eSports Industry Knowledge Alliance Members

This research has confirmed the importance of the selection of eSports industry knowledge alliance members. How to identify and selecting potential partners in practice is the prerequisite for the sustainable development of eSports industry knowledge alliances. Therefore, the selection of eSports industry knowledge alliance members should fully consider the following aspects.

The selection of alliance members needs to consider the complementarity of knowledge. The investigation of the knowledge characteristics of the eSports industry in this paper proves that the knowledge exclusivity among eSports industry knowledge alliance members has a positive impact on alliance performance. Therefore, eSports industry knowledge alliances should select members with different knowledge categories from the existing members and consider the mutual matching of knowledge systems among members when establishing cooperation. Through the differentiated resources invested in by all parties, various members provide alliances with entirely different types of resources or skills.

Organizations with solid learning abilities should be selected as alliance members. The learning ability of eSports industry knowledge alliances determines the effectiveness of eSports knowledge innovation. Therefore, members should be chosen from those organizations that pursue technological progress and maintain a certain speed of knowledge updating. The partners of eSports industry knowledge alliances are not necessarily limited to those inside the eSports industry. They can exist outside the eSports industry, those with strong technical capabilities, or cross-industry partners who occupy a substantial market according to the alliance's knowledge innovation direction.

Build Harmonious Relationships Among Alliance Members

This study proves that alliance membership positively impacts the performance of knowledge alliances in the eSports industry. The influence of member relationships on performance is much stronger than member ability. Based on this, this paper proposes the following recommendations.

During the member selection stage, the similarity of organizational culture among members should be fully

considered. Therefore, in selecting members, especially core members, it is necessary to fully consider relevant enterprises or organizations with an innovative spirit in the organizational culture. Members must recognize the league's eSports knowledge innovation activities rather than profit from joining the company (Prajogo and Ahmed, 2006).

Mutual trust and teamwork within the alliance and among its members should be encouraged. It is necessary to negotiate to determine the ownership of intellectual property rights within the alliance and the sharing ratio of eSports knowledge innovation achievements to reduce the risk of learning among members.

Facilitate Broad Knowledge Sharing Among Consortium Members

For the eSports industry knowledge alliance, attention should be paid to the simultaneous advancement of knowledge sharing in various aspects. As an emerging industry, the eSports industry is more likely to be deeply integrated with other sectors in the future. eSports industry knowledge alliances should promote the deep integration of eSports knowledge and traditional business formats to expand the profit space of the eSports industry. However, the eSports intellectual property is its core resource for any member, and the company hopes to monopolize the cooperation results. Therefore, how to balance the relationship between knowledge possession and knowledge flow direction in this contradictory state and promote cooperation among members, especially knowledge cooperation, has become one of the most critical tasks.

Limitations and Directions for Future Research

There are significant differences between Chinese and Western cultures, and the connotations of variables may be inconsistent against different cultural backgrounds. This study follows the concepts and measurements of Western scholars on member ability, member relationships, and knowledge sharing. Still, it lacks a comparison of the connotations for these variables against the backgrounds of Chinese and Western cultures. Therefore, the comparative analysis of the above variables in different cultural contexts and measurement scales of member ability, member relationships, and knowledge sharing in local Chinese culture needs to be developed.

In the future development of research, the following issues should be considered and explored:

(1) Empirical research on different types of eSports companies needs to be conducted in-depth. eSports industry knowledge alliances cover almost all eSports companies, including eSports

technology developers, eSports game developers, eSports game operators, eSports competition organizers, operators, etc. These eSports companies or organizations that join eSports industry knowledge alliances have different motivations and play different roles. As part of the leading eSports industry knowledge alliance, which eSports enterprise is the most efficient? Which eSports company is the most critical player in the league and critically impacts performance? These issues require in-depth research.

(2) The impact of alliance members' different attitudes toward the effects of eSports innovation on alliance performance needs further research. eSports companies or organizations have different attitudes toward eSports innovation. According to the perspectives of eSports enterprises toward innovation, it is necessary to study their impact on the performance of knowledge alliances in the eSports industry.

(3) The impact of the eSports industry knowledge alliance structure on performance must be further verified. Due to the rapid development of the eSports industry, eSports industry knowledge alliances cover an increasing number of types of organizations, and they become alliance members through different channels. How to describe these structural forms, quantify them and incorporate them into the performance analysis model to find the most effective form of knowledge alliance in the eSports industry requires further in-depth research.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

LY designed the study and analyzed the data. YZ discussed the results. MY drafted the manuscript. All authors have agreed to be accountable for all aspects of the manuscript in ensuring that questions related to the accuracy or integrity of any part of it are appropriately investigated and resolved.

ACKNOWLEDGMENTS

The authors would like to thank the reviewers of this journal for their helpful comments and suggestions.

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Policy Uncertainty, Official Social Capital, and the Effective Corporate Tax Rate – Evidence From Chinese Firms

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OPEN ACCESS

Edited by:

Shiyang Hu,
Chongqing University, China

Reviewed by:

Qinyi Gong,
Northwest Normal University, China
Jing Jia,
Anhui University, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 18 March 2022

Accepted: 26 April 2022

Published: 18 May 2022

Citation:

Wang L, Yang D and Luo D (2022)
Policy Uncertainty, Official Social
Capital, and the Effective Corporate
Tax Rate—Evidence From Chinese
Firms. *Front. Psychol.* 13:899021.
doi: 10.3389/fpsyg.2022.899021

The political environment has a significant impact on the sustainable development of enterprises. This manuscript aims to investigate the effect of policy uncertainty and official social capital on enterprises' effective tax rate (ETR) due to the change of officials. Based on the panel data from the Chinese Industrial Enterprise Database from 1998 to 2009, it is shown that the policy uncertainty caused by the change of local government officials significantly increases the ETR of enterprises. Meanwhile, municipal officials who have social ties with provincial officials in their province also tend to raise the ETR of industrial enterprises, and this tendency is more evident when the officials take office. Further research shows that the effects vary in many aspects for policy uncertainty and social capital on the ETR of enterprises. The findings of this manuscript provide support for a deeper understanding of the change in local government fiscal policies and give suggestions to strengthen political environmental governance for the sustainable development of enterprises.

Keywords: policy uncertainty, official social capital, effective tax rate, official promotion, sustainable development

INTRODUCTION

New institutional economists, represented by Douglas North, have emphasized the influence of the institutional environment on the sustainable development of enterprises. One of them is the region's political environment, especially the policy uncertainty due to the change of government officials. It has shown that when facing pressure for promotion, officials will stimulate macroeconomic growth in various possible ways to achieve their own promotion goals, and the policy uncertainty can have a significant impact on the sustainable development of enterprises (Jones and Olken, 2005; Li and Zhou, 2005; Kahn et al., 2015; Deng et al., 2019; Yu and Mai, 2020; Chen, 2021). In China, various policies such as administrative approval, land acquisition, loan guarantees, and tax exemptions are in the hands of local governments, and the continuity of local government economic and fiscal policies has an essential impact on the development of enterprises and the economy. The government-led economy has been an important feature of China's economic development since the Reform and Opening in 1978. As the government's legal representatives, local officials play a crucial role in the region's economic growth.

Local governments can promote their economic goals through various means, such as promoting infrastructure construction, increasing public services, and adopting specific fiscal measures to affect the sustainable development of enterprises (Earle and Gehlbach, 2015; Ma et al., 2018; He et al., 2019; Chen et al., 2021; Akhtari et al., 2022). Although this economic development mode dominated by government officials has created high economic growth, it has also brought many drawbacks. One of the main problems is policy uncertainty caused by changes of local officials. As the core government officials change, the former officials' economic and regional development policies are at risk of changing during their tenure. The stable government-enterprise relationship and political-enterprise ecology are also likely to be affected by the new officials' new "rules of the game" (Hardouvelis et al., 2018; Cao et al., 2019; Chen et al., 2020). At the same time, it is also common for some local government leaders in China to be transferred frequently, with their terms of office not expiring. Such frequent changes in officials exacerbate the discontinuity of local policies and lead to increased risks for enterprises (Pástor and Veronesi, 2013; Chen et al., 2018). Therefore, one of the hypotheses of this manuscript is that policy uncertainty arising from changes in officials may largely influence the fiscal policy choices of local governments, which in turn affects the sustainable development of enterprises.

Meanwhile, researchers have been increasingly interested in social capital theory. It has been treated as another type of capital besides physical capital and human capital, which plays a vital role in the economic behavior of actors (Putnam, 1993; Stone, 2001; Robison et al., 2002; Kawachi et al., 2008; Muringani et al., 2021). Social capital is rationally seen as a social resource and mobilized to serve its development. It manifests itself as a network of social relations, but unlike what is generally thought of as displaceable social relations, such as relations of production, administrative authorization, etc. It is a network of social connections, such as place of origin, first place of work, first school of education, etc. It has been widely known that China is a society that emphasizes interpersonal relationships and social networks (Kong, 2011; Wang and Kanungo, 2020). Thus, this social capital is presented in the form of social ties, such as kinship, friends, classmates, fellow villagers, neighbors, membership in a particular clique, or party (Borgatti et al., 1998; Neumeyer et al., 2019; Gannon and Roberts, 2020). In China, during the transition period, the government further influences enterprise behavior through economic policies such as corporate taxation to achieve the government's goals, which is also proved by a growing number of studies (Pan et al., 2015; Yang et al., 2015; Cull et al., 2017; Guo and Shi, 2018; Chen et al., 2020). Meanwhile, the effect of social relations such as place of origin, place of birth, place of first work, and other social capital factors of officials in local government behavior have also received increasing attention from scholars. For example, Jia et al. (2015) find that current top officials in China tend to have some social ties to the previous generation of top leaders and a prior history of low-level officials. Fisman et al. (2020) investigate the role of social capital such as origin and alumni in the promotion of officials and find that the promotion probability of officials with the exact origin and alumni ties as top officials is 5–9

percent. It is an unspoken rule of the bureaucracy that local government officials with social capital to government officials at a higher level are more likely to be promoted (Chu et al., 2021; Jia et al., 2021). And social capital helps develop local government officials' loyalty to higher-ranking officials and assists higher-ranking authorities in assessing the competency of promoted officials and learning more about the local economy.

Previous studies have not paid sufficient attention to the long-term impact of policy uncertainty and the social capital of local government officials on the ETR and the sustainability of enterprises. What impact does uncertainty caused by official changes and officials' social capital have on the ETR of enterprises, and what is the impact of enterprises' ETR on their long-term sustainability? Our manuscript aims to provide answers to these questions.

The rest of this manuscript is organized as follows: section "Literature Review and Research Hypothesis" provides a literature review; section "Research Design" presents the data and identification strategy; section "Empirical Results and Analysis" reports the main empirical results, the robustness analysis, the mechanism analysis, and the heterogeneity analysis; section "Conclusion" concludes.

LITERATURE REVIEW AND RESEARCH HYPOTHESIS

Local officials in China have played a crucial role in promoting economic system reform, attracting investment, developing the private economy, promoting exports, and improving infrastructure, among other things. Current research has not thoroughly summarized how the changes in government officials and officials' social capital can affect the ETR of enterprises, which are the focuses of our study. Here we first investigate the previous research on the effect of policy uncertainty and officials' social capital on the ETR of enterprises and then give some hypotheses to test.

Change of Officers and Effective Tax Rate of Enterprises

The effective tax rate (ETR) of enterprises reflects the fairness and efficiency of the tax law in a macroscopic meaning. It is also one of the main tools for the government to formulate and implement macroeconomic policies, which helps the government achieve its macroeconomic goals. In a microscopic meaning, tax incentives are essential tools for local governments to attract foreign investment and the ETR of an enterprise also profoundly affects the corporate performance. This also makes the change of ETR become one of the focuses of corporate tax research (Spooner, 1986; Porcano, 1986; Gupta and Newberry, 1997; Dyreng et al., 2017; Drake et al., 2020). Except for corporate investment and economic performance (Ohrn, 2018; Lin and Jia, 2019), changes in the effective corporate tax rate also influence the internal factor demand of firms (Auerbach, 2018; Kim and Park, 2021), corporate growth (Ftouhi et al., 2015), corporate innovation (Cai et al., 2018; Li et al., 2021), and even entrepreneurs' charitable donations (Baker and Dawson, 2020).

At the same time, as an essential tool, the ETR is closely related to the taxing behavior of the government. Many scholars have begun to explore its influence on the ETR regarding government size, regional competition, and corporate ownership (Zhang, 2008; Wu et al., 2012; Sineviciene and Railiene, 2015; Dang et al., 2019). In reality, the lack of legislative regulation of local governments in China makes local governments use lower tax collection to attract foreign investment when facing fierce regional competition (Tang, 2020). In this manuscript, we aim to investigate the effect of policy uncertainty on enterprises' ETR due to the change of officials, contributing to the literature on policy uncertainty and fiscal policy choices of local officers.

Social Capital of Officials

Social capital refers to the connections between individuals or groups and social networks. It is the interpersonal connections that exist within the fabric of human relationships. Like physical and human capital, social capital connects an individual and others in an organization that can bring them future benefits (Putnam, 2001). The amount of social capital depends mainly on an individual's social network (Borgatti et al., 1998; Burt, 2000). Putnam (1993) first introduced the concept of social capital into political science from a macro perspective. Thus, as an investment in social relations that is expected to be rewarded in the market, social capital has three main aspects: First, social capital is a resource that reflects interpersonal connections with others in the organization. In the long run, it reflects the size of the benefits. Second, social capital does not exist independently but is embedded in social relations. Individuals can interact homogeneously and heterogeneously through their social networks to access these structurally different embedded resources. Third, interaction can enhance the effect of purposeful action. Currently, academic research on social capital has shifted from theoretical analysis to empirical research by quantifying social capital and using econometric methods to examine the role of social capital on economic growth (Thompson, 2018), technological innovation (Landry et al., 2002), human capital (Mishra, 2020), and enterprise development (Habersetzer et al., 2019). However, the existing literature about the impact of officials' social capital on corporate ETR and the sustainable development of the enterprises is inadequate. It will be one of the issues investigated in our manuscript.

Theoretical Analysis and Research

Hypothesis

The change of local officials has become a regular and institutionalized political activity. It implies the policy uncertainty of the local government due to the political instability that can have a direct impact on the sustainable development of the enterprises.

As a Chinese proverb says, "A new broom sweeps clean." When local government officials take office, they are motivated to prove their competence by starting aggressive fiscal expansion activities and generating rapid economic growth (Chen et al., 2005; Akhtari et al., 2022). From the perspective of local officials, the competition for promotion among officials generates short-term behavior. It takes at least 2–3 years for local governments to

implement their development strategy (Lv and Bai, 2019; Chen, 2021). And local officials are usually transferred to another place within 2–3 years, leading to a tendency for officials to mobilize all the resources at their disposal for a short period at the beginning of their term of office (Luo and Qin, 2021). To meet their own fiscal needs, local governments will increase their tax collection from enterprises and raise the ETR of enterprises to raise funds for the fiscal expansion they will undertake. Based on the above analysis, this manuscript puts forward the following hypothesis 1:

Hypothesis 1: Policy uncertainty caused by changes in officials will raise the ETR of enterprises.

Meanwhile, as another Chinese proverb says, "It is easy to be an official if you have friends at court," and it is an unspoken rule of the bureaucracy that local government officials with social capital to government officials at a higher level are more likely to be promoted (Chu et al., 2020; Fisman et al., 2020). In this process, the social capital of local officials plays three roles: firstly, it ensures the loyalty of the promoted officers to the higher-level government officers; secondly, it helps the higher-level government official to know more about the competence of the promoted official; thirdly, through the social capital with local officials, leaders at higher levels can get more information about the local economy. Therefore, the higher level of government tends to choose local government officials who are competent and have social capital. And local officials with social capital to higher-level leaders have a greater incentive to expand fiscally to achieve their own promotion goals, which also results in an expansion of local government fiscal needs that results in a higher level of ETR of enterprises. Based on the above analysis, the following hypothesis 2 is formulated:

Hypothesis 2: Local government officials with social capital have a greater incentive to raise the ETR of enterprises.

And we can expect that local government officials with social capital have a greater incentive to raise the ETR of enterprises when they take office. They are more likely to be promoted and are much urgent to stimulate the economy to achieve their promotion goals. Based on the above analysis, the following hypothesis 3 is formulated:

Hypothesis 3: Local government officials with social capital have a greater incentive to raise the ETR of enterprises when they take office.

The data selected in this manuscript is from the Chinese Industrial Enterprise Database. Compared with the data from listed companies, the database of Chinese Industrial Enterprises contains more samples and richer types of enterprises, and these non-listed companies have a higher probability which is influenced by local government officials, which is more representative of measuring the impact of policy uncertainty caused by changes in government officials on the ETR of enterprises.

Following the research on policy uncertainty and social capital, this manuscript aims to the effect of policy uncertainty and official social capital on enterprises' ETR due to the change of officials. Compared to previous studies, this manuscript

contributes to the literature as follows. First, this manuscript investigates the impact of policy uncertainty caused by the change of local officials on enterprises at the prefectural level. This enriches the study of policy uncertainty. Second, the effect of policy uncertainty due to official change on the ETR of firms is investigated; this extends the existing studies on the evolution of tax policies of local governments (Mendoza and Oviedo, 2006; Cai and Liu, 2009; Caldara et al., 2020). Third, we expand the research on the social capital of local officers. When local government officers change tax policies after taking office, it is also of interest to examine the role of social capital in the process of policy change at this time. Above all, the research in this manuscript contributes to a better understanding of the role of officials' social capital in local government fiscal policy decisions.

RESEARCH DESIGN

Sample Selection and Data Sources

The corporate data in this manuscript comes from the Chinese Industrial Enterprise Database (1998–2009), which includes detailed information on corporate financing. We excluded enterprises with total assets less than fixed assets, fixed assets less than 1 million yuan, less than 30 workers, enterprises founded before 1949, and with an effective corporate tax rate below 0 or more than 1. The data of officials are mainly sourced from the China Research Data Service Platform (CNRDS), which contains rich data about the personal characteristics of municipal party secretaries, such as age, education, and tenure information. The socio-economic data is mainly sourced from the Wind database, which contains rich data on urban economic development, including GDP, population size, government financial status, etc. The final panel data that meets the needs of the empirical study of this manuscript is formed. We finally obtained panel data with information on government officials, firms, and local economies from 1998 to 2009.

Model Setting and Variable Description

According to the theoretical hypotheses stated in the preceding section, the specific models of this manuscript are designed as follows:

$$\ln etr1_{it} = \alpha + \alpha_1 PU_{it} + \beta X_{it} + \sum year + \sum ind + \sum city + \varepsilon_{it} \quad (1)$$

$$\ln etr1_{it} = \alpha + \alpha_1 SC_{it} + \beta X_{it} + \sum year + \sum ind + \sum city + \varepsilon_{it} \quad (2)$$

$$\ln etr1_{it} = \alpha + \alpha_1 PU_{it} + \alpha_2 SC_{it} + \alpha_3 PU_{it} * SC_{it} + \beta X_{it} + \sum year + \sum ind + \sum city + \varepsilon_{it} \quad (3)$$

where $\ln etr1_{it}$ is the logarithm of the ETR level of enterprise i in year t . Here, we use the value of corporate income tax/total corporate profit to represent the ETR of an enterprise. PU_{it} denotes the dummy variable for the time when the local official (municipal secretary) took office; we take the value of the time when the local official (municipal secretary) took office to be 1, otherwise it is 0. SC_{it} represents the social capital of officials, and it is a set of dummy variables; The social capital of officials includes three types: common place of origin, common first place of work, and common first school of education. We take the value of 1 if a local official and the provincial official in the province where he or she is in office have common place of origin, common first place of work, or common first school of education, and 0 otherwise. X_{it} is a group of control variables, including corporate characteristics variables: roa of the corporate (roa), the scale of fixed asset of the corporate (asset), the debt ratio of the corporate (debratio), and the loan level of the corporate (loan); regional socioeconomic variables: the GDP of the sample city (gdp), the average wage of employed persons (income), the deficit of the sample city (deficit), the administrative area of the sample city (area), the FDI of the sample city (fdi_actual), the area of the road in the sample city (road_area), and the fixed asset investment of the city (fix_invest); and personal characteristics variables: the gender of the municipal party secretary (gender) and the level of education of the municipal party secretary (education), $\sum year$, $\sum ind$, and $\sum city$ represent the year fixed effect, the industry fixed effect and region fixed effect, respectively. The variable definitions are given in **Table 1**.

Descriptive Statistical Analysis

The descriptive statistics of the variables are shown in **Table 2**. As can be seen, the mean of enterprises' effective income tax rate during the sample period is 13.6%, which is much lower than the statutory rate. The lower tax rate level gives local government officials more room for discretionary fiscal policy decisions. PU is the time variable of the municipal party secretary taking office; for example, if a municipal party secretary took office in 2000, the value is 1 in 2000 and 0 otherwise.

EMPIRICAL RESULTS AND ANALYSIS

Basic Regression Results

The Impact of Policy Uncertainty on the Effective Tax Rate of Enterprises

First, we discuss the impact of policy uncertainty on the ETR. The main results of equation (1) are presented in **Table 3**. We introduce control variables and control for different fixed effects levels.

Specifically, we find a sound and significant positive effect of local officials' promotion incentives on the ETR of industrial enterprises in their jurisdictions, as shown in column (4) of **Table 3**, which shows that the change of officials increases the ETR of industrial enterprises in their jurisdictions by 2.0% on average. The econometric regression results remain robust after controlling for official variables such as gender and education. The results of the empirical analysis show that: under the

TABLE 1 | Variable definitions.

	Variable	Definition
Dependent variable	etr1	Corporate income tax/total profit of corporate
Independent variables	PU	Change of local officers
	SC	Social capital of local officers
Control variables	roa	Total profit of corporate/total assets of corporate
	asset	The logarithm of the scale of fixed assets of the corporate
	debt	The logarithm of Corporate interest expenditure/total asset
	loan	The logarithm of Corporate liability/total asset of corporate
	gdp	The logarithm of GDP of the sample city
	income	The logarithm of the average wage of employed persons
	deficit	The logarithm of the deficit of the sample city
	area	The logarithm of the administrative area of the sample city
	fdi	The logarithm of the FDI of the sample city
	road	The logarithm of the area of the road in the sample city
	invest	The logarithm of the fixed asset investment of the sample city
gender	The gender of the municipal party secretary	
education	The level of education of the municipal party secretary	

TABLE 2 | Descriptive statistics of the main variables.

Variable	Mean	S.D.	Min.	Max.	N
etr1	0.136	0.165	0.000	0.756	526,722
PU	0.266	0.442	0.000	1.000	526,722
SC	0.231	0.180	0.000	1.000	526,722
roa	0.047	0.186	-0.762	0.208	526,722
asset	8.506	1.592	5.826	12.998	526,722
debt	-0.730	0.666	-2.426	0.368	526,722
loan	-4.492	1.234	-7.233	-1.916	526,722
gdp	4.664	0.943	2.995	6.677	526,722
income	9.539	0.380	8.848	10.247	526,722
deficit	7.886	0.866	5.997	9.563	526,722
area	9.095	0.673	7.597	10.682	526,722
fdi	5.887	1.673	2.613	8.825	526,722
road	2.599	0.928	0.948	4.495	526,722
invest	10.604	1.148	8.428	12.609	526,722
gender	0.018	0.134	0.000	1.000	526,722
education	0.230	0.421	0.000	1.000	526,722

promotion system, local government officials have a strong incentive to develop the economy to gain political advancement. As a result, local officials are encouraged to take every measure to achieve better economic performance, including increased tax collection from enterprises for government investment, to improve the economic performance during their term of office, resulting in a higher level of ETR of enterprises. This verifies Hypothesis 1.

Impact of Social Capital on the Effective Tax Rate of Enterprises

This part discusses the impact of social capital on the ETR. The main results of equation (2) are presented in **Table 4**. Further, we introduce some control variables and thus control for different fixed effects levels.

The results in **Table 4** show that the social capital of officials has a stable and significant positive effect on the productivity of industrial enterprises. The column (4) shows that the social capital of officials increases the ETR of industrial enterprises in the jurisdiction by 2.3% on average. The econometric regression results remain robust after controlling for official variables such as gender and education. The results of the empirical analysis show that: local officials with social capital to government officials at a higher level are more likely to be promoted. They, therefore, have an incentive to demonstrate their competence by promoting rapid local economic growth through fiscal expansion, which exposes local governments to huge financing needs and leads to higher ETR of enterprises. This verifies Hypothesis 2.

The Boosting Role of Social Capital

In this part, we discuss the interaction effect of policy uncertainty and social capital on the ETR. The main results of equation (3) are presented in **Table 5**. Similarly, we introduce some control variables to control different levels of fixed effects on the findings.

In particular, the column (2) of **Table 5** shows that the interaction effect of policy uncertainty caused by official changes and social capital of officials on the ETR of enterprises is significantly positive (2.4%), and the econometric regression results remain robust after controlling for official variables such as gender and education. Meanwhile, columns (3) and (4) are based on the results of group regressions with and without social capital, respectively. The results obtained from the grouped regressions show that local government officials with social capital tend to improve the ETR of enterprises. The results of the empirical analysis show that: local officials with social capital to government officials at a higher level are more likely to raise the ETR of enterprises when they take office, for they are more likely to be promoted and are much urgent to

TABLE 3 | Impact of official assignment on the effective corporate tax rate.

	(1)	(2)	(3)	(4)
Variables	ETR Inetr1	ETR Inetr1	ETR Inetr1	ETR Inetr1
PU	-0.004** (0.002)	0.003 (0.003)	0.003 (0.003)	0.020*** (0.003)
roa		-0.141*** (0.001)	-0.141*** (0.001)	-0.151*** (0.001)
asset		-0.056*** (0.001)	-0.056*** (0.001)	-0.053*** (0.001)
debt		-0.010*** (0.003)	-0.010*** (0.003)	-0.012*** (0.003)
loan		0.041*** (0.001)	0.041*** (0.001)	0.031*** (0.001)
gdp		0.003 (0.007)	0.003 (0.007)	0.070*** (0.024)
income		0.183*** (0.010)	0.183*** (0.010)	0.493*** (0.028)
deficit		-0.027*** (0.002)	-0.027*** (0.002)	0.015*** (0.003)
area		-0.012*** (0.004)	-0.012*** (0.004)	-0.086* (0.048)
fdi		-0.066*** (0.002)	-0.066*** (0.002)	-0.017*** (0.004)
road		-0.037*** (0.004)	-0.037*** (0.004)	0.004 (0.009)
invest		0.150*** (0.006)	0.150*** (0.006)	-0.053*** (0.012)
gender		-0.144*** (0.011)	-0.144*** (0.011)	-0.084*** (0.014)
education		-0.007* (0.004)	-0.007* (0.004)	-0.030*** (0.006)
Constant	-1.666*** (0.001)	-4.052*** (0.112)	-4.052*** (0.112)	-5.263*** (0.511)
Observations	526,722	526,722	526,722	526,722
R-squared	0.021	0.075	0.075	0.110
Year effect	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes
City effect	No	No	No	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

TABLE 4 | Impact of social capital of officials on the ETR of enterprises.

	(1)	(2)	(3)	(4)
Variables	ETR Inetr1	ETR Inetr1	ETR Inetr1	ETR Inetr1
SC	0.060*** (0.003)	0.049*** (0.005)	0.049*** (0.005)	0.023*** (0.005)
Roa		-0.142*** (0.001)	-0.142*** (0.001)	-0.151*** (0.001)
Asset		-0.055*** (0.001)	-0.055*** (0.001)	-0.053*** (0.001)
Debt		-0.010*** (0.003)	-0.010*** (0.003)	-0.012*** (0.003)
Loan		0.041*** (0.001)	0.041*** (0.001)	0.031*** (0.001)
Gdp		0.005 (0.007)	0.005 (0.007)	0.064*** (0.024)
income		0.166*** (0.010)	0.166*** (0.010)	0.476*** (0.029)
deficit		-0.028*** (0.002)	-0.028*** (0.002)	0.014*** (0.003)
Area		-0.017*** (0.004)	-0.017*** (0.004)	-0.075 (0.048)
Fdi		-0.064*** (0.002)	-0.064*** (0.002)	-0.018*** (0.004)
Road		-0.041*** (0.004)	-0.041*** (0.004)	0.005 (0.009)
invest		0.152*** (0.006)	0.152*** (0.006)	-0.049*** (0.012)
gender		-0.138*** (0.011)	-0.138*** (0.011)	-0.081*** (0.014)
education		-0.009** (0.004)	-0.009** (0.004)	-0.032*** (0.006)
Constant	-1.674*** (0.001)	-3.878*** (0.113)	-3.878*** (0.113)	-5.188*** (0.512)
Observations	526,722	526,722	526,722	526,722
R-squared	0.021	0.075	0.075	0.110
Year effect	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes
City effect	No	No	No	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

stimulate the economy to achieve their promotion goals. This verifies Hypothesis 3.

Robustness Test Explained Variables

First, we refer to Johnson (1949) and Burbidge et al. (1988) for the IHS transformation of the dependent variable (etr2), the results are shown in **Table 6** below. Meanwhile, columns (4) and (5) of **Table 6** are the results of group regressions with and without social capital, respectively.

As can be seen from **Table 6** above, after the replacement of the measure of the dependent variable, the results of the

empirical analysis are consistent with the empirical findings of our original model.

Regression Analysis After Excluding Thirty-Five Large and Medium-Sized Cities

Considering larger cities tend to have higher political and economic status, which affects the likelihood of promotion of local government officials. We conduct regression analysis after excluding 35 medium and large cities from the original data sample.¹ The results are shown in **Table 7**. Meanwhile, columns

¹The 35 medium and large cities include Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, Nanjing, Tianjin, Chengdu, Wuhan, Qingdao, Ningbo, Xiamen,

TABLE 5 | Interaction of official change and official social capital on effective corporate tax rate.

	(1)	(2)	(3)	(4)
Variables	ETR lnetr1	ETR lnetr1	ETR lnetr1	ETR lnetr1
PU	0.016*** (0.002)	0.017*** (0.003)	0.020*** (0.004)	-0.015 (0.017)
SC	0.038*** (0.004)	0.016*** (0.006)		
PU*SC	0.001 (0.005)	0.024*** (0.009)		
roa		-0.151*** (0.001)	-0.217*** (0.002)	-0.233*** (0.006)
asset		-0.053*** (0.001)	-0.032*** (0.003)	-0.063*** (0.009)
debratio		-0.012*** (0.003)	0.000 (0.004)	0.058*** (0.012)
loan		0.031*** (0.001)	0.029*** (0.002)	0.035*** (0.006)
gdp		0.068*** (0.024)	0.282*** (0.031)	-0.471*** (0.117)
income		0.473*** (0.029)	0.224*** (0.036)	1.519*** (0.180)
deficit		0.014*** (0.003)	0.001 (0.004)	-0.001 (0.043)
area		-0.076 (0.048)	-0.059 (0.115)	9.279*** (1.608)
fdi		-0.017*** (0.004)	-0.022*** (0.004)	-0.087*** (0.021)
road		0.003 (0.009)	-0.008 (0.011)	-0.407*** (0.077)
invest		-0.047*** (0.012)	0.011 (0.013)	0.161 (0.103)
gender		-0.082*** (0.014)	-0.081*** (0.016)	-0.016 (0.020)
education		-0.030*** (0.006)	-0.035*** (0.007)	-0.051 (0.053)
Constant	-1.675*** (0.001)	-5.196*** (0.512)	-5.120*** (1.124)	-25.075 (0.000)
Observations	526,722	526,722	65,407	461,315
R-squared	0.057	0.110	0.082	0.073
Year effect	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes
City effect	Yes	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

(4) and (5) of Table 7 are based on the results of group regressions with and without social capital, respectively.

As can be seen, the results of the empirical analysis are consistent with the empirical findings of our original

Chongqing, Dalian, Shenyang, Changsha, Xi'an, Zhengzhou, Jinan, Taiyuan, Changchun, Kunming, Hefei, Harbin, Fuzhou, Haikou, Nanchang, Shijiazhuang, Hohhot, Urumqi, Nanning, Lanzhou, Guiyang, Yinchuan, and Xining.

TABLE 6 | Results of regression analysis after IHS transformation for the ETR.

	(1)	(2)	(3)	(4)	(5)
Variables	ETR lnetr2	ETR lnetr2	ETR lnetr2	ETR lnetr2	ETR lnetr2
PU	0.020*** (0.003)		0.016*** (0.003)	0.020*** (0.004)	-0.017 (0.016)
SC		0.022*** (0.005)	0.016*** (0.006)		
PU*SC			0.023** (0.009)		
Constant	-5.211*** (0.505)	-5.138*** (0.506)	-5.146*** (0.506)	-5.091*** (1.115)	-99.259*** (14.968)
Observations	526,722	526,722	526,722	65,407	461,315
R-squared	0.109	0.109	0.109	0.081	0.072
Controls	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes	Yes
City effect	Yes	Yes	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

TABLE 7 | Results of regression analysis after excluding 35 large and medium-sized cities.

	(1)	(2)	(3)	(4)	(5)
Variables	ETR lnetr1	ETR lnetr1	ETR lnetr1	ETR lnetr1	ETR lnetr1
PU	0.011*** (0.004)		0.007* (0.004)	0.008** (0.004)	-0.011 (0.019)
SC		0.034*** (0.006)	0.027*** (0.006)		
PU*SC			0.021** (0.009)		
Constant	-6.787*** (0.578)	-6.560*** (0.581)	-6.572*** (0.581)	-5.735*** (1.022)	-16.868 (14.196)
Observations	415,051	415,051	415,051	356,921	58,130
R-squared	0.108	0.108	0.108	0.107	0.126
Controls	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes	Yes
City effect	Yes	Yes	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

model after excluding 35 medium and large cities from the original data sample.

Regression Analysis Excluding the Effects of the 2008 Tax Reform and the Financial Crisis

To avoid the influence of other reforms in the same period that would invalidate the results explored in this manuscript, we further sort out the different policies during the sample period.

1. Enterprise income tax reform in 2008: In 2008, China implemented the tax reform that reduced enterprises' statutory income tax rate from 33 to 25%. The tax

TABLE 8 | Results of regression analysis for the restricted sample interval from 1998 to 2007.

	(1)	(2)	(3)	(4)	(5)
Variables	ETR Inetr1	ETR Inetr1	ETR Inetr1	ETR Inetr1	ETR Inetr1
PU	0.039*** (0.004)		0.034*** (0.004)	0.037*** (0.004)	-0.067*** (0.025)
SC		0.047*** (0.007)	0.032*** (0.009)		
PU*SC			0.011** (0.004)		
Constant	-2.820*** (0.606)	-3.416*** (0.608)	-3.115*** (0.610)	-7.428*** (1.006)	41.531** (19.730)
Observations	327,807	327,807	327,807	284,215	43,592
R-squared	0.101	0.101	0.101	0.100	0.117
Controls	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes	Yes	Yes
City effect	Yes	Yes	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

policy reform may affect the robustness of our regression analysis results.

- The global economic crisis in 2008: After the global financial crisis broke out in 2008, the central government promoted a huge economic plan to stimulate economic development, which greatly impacted enterprises and local governments.

We use the subsample ranging from 1998 to 2007 to exclude the effects of the 2008 tax reform and the financial crisis. The results are shown in **Table 8**. Meanwhile, columns (4) and (5) of **Table 8** are based on the results of group regressions with and without social capital, respectively.

As shown in **Table 8** above, the results of the empirical analysis are consistent with the empirical findings of our original model. This ensures the robustness of the results of our model.

Mechanisms Analysis

The Role of Promotion Incentives for Officials

When new officials take office, to show their talent, they often implement large-scale economic stimulus measures to boost the economy and improve people's living standards, which is reflected in the increase of local governments' fiscal deficit (Indeficit) at the beginning of the officials' tenure (Zhang and Qian, 2021). As shown in **Table 9**. The result in column (1) of **Table 9** indicates that the new officials' taking office (PU) leads to a 4.4% increase in the deficit of the local government.

This is mainly because: (1) immediately after taking office, local government officials will adopt policies such as increasing local spending to perform better to improve their chances of promotion. (2) Because of the lagging effect of investment in many projects, it is so urgent for officials to seize the time to take such radical economic measures at the beginning of the

term. (3) The average term of the officials at the prefecture-level in China is less than 3 years, so they are more focused on short-term economic growth than long-term (Li, 2018; Xi et al., 2018). When facing the increase in fiscal deficit, local government officials raised the ETR of corporates to meet their own financing needs. The same goes for land transfers (Inbargin_money), shown in column (2) of **Table 9**. This is mainly because (1) immediately after taking office, considering the impact of promotion incentives, local government officials will take actions such as increasing investment and fiscal expenditures to improve their promotion probability; (2) as the investment and economic effects of many projects have a lagging nature, it is so urgent to seize the opportunity to take such radical economic measures at the beginning of the tenure of local officers; (3) the rapidly expanding fiscal deficit shows a drastic need for financing, local governments then have an incentive to take measures such as increasing tax collection, raising the ETR of enterprises and land concessions to meet their own financial needs.

Long-Term Effects of Corporate Tax Rate Fluctuations

In addition to the role of promotion incentives for officials, the negative impact of the higher tax burden on the performance of the enterprises is also a consideration for local government officials to reduce corporate tax collection in the second half of their terms. However, tightened tax enforcement is a double-edged sword and can hardly last long.

Unfavorable changes in tax enforcement may drive out business activities, as shown in columns (3–5) of **Table 9** above.

The results of the empirical analysis show that an increase in the effective corporate tax rate will reduce corporate profitability, depress the amount of corporate investment, and adversely affect the rise in corporate exports. The improvement of the overall economic indicators of enterprises will have a positive impact on the overall economy. Therefore, the tax increase by officials after taking office will hurt enterprises and socio-economic development. Then why do officials still invest in enterprises by increasing tax levies? We believe it is mainly because of the increase in fixed-asset investment during the officials' new term of office and the pressure from the fiscal gap. In terms of the economic and social benefits of long-term enterprise development and the importance of increased investment in regional development, local government officials, after satisfying the short-term financing needs at the beginning of their tenure, will also consider reducing the tax levies on enterprises, fostering a favorable environment for the sustainable development of local enterprises, and promoting the regional economy.

Heterogeneity Analysis

Heterogeneity Analysis According to Different Types of Social Capital

Table A1 in **Appendix** shows the regression analysis of different types of social capital: a common place of origin (same_nativep), the common first place of work

TABLE 9 | Impact of official assignment on local fiscal deficits.

	(1)	(2)	(3)	(4)	(5)
Variables	Fiscal deficit Indeficit	Land premium Inbargin_money	Asset profitability Inroa	Long-term investment Ininvest	Export Inexport
PU	0.044*** (0.001)	0.075*** (0.007)			
Inetr1			-0.260*** (0.002)	-0.018*** (0.006)	-0.018*** (0.003)
Constant	2.665*** (0.176)	-9.349*** (0.128)	7.335*** (0.116)	-6.217*** (0.148)	-6.311*** (0.235)
Observations	1,450,817	1,063,720	813,130	114,883	213,394
R-squared	0.467	0.140	0.078	0.112	0.172
Controls	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes
Ind effect	No	Yes	Yes	Yes	Yes
City effect	Yes	Yes	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

(same_workp), and common first-degree school (same_edu_f). Government officials who have a common place of origin with provincial officials are more motivated to raise the ETR of industrial enterprises. In contrast, the effect of the common first place of work factor is insignificant, and the common first educational school factor mainly plays a negative role.

From the results of **Table A1**, it can be seen that hometown relations (common place of origin) have a much higher priority in the bureaucratic ranking than colleague relations (common first place of work) and classmate relations (common first school of education).

Heterogeneity Analysis According to Enterprise Factor Intensity

Factor intensity refers to the ratio between the factors of production required to produce different goods. Factor intensity of enterprises is also an important aspect of enterprise heterogeneity. We classify industrial enterprises into labor-intensive, capital-intensive, and technology-intensive industries according to their industries. The regression results are shown in **Table A2** in **Appendix**.

The regression results in **Table A2** show that the ETR level of enterprises in labor-intensive industries, capital-intensive industries, and technology-intensive industries is subject to a more significant factor of change by local government officials compared to that of labor-intensive industries. This is because: (1) compared to local labor employment, the improvement of the ruling performance represented by the output value of local enterprises and even regional GDP is an important issue of urgent concern for local government officials and has a higher priority in the sequence of concerns of local officials, which is also an objective requirement for the promotion tournament of officials; (2) compared to labor-intensive industries, capital-intensive industries, and technology-intensive industries, enterprises tend to have a larger enterprise

scale, higher initial investment, and higher tax contribution to are one of the primary sources of tax revenue for local governments, so their ETR levels are also more likely to be affected by the change of officials factor.

CONCLUSION

The political environment has a significant impact on the sustainable development of enterprises. As the legal representatives of government power, local officials can influence the economic policies, thus playing a crucial role in the development of the enterprises. This manuscript empirically examines the effect of policy uncertainty and social capital of officers on the ETR of enterprises. The main conclusions are:

First, the policy uncertainty caused by local government officials' change significantly increases the enterprises' ETR. Meanwhile, municipal officials who have social ties with provincial officials in their province also tend to raise the ETR of industrial enterprises.

Second, the interaction effect of policy uncertainty and the social capital of local officials are positive. It means the local officials who have social ties with provincial officials have more incentive to raise the ETR of industrial enterprises when taking office.

Third, further research show that the effect of political uncertainty on the ETR is heterogeneous, i.e., the effect on the ETR is more pronounced for enterprises in the capital-intensive and technology-intensive industries, and in addition, it has been proved that the different types of social capital affect officials' fiscal decisions differently.

The findings of this manuscript are informative in understanding the impact of policy uncertainty on the ETR of firms and the role played by the social capital of officials in this process. These also provide the basis for measures to strengthen

government regulations, improve incentives for officials to be promoted, and improve the policy-making and macro-control system to promote the sustainable development of enterprises.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The data used to support the findings of this study is available upon request. Requests to access these datasets should be directed to LW, fengzhizi@pku.edu.cn.

AUTHOR CONTRIBUTIONS

LW was the first person in charge of this manuscript and mainly responsible for the theoretical justification, methodological design, data collection, statistical analysis, and description of the

results of this manuscript. DY was responsible for improving the whole design and the editing of the manuscript, including the presentation of conclusions, and policy recommendations. DL was mainly responsible for the refinement and improvement of the technical aspects of the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This research was supported by the Humanities and Social Science Fund of Ministry of Education of the People's Republic of China (Grant No. 20YJC790160), the Fundamental Research Funds for the Central Universities (Grant No. JBK21YJ17) in China, and the Joint Lab of Data Science and Business Intelligence at Southwestern University of Finance and Economics.

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APPENDIX

Tables A1, A2 reports the results of heterogeneity analysis according to gender and age, first-degree and first-degree major, different types of social capital, enterprise location, and enterprise factor intensity.

TABLE A1 | Regression analysis grouped by different types of social capital.

	(1)	(2)	(3)
Variables	ETR lnetr1	ETR lnetr1	ETR lnetr1
same_nativep	0.047*** (0.006)		
same_workp		0.021 (0.040)	
same_edu_f			-0.025** (0.010)
Constant	-4.800*** (0.515)	-5.248*** (0.511)	-5.119*** (0.512)
Observations	526,722	526,722	526,722
R-squared	0.110	0.110	0.110
Controls	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes
City effect	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

TABLE A2 | Regression analysis of firms grouped by factor intensity.

	(1)	(2)	(3)
Variables	labor lnetr1	capital lnetr1	technology lnetr1
PU	-0.003 (0.010)	0.024*** (0.006)	0.023*** (0.004)
Constant	-6.034*** (1.466)	-3.307*** (0.897)	-6.254*** (0.713)
Observations	64,222	168,546	292,746
R-squared	0.109	0.107	0.118
Controls	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Ind effect	Yes	Yes	Yes
City effect	Yes	Yes	Yes

***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.



The Impact of Financial Redundancy on Corporate Social Responsibility Performance: Evidence From Chinese Listed Firms

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OPEN ACCESS

Edited by:

Shiyang Hu,
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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 24 February 2022

Accepted: 02 May 2022

Published: 19 May 2022

Citation:

He L, Gan S and Zhong T (2022)
The Impact of Financial Redundancy
on Corporate Social Responsibility
Performance: Evidence From Chinese
Listed Firms.
Front. Psychol. 13:882731.
doi: 10.3389/fpsyg.2022.882731

This study examines the impact of financial redundancy on corporate social responsibility (CSR) based on a sample of Chinese listed firms from 2010 to 2020. The results indicate that financial redundancy has a significant positive effect on CSR. However, financially redundant resources are not balanced in terms of how they encourage firms to undertake different dimensions of social responsibility; specifically, firms actively take social responsibility toward shareholders and the public but take less responsibility for employees and the environment. The incentive for firms with financially redundant resources to promote CSR initiatives is attributable to their high level of social awareness and pursuit of reputation. Consistent with their motives, our economic consequence analysis reveals that the incremental effect of CSR driven by financial redundancy improves corporate reputation but has no enhancement effect on corporate performance. Finally, our extended analysis reveals that the relative impact of financial redundancy on CSR depends on several organizational variables that influence a firm's preferences for CSR investments. The positive impact of financial redundancy on CSR is stronger among firms with high managerial career concerns and firms in regions with high market competition. This research provides a necessary structure for future CSR studies to follow. By delving deeply into the relationship between financial redundancy and CSR, it enables scholars to better address the critical management question of whether wealthy firms do more good for society compared to those that are less wealthy.

Keywords: financial redundancy, corporate social responsibility, motivation, consequences, managerial career concerns, market competition

INTRODUCTION

With the frequent occurrence of natural disasters, environmental pollution, issues with employee rights protection, problems with food safety, instances of tax evasion, and other incidents in China, the call for enterprises to assume social responsibility has increased dramatically. China has launched a number of initiatives to promote corporate social responsibility (CSR)

development. However, in contrast to the increasing number of laws and regulations, firms are taking socially responsible actions in a high-profile manner while at the same time committing socially irresponsible acts. For example, in 2010, Foxconn donated resources to earthquake-stricken areas; however, in the same year, 13 Foxconn employees jumped from a building. Similarly, Vanke, which won the “Best Corporate Citizen award in China,” has repeatedly been found to have product quality problems. The lack of CSR in various industries is becoming a common phenomenon, which seems to indicate that the manifestation of CSR in China is complex and heterogeneous. As a socialist country, China’s CSR performance is among the lowest of all global economies. Therefore, it is necessary to explore firms’ motivations for undertaking CSR in the context of China. Such research will have important theoretical and practical significance for expanding research on CSR and promoting China’s sustainable growth.

CSR pertains to actions that a firm undertakes beyond the firm’s interests and legal requirements, and can refer to employees, the environment, suppliers, consumers, the public, and other parties (Oh et al., 2011; Marakova et al., 2021). Research on the driving factors of CSR has always been a key topic in academia. Early studies have observed several antecedents of CSR, including external factors, such as public attention (Zyglidopoulos et al., 2012; Cheng and Liu, 2018; El Ghouli et al., 2019) and institutional environment (Flammer, 2015; Han et al., 2022); and internal factors, such as corporate governance (Hong et al., 2016), ownership structure (Oh et al., 2011; Li et al., 2021), executives characteristics (Zu and Song, 2009; Fabrizi et al., 2014), and board characteristics (Chang et al., 2017; Ardito et al., 2021). It must be recognized that firms face financial costs for their socially responsible investments, and adequate funding is a basic prerequisite for enterprises to undertake social responsibility (Leong and Yang, 2021; Xiao et al., 2021).

Socially responsible investment is one of the investment behaviors of firms. Firms have a hierarchy of investment priorities, and prior research has suggested that firms place their core business investment needs at the top of this hierarchy and CSR lower down (Waddock and Graves, 1997; Sun et al., 2021). One critical implication of this is that firms’ CSR-related actions may depend on whether their core business investment needs have already been met; that is, firms will undertake social responsibility only after satisfying normal corporate operations and thereafter having surplus resources.

With the development of China’s capital market, a particular financial phenomenon has appeared in the financial practice of firms: that is, firms often hoard large amounts of cash while reducing interest-bearing debt. Studies have defined this as financial redundancy, which depicts a financial status in which the firm retains liquid capital that exceeds its operating demands and has a low interest-bearing debt ratio (Myers and Majluf, 1984; Alessandri et al., 2014). Financial redundancy—a major form of organizational redundancy—is a financial resource that the organization has acquired but not designated for necessary consumption, and that can be freely used by managers. According to our survey, more than half of listed firms in China have hoarded large amounts of financially redundant resources, and

this has become a normalized financial phenomenon among Chinese firms. Financially redundant resources are those that exist beyond resources needed for enterprises to maintain operations; they can be used to meet the other requirements of stakeholders, and their attributes to be allocated and the consumption characteristics of resources to undertake social responsibility are complementary in function. However, few studies have focused on this point. Thus, a question remains as to whether firms that are rich in financial resources engage in more social responsibility compared to those that are not.

Theoretically, the impact of financial redundancy on CSR is ambiguous. On the one hand, financial redundancy can solve firms’ financial problems; in addition, it encourages strategic behavior, eases adaptation to new environments, fosters long-term thinking, and enables the exploration of uncertain investment opportunities. Sufficient financially redundant resources play the role of a “resource buffer pool” when firms face resource bottlenecks and ensure the sustainability and stability of the CSR investment. On the other hand, the high flexibility of financially redundant resource makes firms extremely vulnerable to agency problems (Shahzad et al., 2016; Suzuki, 2018). Excessive redundant resources will weaken firms’ internal control, leading managers to allocate redundant resources to low-risk investment activities that are beneficial to them personally, thereby avoiding CSR investment projects that increase corporate risks, have a long profit cycle, and are slow to yield results. Consequently, what is the effect of financial redundancy on CSR? What is the mechanical path therein? Does the effect differ under diverse conditions? To explore these issues, we select data from Chinese listed firms from 2010 to 2020 to explore the relationship between financial redundancy and CSR in this paper, as well as the heterogeneity of the relationship in different environments, and to further investigate the motivations to undertake CSR and the economic consequences of doing so.

Our work contributes to the literature in the following aspects. First, this study expands on previous research regarding the strategic motivation of CSR. The results show that firms will use tactical behaviors to take on the part of social responsibilities that are conducive to the firm’s short-term development, while avoiding social responsibility projects that require long-term investment and are slow to yield results. This finding provides a new perspective on the strategic motivation for CSR. Second, our study enriches the relevant literature on CSR. The early literature mainly studied the influencing factors of CSR from a single dimension and lacked a classification system to explore the motivations for undertaking social responsibility in different dimensions (Flammer, 2015). Social responsibility has now become a multidimensional concept. Hence, this paper focuses on five aspects to study the impact of financial redundancy on CSR in different dimensions, which can deepen understanding of the “black box” of CSR. Third, this paper expands the literature on financial status and CSR. Existing studies have discussed the factors influencing CSR performance from a financial perspective (Waddock and Graves, 1997; Lin et al., 2019; Hou et al., 2021), overlooking the transmission mechanisms in depth. Our study fills this gap by examining the motivations and economic

consequences of firms with financially redundant resources engaging in CSR initiatives, and clarifying that the involvement of such firms in CSR initiatives is driven by a combination of social awareness and reputation-seeking motives. This finding augments the relevant literature empirically and theoretically, especially in the context of emerging countries. Finally, our results show that the relative impact of financial redundancy on CSR depends on several variables that influence the structure of a firm's investment priorities (managerial career concerns and market competition). These results extend past findings that have documented a link between these factors and CSR itself, suggesting that they not only influence a firm's absolute level of CSR but also affect its willingness to change CSR strategy under the influence of internal financial resources.

LITERATURE REVIEW

Reasons for Financial Redundancy

There are several reasons why for the existence of the phenomenon of financial redundancy in Chinese listed firms. (1) Corporate life cycle. When the firm is in the early stages of entrepreneurship, it may have debt financing constraints and hold large amounts of cash in anticipation of investment opportunities. Firms in a more mature stage have entered a state of relatively stable and continuous growth, and tend to hoard large amounts of monetary funds. (2) Traditional culture. China's traditional culture emphasizes risk avoidance and preparedness, and these traits when transferred to corporate financial decisions are reflected as financial soundness and risk aversion. The traditional culture makes corporate decision-making toward avoiding debt repayment risks, using less financial leverage, and relying on internal financing. Under the long-term influence of this business strategy, firms will be prone to the phenomenon of financial redundancy. (3) Management's pursuit of personal interests. To pursue personal interests, managers may reduce or avoid paying dividends, which causes large amounts of funds within the firm, and the long-term accumulation of funds eventually leads to financial redundancy. (4) Some listed firms achieve equity refinancing conditions through earnings management and fabricated investment projects and then carry out financial activities such as supplementing working capital and repaying debt after obtaining funds, which also causes the phenomenon of financial redundancy.

The Linkage of Financial Redundancy With Other Financial Concepts

The concept of financial redundancy as used in this paper is both related to and distinct from those of capital structure, working capital, and free cash flow. The capital structure mainly reflects the proportional allocation on the right-hand side of the balance sheet; that is, the relationship between long-term liabilities and owners' equity. Financial redundancy proposed in this paper refers to the financial phenomenon in which the firm's liquidity funds are greater than its liabilities. Financial redundancy can be concentrated on both the left and right sides of the balance sheet, and specifically considers the difference between assets

and liabilities, which can more intuitively measure the financial risk of the firm than capital structure. Working capital is the difference between current assets and current liabilities, which reflects the short-term financial status of the firm. However, financial redundancy does not directly compare the size of the firm's current assets and current liabilities; it more accurately reflects, to a certain extent, the medium- and long-term financial position of the firm from the perspective of the level of cash holdings and the debt commitment level. The term "free cash flow" was first coined by Jensen in 1986. After observing highly profitable oil firms for about 20 years, he found that firms did not pay cash dividends to shareholders and squandered the remaining cash on inefficient investment activities. He thus termed the cash that should be returned to shareholders but remains held in the firm free cash flow. Financial redundancy represents a financial situation in which a firm has good financial performance, relatively high free cash flow, and lower dividends. It can also be referred to as free cash flow increment, which is a kind of financial redundancy formed *via* the accumulation of free cash flow within the firm over many years. However, free cash flow only focuses on cash flow, while financial redundancy takes into account both cash flow and stock, and integrates the firm's cash holdings and liabilities. Therefore, it is better than free cash flow as an indicator to describe a firm's medium- and long-term financial status.

Motivations for Corporate Social Responsibility

Corporate social responsibility refers to the responsibility of enterprises to take into account the government, suppliers, customers, employees, and other stakeholders, as well as duties related to environmental protection. Existing literature has conducted rich explorations on the motivations of firms to undertake social responsibility. These motivations can be divided into altruistic, self-interest, and strategic.

Altruistic motivation refers to firms engaging in CSR behavior based on moral and ethical. When it comes to altruistic motives, CSR is seen as a true attempt by firms to solve social problems and improve overall social welfare through socially responsible behaviors. Previous studies have verified the altruistic motivation of social responsibility based on legitimacy theory and social contract theory (Ferrell et al., 2016; Rossi et al., 2021).

Self-interest motivation holds that firms take on social responsibility as a tool to seek personal benefits and as a means to cover up or whitewash their improper behaviors. Drawing on opportunistic tool theory, shareholder primacy theory, attribution theory, and principal-agent theory, scholars have conducted empirical studies on this motivation from the perspectives of earnings management, tax evasion, negative events, and political connection. For example, Prior et al. (2008) found that enterprises undertake social responsibility in order to conceal earnings management behavior, while Kotchen and Moon (2012) demonstrated that firms may simply use CSR to whitewash corporate irresponsibility.

Strategic motivation can be mainly explained based on resource dependence theory, stakeholder theory, competitive

advantage theory, and strategic choice theory. It is believed that firms can improve their strategic position and obtain various strategic resources by assuming social responsibility. Dhaliwal et al. (2014) and Marakova et al. (2021) contended that CSR activities can not only build a positive corporate image and enhance competitive advantage but also provide key resources for the sustainable development of firms by meeting the requirements of various stakeholders.

Financial Resources and Corporate Social Responsibility

As stakeholders pay increasing attention to CSR, some scholars have begun to explore the driving factors of CSR from the perspective of financial resources. However, evidence on the impact of corporate financial resources on CSR is mixed. Based on the resource dependence theory, most scholars have agreed that higher financial performance leads enterprises to take on more social responsibilities. For example, Lin et al. (2019) asserted that better financial performance of firms leads to higher CSR engagement. Waddock and Graves (1997) claimed that firms with high profitability can invest more in CSR compared to firms with lower profits. Nevertheless, some scholars have stated that financial resources do not make a positive contribution to CSR activities. For instance, Julian and Ofori-Dankwa (2013) studied the influence of financial resource availability on CSR and found that there are large differences between economies. Taking Ghana as the study subject, they found that firms with more financial resources spend less on CSR. Similarly, Shahzad et al. (2016) highlighted that excessive slack increases managers' complacency and idleness, resulting in a lack of motivation to undertake CSR. Using data from Nigerian, Boso et al. (2017) showed that increases in financial resource slack are associated with decreases in sustainability spending by firms.

In short, while CSR has been extensively explored and studied, deficiencies remain. First, there is still controversy surrounding the motivations of enterprises to fulfill social responsibilities. CSR is a multidimensional variable, environmental responsibility and charitable donations only reflect one aspect of CSR. Therefore, it is necessary to analyze the various dimensions of social responsibility indicators, as well as the economic consequences of CSR, which can be used to comprehensively evaluate CSR motives from a more detailed perspective. Second, in terms of financial indicators, prior studies have used income statement data to reflect the short-term financial conditions of firms, but these indicators may be undermined by earnings management (Li et al., 2014). Therefore, when studying the relationship between corporate financial resources and CSR, it may be difficult to draw reliable conclusions without excluding the influence of such noise. Third, existing studies have not reached a consensus on the impact of financial resources on CSR. A possible reason for this is that enterprises have different characteristics in allocating financial resources in different capital markets. As Julian and Ofori-Dankwa (2013) and Li et al. (2021) pointed out, institutional differences between developed and developing economies may result in different CSR implications. In addition, existing literature has not analyzed

the mechanisms underlying the impact of financial resources on CSR, which may be another reason for the controversial conclusions. Financial redundancy refers to financial resources that exceed the operational requirements of the firm and can be used to meet the other needs of stakeholders. The attributes of financial redundancy need to be allocated are complementary to the resource consumption characteristics of undertaking social responsibility. Financial redundancy has developed into a common financial phenomenon among Chinese listed firms, but few studies have explored the relationship between financial redundancy and CSR in the unique context of China's socialist market economy, and, in particular, no specific explanation has been given for the mechanistic paths involved.

HYPOTHESIS DEVELOPMENT

Financial redundancy is a type of redundant resource, which is caused by good financial performance, low dividends, and the accumulation of free cash flow within the firm. Financial redundancy plays a decisive role in a firm's long-term investment decisions. When the degree of financial redundancy is high, it can not only improve the firm's financial ability but also increase its motivation to undertake social responsibility activities, and ultimately improve CSR performance.

From the perspective of ability, financial redundancy affects the financial strength of enterprises to engage in social responsibility activities; specifically, greater financial redundancy is expected to lead to greater financial support for CSR activities. Enterprises need to pay financial costs to undertake social responsibility initiatives, including direct economic costs and opportunity costs (Sprinkle and Maines, 2010). However, the benefits of CSR come in both monetary and non-monetary forms, and there is a time lag in converting non-monetary benefits into monetary benefits. Since both inputs and outputs of social responsibility need financial support, enterprises can only develop socially responsible activities when they have sufficient financial resources. Financial redundancy implies that the firm has large cash reserves, low debt levels, and low financing costs (Alessandri et al., 2014; Xiao et al., 2021). The higher the degree of financial redundancy, the greater the firm's remaining discretionary capital. Financially redundant resources can not only provide financial support for CSR but also compensate for the revenue lag when social responsibility is transformed into economic performance. Conversely, when the firm is in financial distress, its economic needs for survival are far higher than its social needs. In such cases firms tend to adopt conservative business strategies and allocate energy and capital to projects that can quickly improve performance (March and Shapira, 1987; Leong and Yang, 2021). This results in enterprises paying less attention to long-term investment-oriented social responsibility activities and decreasing investments in CSR projects.

From the perspective of motivation, financial redundancy can affect the importance enterprises attach to social responsibility. Based on firm-level motivation, firms with financially redundant resources usually have strong financial strength, large scale, and dominant position in the industry, and their behavior is

widely scrutinized by outsiders. However, firms that receive more external attention are more vulnerable to stakeholder pressures. As stakeholders place increasing value on CSR, firms may respond to this preference by devoting available resources to CSR (Zyglidopoulos et al., 2012; El Ghoul et al., 2019). In addition, external attention will enhance the supervision effect of the external market. Greater external attention will result in severe penalties for firms that evade their social responsibility or fail to meet public expectations (Sun et al., 2021). Such firms, especially those that have financial redundancy, are likely to suffer reputational damage for not participating in CSR initiatives. Finally, external attention can accelerate the process of transforming CSR into financial performance, encouraging enterprises to fulfill more social responsibility. Thus, firms with high levels of financial redundancy will attract more external attention, which will enhance their motivation to undertake social responsibility driven by the two aspects of incentive and supervision.

In terms of executive motivation, when firms possess high levels of financial redundancy there is ample room for executives to allocate resources to projects that benefit private interests. Malmendier et al. (2011) asserted that executives become overconfident when a firm's redundant resources exceed a certain level. The higher the level of financial redundancy, the higher the possibility of executive overconfidence, and the higher the executives' desire to increase reputation and achieve self-achievement. Executives of firms with financially redundant resources pay more attention to spiritual satisfaction after meeting profit demands, and fulfilling social responsibility can satisfy their needs to improve social status, build a good image, and demonstrate their ability (Barnea and Rubin, 2010; Masulis and Reza, 2015). Especially in recent years, China has launched a series of social responsibility awards for outstanding entrepreneurs and most respected firms, which have pushed enterprises to practice greater social responsibility. Therefore, due to the desire for reputation, executives of firms with financially redundant resources tend to use corporate funds to support their social responsibility preferences, so as to achieve a sense of self-achievement and superiority. On the other hand, financial redundancy may result from managers hoarding large amounts of funds within the firm by paying few or no dividends. If managers spend large amounts of funds on on-the-job spending or discretionary expenses will trigger dissatisfaction from investors and shareholders. Therefore, managers have an incentive to find a rational outlet for these redundant resources. Social responsibility can bring reputation to them and also easily receive support from stakeholders, so CSR provides a suitable outlet for these redundant funds.

Therefore, our first hypothesis is drawn from the discussion above, and is stated formally below:

Hypothesis 1: Financial redundancy has a positive effect on CSR performance.

Social responsibility is a multidimensional concept, and firms need to meet the requirements of various stakeholders, including the government, shareholders, consumers, employees,

and the public. Excess financial resources will lead to an increase in agency costs and managers' self-interested motives (John et al., 2017). Different dimensions of social responsibility have different costs and benefits, and the principal-agent problem also widely exists in CSR behavior (Masulis and Reza, 2015). Due to the agency problem, financially redundant firms may face strategic choices when performing various dimensions of social responsibility.

On the one hand, limited resources drive firms to be selective regarding their socially responsible investments. CSR requires management to construct multiple objectives that meet the needs of various stakeholders, but different interest groups have different needs and expectations, and corporate resources are limited. Trade-off theory states that under the condition of limited resources enterprises cannot fully satisfy the demands of every stakeholder; thus, firms will inevitably adjust and weigh the needs of these disparate groups (Krishnamurti et al., 2021). In the face of the needs and pressures of powerful stakeholders, enterprises usually give priority to their social responsibilities, while the social responsibility of other vulnerable stakeholders is deferred or ignored. On the other hand, the costs involved in social responsibility initiatives may result in short-sighted investment behaviors of enterprises. CSR activities are complex processes with high investment, multiple levels, and long cycles; these factors require enterprises to continuously invest large amounts of capital and resources, but without seeing benefits until the next period or a certain period in the future (Waddock and Graves, 1997). Thus, redundant financial resources in firms will create agency problems, which may prompt firms to make short-sighted decisions when making socially responsible investments. Enterprises prefer short-cycle, high-profile, and low-cost CSR practices, and dislike long-term social responsibility because it will reduce corporate value in the short term.

Firms with financially redundant resources actively assume shareholder responsibility not only drive original shareholders to continue to invest in the firm but also attract new shareholders to join the firm, which is conducive to improving the firm's financing capacity. Firms undertake public responsibility, such as charitable donations and disaster relief. Under the influence of media publicity, these public responsibilities will have a rapid positive impact on firms, which makes corporate executives more inclined to use the firm's available funds to invest in public responsibility to obtain reputation benefits quickly. Supply chain responsibility includes responsibility to consumers and suppliers. Customers are the firm's main source of revenue, and suppliers are the firm's guarantee to enter the market. Firms undertaking supply chain responsibility can directly bring economic inflow and promote the growth of economic profit.

Conversely, compared with other responsibilities, employee responsibility and environmental responsibility are more easily affected by policy regulations, and enterprises lack the initiative to undertake these responsibilities. The power of enterprise employees is relatively weak, and managers may reduce CSR costs by reducing employee compensation to achieve other responsibility goals. Meanwhile, the agency problem caused by financial redundancy will make it difficult to guarantee the

rights and interests of employees. Environmental responsibility entails the characteristics of positive externality, long cycle, slow effect, and high cost. For listed firms with abundant financial resources, engaging in environmental investment will crowd out investment funds for other economic projects and reduce short-term performance even if they have significant funds. Motivated by the pursuit of personal benefits, Managers prefer to spend money on social responsibility that can quickly generate revenue inflows and are unwilling to invest in environmental protection. For example, Campbell (2007) found that firms donate large amounts of money to charities but spend little on employees and the environment. Briscese et al. (2021) established a game model to demonstrate that firms compensate for donations by reducing employees' wages; that is, firms increase their charitable donations by significantly reducing employees' incomes through an exchange mechanism.

In sum, we believe that the firm is a complex organization that integrates egoism and altruism. On the one hand, it uses egoism to pursue profits; on the other hand, as a social entity, it is afraid of being disconnected from society. Therefore, the firm may show unbalanced in undertaking social responsibility. Combining these arguments, our second hypothesis is formally stated below:

Hypothesis 2: Financial redundancy has an unbalanced effect in promoting enterprises to take on different dimensions of social responsibility, such that enterprises will selectively undertake social responsibility.

RESEARCH DESIGN

Data

In this study, we collected data on Chinese A-share listed firms from 2010 to 2020. CSR information at the firm level was extracted from Hexun.net¹. We choose to start our sample from 2010 because Hexun has published CSR data since this date. The website evaluates the social responsibility reports, sustainability reports, and financial reports of all listed firms, and the scores of CSR are given different weights according to the nature of the industry, which can comprehensively and fairly reflect the level of CSR. All financial data were extracted from the China Stock Market and Accounting Research (CSMAR) database and the Chinese Research Data Services (CNRDS) platform. First, we excluded the sample with unavailable or missing data. Second, we eliminated financial, insurance, and securities listed firms, and listed firms subject to special treatment and particular transfer to reduce measurement error. Third, to reduce the potential impact of outliers, all continuous variables were winsorized at the 1% and 99% quantiles. Following these procedures, the final sample comprised 25,044 firm-year observations from 3,310 Chinese listed firms.

Independent Variable

The independent variable in this paper is financial redundancy (*FEX*). There is no uniform measurement

¹<http://stockdata.stock.hexun.com>

standard for financial redundancy in academia. For example, Julian and Ofori-Dankwa (2013) and Boso et al. (2017) used return on sales, return on equity, and net profit as proxy variables for financial slack resources. Shahzad et al. (2016) calculated excess working capital as a measure of financial slack by subtracting the firm's current liabilities from its current assets. Leyva-de la Hiz et al. (2019) adopted the current ratio and return on assets as financial slack proxy variables. Previous literature has mainly used simple and general financial indicators to measure financial redundancy. For example, the current ratio only reflects the liquidity capacity of enterprises. Different enterprises have different requirements for asset liquidity due to variations in the nature of their business and their operating conditions. The net profit index only shows the current profitability of the firm, and cannot reflect its financial redundancy. Working capital only reflects a firm's short-term financial redundancy, not its long-term financial redundancy. Other indicators face similar limitations. Therefore, it is necessary to improve the existing metrics. Referring to the definition of financial redundancy proposed by Myers and Majluf (1984) and Alessandri et al. (2014), financial redundancy refers to the financial status in which the capital is held by the firm exceeds its operating demand and has a low interest-bearing liability ratio. We measure the degree of financial redundancy through the difference between the sum of monetary funds plus trading financial assets and interest-bearing liabilities after the standardization of total assets. Monetary funds comprise the cash holdings accumulated over a long period, and transaction financial assets are financial assets with high liquidity. The sum of the two reflects the number of funds have accumulated by the firm over time. Interest-bearing liabilities indicate the firm's debt situation. The former minus the latter represents the degree of redundancy in the firm's discretionary funds available after debt repayment. To eliminate differences in the individual characteristics of firms, total assets are used for standardization. A higher value of this indicator indicates a higher level of financial redundancy in the firm. In addition, firms with a value greater than 0 are considered financially redundant firms, while those with values less than 0 are called non-financially redundant firms.

Dependent Variable

The dependent variable is CSR. CSR data were mainly obtained from the scores of independent rating agencies. Compared with questionnaire surveys, scoring data can reduce small-sample problems and improve research objectivity and repeatability. The most popular CSR databases are KLD, RNS, and Hexun. However, the KLD database is for United States firms and lacks data for Chinese firms; RNS only uses social responsibility reports to evaluate CSR, but not all firms disclose their social responsibility reports. There is thus a lack of CSR data for firms that do not disclose social responsibility reports. Based on public information, financial reports, social responsibility reports, and sustainability reports, Hexun evaluates the CSR of all listed firms in China. The Hexun score reflects the extent to which firms undertake social responsibility, with higher scores indicating better CSR performance. The total score of Hexun is 100 points. The Hexun CSR score is being

increasingly used and recognized as the most authoritative indicator of CSR performance of Chinese listed firms (Hou et al., 2021; Sun et al., 2021). Hence, to analyze the CSR performance of listed firms and avoid sample selection bias, the CSR data were obtained from Hexun. In addition, this paper divides social responsibility into five indicators: shareholder responsibility (*SH*), employee responsibility (*EM*), supply chain responsibility (*SCC*), environmental responsibility (*ENV*), and public responsibility (*SOC*).

Control Variables

We control for several well-known determinants of CSR based on previous research (Flammer, 2015; Chang et al., 2017; Han et al., 2022). (1) Property rights (*State*). A dummy variable that equals 1 if the controlling shareholder of the firm is state-owned, and 0 otherwise. (2) Firm size (*Size*). The logarithm of total revenue. (3) Ownership concentration (*Top*). The shareholding percentage of the largest shareholder. (4) Firm performance (*Roa*). The return on assets measures the firm's profitability. (5) Financial leverage (*Lev*). The ratio of liabilities to assets. (6) The growth rate of operating income (*Growth*). The ratio of current year's revenue increase to last year's total revenue. (7) Executive compensation (*Salary*). The natural logarithm of the total compensation of the top three executives. (8) CEO-Chairman duality (*Dual*). A dummy variable that equals 1 if a firm's chairman and CEO are the same people and 0 otherwise. (9) Board size (*Board*). The total number of directors on board. (10) Firm age (*Age*). The logarithm of 1 plus the difference value between the year of the current year and the year when the firm established. Furthermore, we control industry (*Industry*) and year (*Year*) effects.

Model Building

To investigate whether financial redundancy can promote CSR performance, we conduct the ordinary least square (OLS) regressions model. Considering that CSR has a certain time lag, and at the same time, to further reduce the potential endogenous problems that may exist between the two, social responsibility data lagging one period is applied. The regression model is as follows:

$$CSR_{i,t+1} = \alpha_1 + \alpha_2 FEX_{i,t} + \sum_j \alpha_j Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where *i* and *t* denote the firm and the year, respectively. *CSR* is the dependent variable, which represents CSR performance. The key independent variable is *FEX*, which is our proxy for financial redundancy, we measure the degree of financial redundancy through the difference between the sum of monetary funds plus trading financial assets and interest-bearing liabilities after the standardization of total assets; *Control* is a vector of control variables, including property rights (*State*), firm size (*Size*), firm age (*Age*), leverage ratio (*Lev*), return on assets (*Roa*), the growth rate of operating income (*Growth*), executive compensation (*Salary*), ownership concentration (*Top*), the total number of directors on board (*Board*), CEO-Chairman duality (*Dual*), as well as industry (*Industry*) and year (*Year*). ε is the error term.

To verify hypothesis 2, financial redundancy has an unbalanced effect on firms undertaking social responsibility projects of different dimensions, we construct the following model:

$$\begin{aligned} & SH_{i,t+1}/EM_{i,t+1}/SCC_{i,t+1}/ENV_{i,t+1}/SOC_{i,t+1} \\ & = \beta_1 + \beta_2 FEX_{i,t} + \sum_j \beta_j Control_{i,t} + \varepsilon_{i,t} \quad (2) \end{aligned}$$

RESULTS

Descriptive Statistics

Table 1 summarizes the descriptive statistics. There are big differences in social responsibility scores between different firms, the mean and median of CSR are 23.758 and 21.900, respectively, the median is lower than the mean, suggesting that the level of CSR in China at a relatively low level (Sun et al., 2021). The minimum and maximum values of the five sub-indicators of CSR are far from each other, indicating that the development of social responsibility in China is extremely unbalanced. Correspondingly, the differences in the degree of financial redundancy of various firms are also obvious, with the minimum value of -0.533 , and the maximum value of 0.687 .

We conduct univariate tests to compare the mean value of CSR between financially redundant firms and non-financially redundant firms. The univariate test results are shown in **Table 2**. The results show that the mean CSR of the former is significantly higher than the mean CSR of the latter, indicating that firms with more financially redundant resources engage in more CSR activities than firms with less financially redundant resources.

Baseline Results

The univariate analysis provides us with preliminary evidence on the positive relationship between financial redundancy and CSR. In this section, we perform multivariate regressions to investigate the basic linear results of the impact of financial redundancy on the firm's overall CSR performance. Column (1) of **Table 3** shows the OLS estimation results. The coefficient of *FEX* is positive and significant, which provides strong support for Hypothesis 1. In other words, firms with financially redundant resources invest more resources in social responsibility activities, and their CSR score is higher, which is consistent with our expectation that financial redundancy promote firms to undertake social responsibility. From the perspective of economic significance, it indicates that a one standard deviation increase in the degree of corporate financial redundancy increases the CSR score by 0.028 ($=2.654 \times 0.253/23.758$).

Further, this paper subdivides CSR indicator into five dimensions: shareholder responsibility (*SH*), employee responsibility (*EM*), supply chain responsibility (*SCC*), environmental responsibility (*ENV*), and public responsibility (*SOC*). Columns (2)–(5) of **Table 3** show the regression results of financial redundancy on various dimensions of CSR. The regression coefficients of financial redundancy (*FEX*) are

TABLE 1 | Descriptive statistics of variables.

Variable	N	Mean	Median	Min	Max	SD
CSR	25,044	23.758	21.900	-18.450	90.870	15.666
SH	25,044	13.844	14.560	-12.670	28.190	6.524
SCC	25,044	2.533	1.560	-0.160	15	2.926
EM	25,044	1.376	0	0	20	4.301
SOC	25,044	4.582	4.190	-15	30	4.487
ENV	25,044	1.424	0	0	30	4.632
FEX	25,044	0.030	0.019	-0.533	0.687	0.253
State	25,044	0.367	0	0	1	0.482
Size	25,044	21.415	21.271	18.281	25.485	1.445
Roa	25,044	0.041	0.039	-0.201	0.193	0.054
Lev	25,044	0.419	0.410	0.048	0.876	0.209
Growth	25,044	0.196	0.119	-0.520	2.966	0.443
Top	25,044	0.347	0.330	0.034	0.746	0.152
Salary	25,044	14.321	14.300	12.651	16.268	0.697
Dual	25,044	0.273	0	0	1	0.445
Board	25,044	3.185	3	0	8	0.589
Age	25,044	2.780	2.833	1.386	3.434	0.385

TABLE 2 | Univariate tests.

Variables	Financially redundant firms		Non-financially redundant firms		Mean-Diff	T-Test
	Obs	Mean	Obs	Mean		
CSR	13,287	24.577	11,757	22.833	-1.744***	-8.805
State	13,287	0.293	11,757	0.451	0.157***	26.113
Size	13,287	21.868	11,757	21.013	0.855***	48.921
Roa	13,287	0.057	11,757	0.023	-0.035***	-53.215
Lev	13,287	0.300	11,757	0.554	0.253***	120.321
Growth	13,287	0.191	11,757	0.202	0.011*	1.932
Top	13,287	0.346	11,757	0.347	0.001	0.510
Salary	13,287	14.306	11,757	14.337	0.031***	3.494
Dual	13,287	0.319	11,757	0.219	-0.100***	-17.857
Board	13,287	3.118	11,757	3.262	0.144***	19.461
Age	13,287	2.724	11,757	2.843	0.119***	24.700

* and *** stand for the significance levels of 10 and 1%, respectively.

significantly positively correlated with shareholder responsibility (SH) and public responsibility (SOC) at the level of 1%, but are significantly negatively correlated with employee responsibility (EM) and environmental responsibility (ENV) at the level of 1%, and are not significant with regard to supply chain responsibility (SCC). This finding shows that firms with financial redundancy still have the characteristics of “economic man,” and redundant resources aggravate the agency problem. Thus, even if enterprises have redundant financial resources, driven by self-interest motives they will be more willing to invest in social responsibility projects that can quickly bring profits to the firm. Employees and environmental responsibility will crowd out investment funds for other economic projects and reduce short-term performance. Therefore, firms with financial redundancy will not take the initiative to increase their responsibility investment in these aspects.

Motivation Test

In this section, we aim to investigate the reason why firms with financially redundant resources toward better CSR practices

compared to those without. According to the hypothetical derivation logic, the incentive for firms with financial redundancy to promote CSR initiatives may be attributable to their high level of social awareness and pursuit of reputation.

The Social Awareness Motivation

Firms with financially redundant resources are usually large and subject to significant external attention. This means that their behavior is closely watched by the government, investors, media, and analysts. As external attention increases, corporate decisions become more complex and diverse because firms feel that their actions are being closely monitored and they must consider the interests of stakeholder groups in their decision-making process (Lindgreen et al., 2009; Jiang et al., 2022). Firms that receive large external attention are more inclined to display stronger social consciousness, which will encourage them to practice better CSR behavior.

To test whether firms that receive more attention will transfer public social awareness into corporate practices, we capture the social awareness of firms with financial redundancy using the

TABLE 3 | The impact of financial redundancy on CSR.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	CSR	SH	SCC	EM	ENV	SOC
FEX	2.654*** (5.099)	3.776*** (19.141)	0.071 (0.709)	-0.959*** (-6.209)	-1.353*** (-8.182)	1.119*** (7.052)
State	1.037*** (4.674)	-0.527*** (-6.520)	0.609*** (13.855)	0.371*** (5.641)	0.596*** (8.573)	-0.012 (-0.179)
Size	2.205*** (24.427)	0.681*** (19.063)	0.272*** (15.365)	0.447*** (16.984)	0.520*** (17.816)	0.285*** (10.265)
Roa	64.807*** (33.261)	50.990*** (53.974)	1.501*** (4.552)	3.108*** (6.194)	1.696*** (3.185)	7.510*** (12.057)
Lev	-5.855*** (-8.406)	-3.209*** (-10.627)	-0.030 (-0.234)	-1.223*** (-6.420)	-1.352*** (-6.409)	-0.040 (-0.176)
Growth	0.128 (0.641)	0.126 (1.497)	0.114*** (2.952)	-0.087 (-1.566)	-0.097* (-1.728)	0.072 (1.042)
Top	4.068*** (6.686)	3.475*** (15.331)	-0.141 (-1.191)	-0.093 (-0.505)	-0.021 (-0.108)	0.847*** (4.637)
Salary	3.210*** (20.634)	1.151*** (18.939)	0.741*** (24.933)	0.545*** (12.052)	0.457*** (9.552)	0.315*** (6.653)
Dual	-0.248 (-1.342)	-0.012 (-0.160)	-0.094*** (-2.693)	-0.050 (-0.949)	-0.066 (-1.195)	-0.025 (-0.419)
Board	0.808*** (4.503)	0.185*** (3.061)	0.136*** (3.735)	0.247*** (4.578)	0.233*** (3.884)	0.007 (0.142)
Age	0.641** (2.465)	-0.522*** (-5.520)	0.064 (1.232)	0.295*** (3.873)	-0.038 (-0.438)	0.842*** (11.732)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-80.794*** (-10.486)	-29.632*** (-5.333)	-13.131*** (-25.149)	-12.789*** (-15.862)	-11.813*** (-14.947)	-13.429*** (-11.792)
N	25,044	25,044	25,044	25,044	25,044	25,044
Adj. R-square	0.282	0.387	0.211	0.184	0.186	0.200

*** and ** indicate statistical significance at the 1 and 5% levels, respectively. The numbers in parentheses are *t* values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

interaction term of external attention and financial redundancy ($FEX \times Attention$). External attention refers to the degree of attention paid to the firm by the external public, such as the government, investors, analysts, creditors, media, and consumers. In line with Cheng and Liu (2018), we use the natural logarithm of the internet search volume of Chinese listed companies as a proxy variable for external public attention to the firm. In column (1) of **Table 4**, the interaction term between financial redundancy and external attention is included, and its coefficient is positive and statistically significant, indicating that external attention drives enterprises to consider public interest and motivates them to invest available funds in socially responsible activities.

The Reputation Motivation

Alternatively, firms with financial redundancy for CSR may stem from the desire of corporate executives to improve their reputation and social status through CSR engagement. Maslow's hierarchy of needs theory points out that people pursue spiritual satisfaction once their material needs have been satisfied. Social responsibility has become an important tool to meet the needs of executives to enhance their social status and reputation (Barnea and Rubin, 2010; Masulis and Reza, 2015). Therefore, this paper attempts

to explore whether corporate executives assign financially redundant resources to social responsibility activities to pursue reputation.

According to behavioral theory, the pay gap is an important part of social behavioral psychology, as it has a profound impact on whether executives pursue personal interests or actively achieve organizational goals. Drawing on Hou et al. (2021), this paper takes the percentage of executive compensation with total compensation as the standard to measure the degree of executives' pursuit of reputation. The higher the value, the higher the monetary remuneration executives have received from the firm. Executives are more likely to pursue spiritual satisfaction when their profit needs are satisfied and are then more likely to use redundant resources to invest in social responsibility activities to pursue reputation. A smaller pay differential represents a greater incentive for executives to pursue economic benefits and deliberately avoid social responsibility. The results regarding this aspect are presented in column (2) of **Table 4**. The interaction term of $FEX \times Reputation$ is significant and positive, indicating that executives of firms with financially redundant resources are more inclined to use corporate funds to support their preference for social responsibility initiatives, and are willing to invest funds in such initiatives.

Economic Consequences Test

The above findings confirm that financial redundancy can enhance CSR performance, but have yet to examine the ultimate impact of such promotion on firms. Therefore, it is necessary to further examine the economic consequences of financial redundancy on CSR to provide in-depth insights into motivations regarding CSR. The economic consequences of undertaking social responsibility include monetary and non-monetary benefits. Monetary benefits are measured

according to corporate profitability, while non-monetary benefits are measured according to reputation. Below, we extend our study by exploring the incremental effects of CSR driven by financial redundancy from these two aspects.

First, we look into the interplay between financial redundancy and CSR performance on firm profitability. We empirically examine whether firms with significant financial redundancy can obtain profit-related benefits from enhanced CSR activities. To do so, we focus on Tobin's q, which is a measure of a firm's operating performance as a critical indicator, with the following specification:

TABLE 4 | Motivation test.

Variables	(1)	(2)
	External attention	Pursuing reputation
	CSR	CSR
FEX	1.635* (1.884)	2.228*** (3.709)
FEX × Attention	0.144** (2.027)	
FEX × Reputation		12.633* (1.714)
Attention	0.231*** (12.618)	
Reputation		-2.537 (-1.583)
State	2.097*** (9.127)	1.026*** (4.625)
Size	1.906*** (20.364)	2.173*** (23.412)
Roa	74.542*** (37.252)	64.951*** (33.293)
Lev	-3.371*** (-4.710)	-5.842*** (-8.390)
Growth	0.539*** (2.658)	0.138 (0.691)
Top	4.157*** (6.606)	4.065*** (6.682)
Salary	1.872*** (12.088)	3.237*** (20.729)
Dual	-0.426** (-2.254)	-0.260 (-1.404)
Board	1.328*** (7.095)	0.806*** (4.495)
Age	-2.491*** (-9.929)	0.645** (2.482)
Year	Yes	Yes
Industry	Yes	Yes
Constant	-46.015*** (-20.458)	-80.297*** (-10.408)
N	25,044	25,044
Adj. R-square	0.234	0.282

***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively. The numbers in parentheses are t values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

$$TQ_{i,t+1} = \delta_1 + \delta_2 FEX_{i,t} + \delta_3 CSR_{i,t+1} + \delta_4 FEX_{i,t} \times CSR_{i,t+1} + \sum_j \delta_j Control_{i,t} + \varepsilon_{i,t} \tag{3}$$

Where *TQ* represents firm performance, using market value divided by total assets (Hou et al., 2021). The incremental effect of CSR through the presence of financial redundancy on firm profitability is captured by the interaction term between *FEX* and *CSR*. We control for several factors, including firm size, asset-liability ratio, the ratio of independent directors, the proportion of tangible asset, power balance with shareholder structure, firm age, and year and industry dummies. To the best of our knowledge, these factors can significantly affect corporate profitability. The results are shown in column (1) of **Table 5**. Among them, the coefficient of *FEX* × *CSR* is negative and significant at the level of 10%, indicating that increased CSR performance of firms with financial redundancy will not improve their profitability. As mentioned above, firms with financial redundancy will receive greater external attention. Firms participate in CSR to meet the expectations of, and pressure from, different stakeholders. In other words, firms with financial redundancy implement CSR behavior only in response to stakeholder pressure, and would not do so without such pressure. In this case, the stakeholder-driven motivation does not enhance corporate performance. This finding is consistent with empirical results found by Zhao et al. (2020). In addition, this result is in line with our subdivision indicators, in which we examine the impact of financial redundancy on different dimensions of social responsibility. Firms selectively undertake social responsibilities that can quickly improve short-term performance, and avoid social responsibilities that require long-term investment. Through the exchange mechanism, firms reduce some responsibilities in exchange for increasing others. However, this mode of strategically undertaking social responsibility will not increase corporate value.

Second, we examine the interaction between *FEX* and *CSR* on corporate reputation. The ranking method established by *Fortune* magazine in 1983, combines qualitative and quantitative reputation and is one of the most authoritative reputation ranking standards. However, the number of Chinese firms selected by *Fortune* magazine every year is small, and some non-listed firms are also included; thus, it provides insufficient data for this study. Fortunately, there are also authoritative institutions in China that evaluate the reputation of firms. *The*

economic observer, an authoritative economic journal in China, provides a list of “China’s Most Respected Firms” every year, and the Chinese version of *Fortune* magazine also indicates “China’s Most Admired Firms”; these are two representative lists of corporate reputation in China. Therefore, by examining whether the sample firms are included on the above three lists, with 1 indicating inclusion and 0 otherwise, giving us a corporate reputation value ranging from 0 to 3. We then reestimate Equation 3 by replacing *TQ* with *CR*. Firm size, firm age, asset-liability ratio, return on equity, market power, the ratio of independent directors, year, and industry are selected as control variables. The result is displayed in column (2) of **Table 5**. The results clearly indicate that the coefficient on the interaction term, *FEX* × *CSR*, is positive and significant, which means that, on average, firms with more financially redundant resources perform better at propelling CSR practices, consequently gaining significant improvements in reputation. This conclusion also reflects the motivation of firms with financial redundancy to actively undertake social responsibility to gain reputation, improve social status, and pursue a sense of achievement.

Collectively, the results presented in this part imply that the enhanced CSR performance driven by financial redundancy improves corporate reputation, but has no enhancement effect on corporate performance. The economic consequences test further verifies the correctness of the hypothesis logic structure and the completeness of the motivation test. It also demonstrates that firms with financial redundancy strategically undertake social responsibility.

Further Analysis

Previous studies have demonstrated that firms with available resources follow a specific investment sequence. To test the influence of other variables that may affect the relationship between financial redundancy and CSR, we examine how two key variables—managerial career concerns and market competition—affect the relationship between financial redundancy and CSR at the level of individual managers, as well as at the level of the external environment.

Managerial Career Concerns

There is no doubt that socially responsible investment is made primarily based on senior management decisions (Zu and Song, 2009; Fabrizi et al., 2014). Studies of the relationship between financial redundancy and CSR have to take into account the decision-making role of managers. Upper echelons theory suggests that the subjective cognition and values of managers have a significant impact on corporate strategic decisions. According to career focus theory, managers consider the impact of their actions on future career prospects during the decision-making process. Career concerns shape managers’ perceptions and beliefs, and managers’ varying degrees of career concern directly affect their use of corporate resources and implementation of a CSR investment strategy. Drawing on Li et al. (2017), we divided our sample into high career concerns and low career concerns according to the average age of managers. Columns (1) and (2) of **Table 6** show the relevant results. The results show that in the sample with high career

concerns, the coefficient of *FEX* is positive and significant, while the coefficient of *FEX* fails the significance test in the sample with low career concerns. Thus, as corporate financial redundancy increases, the motivation of managers to make profitability their primary goal gradually weakens. Managers with high career concerns have a strong desire for achievement and reputation, which leads to young managers taking advantage of redundant resources to participate in social activities to gain a good social reputation. In contrast, managers with low career concerns tend to follow the firm’s existing strategy, make conservative decisions, and avoid engaging in the social responsibility practices.

Market Competition

According to stakeholder theory, a firm’s stakeholders are those groups whose behaviors and interests are directly or indirectly affected by the firm’s behavior. Two categories of market participants are often discussed: primary stakeholders, which includes employees, customers, suppliers, distributors, competitors, shareholders, and state regulators; and secondary

TABLE 5 | The incremental effect of CSR on profitability and corporate reputation.

Variables	(1)	(2)
	TQ	CR
FEX	3.762*** (2.919)	0.041*** (3.496)
FEX × CSR	−0.056* (−1.651)	0.001** (2.021)
CSR	0.000 (0.053)	0.001*** (10.183)
Size	−0.475*** (−10.456)	0.010*** (3.847)
Lev	2.022*** (4.386)	0.146*** (15.140)
Tangible	0.255** (2.145)	
Ebd	−0.001 (−1.541)	
Inde	0.016*** (4.180)	0.001*** (5.392)
Age	0.518*** (4.668)	0.016*** (4.294)
Roe		0.000 (0.074)
MK		0.040** (2.484)
Year	Yes	Yes
Industry	Yes	Yes
Constant	7.756*** (14.156)	−0.158*** (−8.189)
N	23,960	21,586
Adj. R-square	0.036	0.034

***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively. The numbers in parentheses are *t* values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

stakeholders, such as community activists, religious leaders, and non-governmental organizations. We argue that the two stakeholder groups will exert enormous pressure on firms through the market and require them to undertake corresponding social responsibilities. In turn, market competition will affect the relationship between financial redundancy and CSR. Our measure of market competition is the Herfindahl-Hirschman index (HHI), which is calculated by summing up the sales-based square market shares of all firms in the given industry. According to the industry median, the whole sample is divided into two groups: high market competition and low market competition. The results are shown in **Table 6**, columns (3) and (4), demonstrate that in the subsample regression of high market competition and low market competition, the coefficients of *FEX* are 9.089 and 0.657, respectively, with the latter failing the significance test. Findings show that the relationship between financial redundancy and CSR is influenced by degrees of pressure from a firm's target market. The fiercely competitive environment prompts firms to engage in CSR practices because CSR can be used to differentiate themselves from competitors in the industry, and can also meet the needs of market stakeholders. The more competitive the market, the higher the level of CSR participation.

ROBUSTNESS TEST

Mitigating Potential Endogeneity Driven by Reverse Causality

Reverse causality may potentially bias our results because firms may obtain benefits from social responsibility activities, which in turn increases the level of financial redundancy. To rule out reverse causality as an alternative explanation for our results, following Dyck et al. (2019) and Li et al. (2021), we use the Granger causality test by estimating two symmetric sets of regressions; that is, we regress *CSR* on lagged *FEX* and lagged *CSR*, and *FEX* on lagged *CSR* and lagged *FEX*, with the same set of control variables, separately. The results are shown in **Table 7**, columns (1) and (2), and show that the coefficient of *FEX* is positive and significant, but that on *CSR* is not. Thus, we conclude that it is the financial redundancy that drives firms to engage in CSR practices, rather than firms reserving financial resources for social responsibility.

Mitigating Potential Endogeneity Driven by Sample Selection Bias

Although the lag effect applied in this paper can alleviate certain endogeneity concerns, there may still be an endogeneity problem caused by sample selection bias. The propensity score matching (PSM) method is adopted to solve this problem. We construct a treatment group of financially redundant firms and a control group of non-financially redundant firms based on a common set of firm characteristics (*Size*, *Roa*, *Lev*, *Growth*, *Top*, *Salary*, *Age*), as well as the year, area, and industry dummies. This study uses the one-to-one nearest neighbor matching method. A total of 11,756 financially redundant samples are matched to

TABLE 6 | Further analysis.

Variables	(1)	(2)	(3)	(4)
	High_career concerns	Low_career concerns	High_HHI	Low_HHI
	CSR	CSR	CSR	CSR
FEX	10.620*** (14.006)	1.042 (1.464)	9.089*** (13.384)	0.657 (0.793)
State	3.174*** (23.256)	2.729*** (22.847)	3.034*** (26.990)	2.632*** (17.912)
Size	-8.957*** (-9.676)	-14.681*** (-14.977)	-10.172*** (-11.968)	-14.479*** (-13.101)
Roa	1.330*** (5.015)	1.546*** (4.871)	1.286*** (4.972)	1.539*** (4.813)
Lev	9.070*** (9.933)	4.508*** (5.415)	6.424*** (7.938)	4.919*** (5.210)
Growth	3.060*** (13.530)	4.533*** (20.726)	3.714*** (18.165)	4.063*** (16.739)
Top	-0.638** (-2.530)	-0.092 (-0.322)	-0.749*** (-3.023)	0.181 (0.635)
Salary	1.765*** (5.925)	0.368 (1.602)	0.721*** (3.132)	0.936*** (3.247)
Dual	1.292*** (3.658)	0.638 (1.613)	1.076*** (2.993)	1.237*** (3.279)
Board	10.620*** (14.006)	1.042 (1.464)	9.089*** (13.384)	0.657 (0.793)
Age	3.174*** (23.256)	2.729*** (22.847)	3.034*** (26.990)	2.632*** (17.912)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Constant	-111.029*** (-27.132)	-86.765*** (-23.397)	-113.959*** (-39.003)	-103.212*** (-29.594)
N	12,218	12,826	14,988	10,056
Adj. R-square	0.242	0.259	0.278	0.211

*** and ** indicate statistical significance at the 1 and 5% levels, respectively. The numbers in parentheses are t values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

11,756 non-financially redundant samples with the most similar characteristics, and a total of 23,512 firm-year observations are obtained. Using the matched sample, this study reestimates Equation 1. The regression results are shown in column (3) of **Table 7** and are qualitatively similar to those reported in column (1) of **Table 3**, which indicates that there is no substantial change in the conclusions of this paper.

Mitigating Potential Endogeneity Driven by Omitted Variables

Although using an extensive list of control variables (in Equation 1) helps to reduce omitted variables bias in estimating the relationship between financial redundancy and CSR, the regression results still suffer from endogenous bias caused by unobserved omission variables. We used two methods of adding control variables and applying a fixed-effects model to mitigate potential endogeneity driven by omitted variables.

We use a fixed-effects model to control for relevant unobserved and observed time-invariant firm-specific factors that, if omitted from the model, often lead to considerable bias in the estimated results. The result is presented in column (4) of **Table 7**. Unsurprisingly, a positive and statistically significant relationship between financial redundancy and CSR still exists, which proves that our research conclusions have good robustness.

There is empirical evidence that research and development (R&D) expenditures are correlated with CSR choice (Padgett and Galan, 2010; Li et al., 2021). Similarly, the degree of marketization, the ratio of independent directors, and the management expense ratio are related to CSR investment (Flammer, 2015; Ardito et al., 2021; Shen et al., 2021). We additionally include regional marketization

TABLE 7 | Endogeneity test.

Variables	(1)		(2)	(3)	(4)	(5)
	Granger causality test		FEX	PSM	Fixed-effects	Add control variables
	CSR	FEX				
FEX	3.059*** (7.073)	0.820*** (164.839)	3.094*** (5.643)	4.124*** (5.802)	2.691*** (5.126)	
CSR	0.536*** (64.332)	-0.000 (-0.005)				
State	0.206 (1.091)	0.014*** (7.959)	0.850*** (3.769)	-0.004 (-0.007)	1.207*** (5.411)	
Size	0.882*** (11.124)	-0.003*** (-3.953)	2.232*** (24.124)	1.168*** (5.986)	2.178*** (24.042)	
Roa	8.008*** (4.255)	0.050** (2.369)	64.286*** (31.602)	21.667*** (10.657)	64.988*** (33.169)	
Lev	-2.725*** (-4.568)	-0.036*** (-5.427)	-5.980*** (-8.309)	0.192 (0.183)	-5.627*** (-8.059)	
Growth	0.563*** (3.180)	-0.006*** (-2.801)	0.081 (0.397)	1.459*** (7.590)	0.125 (0.627)	
Top	3.087*** (5.953)	0.017*** (3.344)	4.286*** (6.809)	4.585*** (3.784)	3.952*** (6.465)	
Salary	1.624*** (12.309)	0.003* (1.902)	3.292*** (20.360)	1.958*** (7.665)	3.139*** (19.887)	
Dual	-0.180 (-1.130)	-0.005*** (-2.589)	-0.279 (-1.446)	-0.584** (-2.092)	-0.326* (-1.754)	
Board	0.304** (1.994)	-0.002* (-1.875)	0.826*** (4.490)	0.249 (0.999)	0.790*** (4.313)	
Age	0.449** (2.059)	0.014*** (6.199)	2.067*** (2.910)	2.349** (2.060)	0.700*** (2.678)	
RD					0.710 (0.139)	
ME					-5.297** (-2.186)	
Inde					0.028* (1.726)	
Market					1.528*** (6.195)	
Year	Yes	Yes	Yes	Yes	Yes	
Industry	Yes	Yes	Yes	Yes	Yes	
Firm	No	No	No	Yes	No	
Constant	-47.328*** (-5.468)	-0.060 (-1.482)	-72.438*** (-29.069)	-31.179*** (-5.938)	-80.968*** (-10.342)	
N	25,044	25,044	23,512	25,044	25,030	
Adj. R-square	0.476	0.788	0.285	0.052	0.283	

***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively. The numbers in parentheses are t values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

degree (*Market*), R&D expenditure (*RD*), the ratio of independent directors (*Inde*), and management expense ratio (*ME*) as control variables in Equation 1. The results are displayed in column (5) of **Table 7**. The coefficient of *FEX* remains positive and statistically significant at the conventional level, reaffirming the positive influence of financial redundancy on CSR despite the inclusion of some additional variables.

Replacing Variables

We use additional methods to remeasure CSR to strengthen the conclusions. Specifically, we apply three methods that are commonly used in academia to remeasure CSR. First, the CSR rating given by Hexun is used instead of the score. The higher the rating, the better the CSR performance. The ratings are A to E, so the CSR variable is assigned values 5 to 1 accordingly. Second, the social contribution per share is used to measure the CSR performance of listed firms. Third, the difference between the next year's CSR score and the current year's CSR score is used to measure CSR. Equation 1 is tested by remeasuring CSR

through the above three methods. The results in columns (1)–(3) of **Table 8** imply that the coefficients of *FEX* are always positive and significant even if the measurement method of CSR is changed.

We also replace the measure of financial redundancy. We use dummy variables to remeasure financial redundancy. If the sum of monetary funds and transactional financial assets of the firm is greater than the total amount of interest-bearing liabilities of the firm, *FEX* is coded as 1, and 0 otherwise. Equation 1 is retested and the results are presented in column (4) of **Table 8**. In addition, considering that industry characteristics may affect corporate financial redundancy, referring to Harford et al. (2008), the industry-adjusted financial redundancy index is used as a proxy for financial redundancy to conduct robustness tests, and the results are shown in column (5). In both cases, the evidence reconfirms our main findings.

In sum, our results are robust after a series of replacement variable measures and further confirm that financial redundancy plays an important role in promoting CSR activities.

TABLE 8 | Replacing variables.

Variables	(1)	(2)	(3)	(4)	(5)
	CSR	CSR	CSR	CSR	CSR
FEX	0.038** (1.974)	1.294*** (10.945)	3.410*** (7.103)	1.079*** (4.910)	2.868*** (5.496)
State	0.056*** (6.587)	0.057 (1.350)	−0.515** (−2.411)	1.019*** (4.587)	1.032*** (4.650)
Size	0.065*** (20.181)	0.297*** (14.875)	−0.266*** (−2.970)	2.191*** (24.328)	2.208*** (24.451)
Roa	0.154*** (2.858)	7.251*** (19.022)	−41.217*** (−22.566)	65.264*** (33.651)	64.722*** (33.231)
Lev	−0.218*** (−8.580)	1.517*** (12.458)	−0.012 (−0.018)	−6.429*** (−9.798)	−5.705*** (−8.216)
Growth	−0.000*** (−4.262)	0.039 (1.326)	0.940*** (4.786)	0.130 (0.650)	0.127 (0.635)
Top	0.055*** (2.408)	0.340*** (3.197)	2.238*** (3.830)	4.135*** (6.807)	4.062*** (6.676)
Salary	0.086*** (14.752)	0.154*** (3.080)	0.250* (1.700)	3.239*** (20.855)	3.203*** (20.587)
Dual	−0.006 (−0.831)	0.097*** (2.622)	−0.121 (−0.674)	−0.237 (−1.282)	−0.250 (−1.352)
Board	0.024*** (3.491)	0.043* (1.841)	−0.133 (−0.771)	0.801*** (4.467)	0.809*** (4.513)
Age	0.014 (1.401)	−0.032 (−0.774)	0.284 (1.167)	0.608** (2.342)	0.646** (2.485)
Year	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Constant	−2.091*** (−20.847)	−10.006*** (−16.439)	−18.325* (−1.904)	−80.126*** (−10.432)	−79.052*** (−10.392)
N	25,044	16,349	25,044	25,044	25,044
Adj. R-square	0.181	0.138	0.101	0.282	0.282

***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively. The numbers in parentheses are *t* values; cluster-robust standard errors are used in model estimates to eliminate the heteroscedasticity effect.

CONCLUSION

This study takes Chinese A-share listed firms from 2010 to 2020 as the research object. Based on stakeholder theory, resource slack theory, agency cost theory, and behavioral theory, the influence of financial redundancy on CSR is discussed from the perspective of social responsibility as a whole, and social responsibility from various dimensions. The main results are as follows: (1) firms with financial redundancy have significantly higher CSR concerns vs. those without such resources, that is to say, financial redundancy significantly improves their overall CSR performance. This result remains following a series of robustness tests. (2) Through the decomposition of social responsibility indicators, it can be found that firms with financial redundancy give priority to strengthening their social responsibility performance in relation to shareholders and the public, while ignoring their responsibility to employees and the environment. (3) By examining the motivations and economic consequences of CSR, we show that firms with financial redundancy take on more social responsibility to meet social needs and obtain reputation, which further reveals that firms undertaking social responsibility is a strategic behavior. (4) Further analysis shows that the positive impact of financial redundancy on CSR is more significant in firms with high managerial career concerns and high market competition than firms with low managerial career concerns and low market competition.

Our findings have important implications for enterprises and governments. For enterprises, on the one hand, firms leaders should establish a scientific perception of social responsibility. Although the fulfillment of social responsibilities entails financial cost, the motivation for enterprises to fulfill their social responsibilities should not only be self-interested as a profit-making tool, but should also embed social responsibility missions into corporate strategies and business operations. Choosing to assume social responsibilities for short-term effects and avoiding social responsibilities that can bring long-term effects neither brings lasting economic benefits nor become competitive advantage to the firm. The firm needs to incorporate multidimensional social responsibility into corporate strategic considerations. On the other hand, companies need to establish

a good corporate governance mechanism. Companies can reduce agency problems by separating the position of chairman and CEO, increasing the size of directors' ownership structure, and providing appropriate incentives to senior management. Stimulating the decision-making of enterprise managers and shareholders reflect the needs of stakeholders, thereby preventing and curbing all kinds of misconduct that may damage the interests of enterprises. The government needs to improve the external institutional environment. Catering to social needs and reputation mechanisms are the motivations for financially redundant firms to fulfill their social responsibilities. If the government further promulgates policies to strengthen the necessity for enterprises to undertake social responsibility and strengthens the supervision role of media on corporate social responsibility behaviors, which can help enterprises to establish standardized social responsibility content and boundary.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

LH chose the research ideas, formed the study framework, and wrote the manuscript. SG collected and analyzed the data. TZ reviewed and edited the manuscript. All authors read and approved the final manuscript.

FUNDING

This research was supported by the National Social Science Foundation of China (Grant Number: 21BJY121).

ACKNOWLEDGMENTS

We would like to thank Sichuan University for providing equipment support for this study.

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The Functions of the Board of Directors in Corporate Philanthropy: An Empirical Study From China

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OPEN ACCESS

Edited by:

Haiyue Liu,
Sichuan University,
China

Reviewed by:

Maria Kovacova,
University of Žilina,
Slovakia
Muhammad Zulqarnain Arshad,
Universiti Utara Malaysia, Malaysia

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 08 January 2022

Accepted: 27 April 2022

Published: 24 May 2022

Citation:

Pan Q and Huang Z (2022) The
Functions of the Board of Directors in
Corporate Philanthropy: An Empirical
Study From China.
Front. Psychol. 13:850980.
doi: 10.3389/fpsyg.2022.850980

As an important way for enterprises to fulfill social responsibility, corporate philanthropy (CP) has attracted much attention from the academic community. But there are still few well-targeted theoretical and empirical studies on what functions the board of directors (BOD) should perform to better fulfill philanthropic responsibilities. Taking this deficiency as a breakthrough, this study focuses on Chinese state-owned and private enterprises to analyze and test the functions performed by the BOD in CP. Based on the sample of Chinese A-share listed companies from 2008 to 2019, the empirical results show that the BOD of state-owned enterprises mainly performs a monitoring function in CP while that of private enterprises mainly performs a consulting function. The above findings remain valid when potential biases in the quantitative analysis are considered. Further research shows that environmental dynamism and board fault lines inhibit the performance of the above two functions. The contributions of the study include clarifying the functional characteristics of the BOD in CP and its influencing factors, revealing new theories to the formation mechanism of CP, which provide references for enterprises to optimize philanthropic decision-making. The limitation should also be emphasized that our findings are based only on Chinese contexts.

Keywords: corporate philanthropy, board of directors, monitoring, consulting, environmental dynamism, board fault lines

INTRODUCTION

With the comprehensive advancement and rapid development of social welfare undertakings, corporate social responsibility (CSR) has become a significant issue of public concern. More and more enterprises are increasingly focused on practicing CSR. Many enterprises are diligently seeking ways to demonstrate social responsibility through corporate philanthropy (Erusalimsky et al., 2006; Luo et al., 2020; Jonawski, 2021). According to the 2019 Report on Chinese Charitable Donations, enterprises are the main source of charitable donations in China. More than 90% of enterprises have participated in charity work in different ways while enterprises' donations accounted for more than 60% of the total.

Although CP has become an important means for such enterprises to practice CSR, the empirical studies needed to explore how to perform CP effectively are still lacking, especially regarding what functions the board of directors (BOD) should perform (Rao and Tilt, 2016; Boivie et al., 2021).

In practice, due to the lack of reasonable philanthropic decision-making, enterprises have failed to establish a positive image in society through CP. Instead, unnecessary troubles can arise. In December 2020, minority shareholders filed a class action lawsuit against Kweichow Moutai over an external donation of 809 million RMB, and Kweichow Moutai was eventually forced to cancel the donation. Similarly, in April 2020, Vanke donated 200 million shares worth about 5.3 billion to the Tsinghua University Education Foundation. The decision was challenged by the employees of Vanke, who urged Tsinghua University to return the donation.

To avoid such embarrassment caused by donations, it is necessary to optimize the work of CP. This requires further exploration of the formation mechanism of CP, especially fully understanding the functions of the BOD (Krüger, 2009; Rao and Tilt, 2016; Zhuang et al., 2018), making full use of the BOD as the hub of enterprise's management mechanism, formulating appropriate philanthropy plans to respond to the demands of stakeholders and ultimately improving CP satisfaction.

Although it is clear that the above-mentioned topics require further research, few studies have addressed them directly (Rao and Tilt, 2016). Some literature has examined the formation mechanism of CP from the perspective of the BOD, but most analyze the relationship between the characteristics of the BOD and CP. As a result, even if we find that a particular characteristic of the BOD affects CP, it is still not clear which function of the BOD works (Wang and Coffey, 1992; Williams, 2003; Gautier and Pache, 2015; Cha and Rew, 2018; Boivie et al., 2021; Endrikat et al., 2021). In fact, only by clearly identifying the functions of the BOD in CP can we better understand and improve the functions and eventually optimize and improve CP decision-making in a scientific way. Actually, this is also an important issue that has not been effectively explored in the current CSR research (Rao and Tilt, 2016; Bolourian et al., 2021).

In this study, we intend to improve these research deficiencies. Specifically, taking the monitoring and consulting function of the BOD as starting point, and considering the differences in the philanthropic motivations of enterprises with different property rights, this study develops a performance model of CP and uses it as a basis for inference to test the functions of the BOD of state-owned and private enterprises in CP. Based on the samples of Chinese A-share listed companies, the empirical results show that the BOD of state-owned enterprise (SOEs) mainly perform a monitoring function while that of private enterprises mainly perform a consulting function in CP. In addition, environmental dynamism and board fault lines inhibit the performance of these two functions.

The remainder of the study is structured as follows. In section "Literature Review and Hypothesis Development," we review the prior research on the functions of the BOD and CP, propose the hypotheses. Section "Research Design" describes the data source, variables, and model. In section "Empirical Results and Analysis," regression analysis is conducted to examine the hypotheses, followed by heterogeneity analysis and robustness checks. Section "Extension Analysis" tests the

moderate effects of environmental dynamism and board fault lines. "Discussion" summarizes the contributions, proposes policy recommendations, future research, and conclusions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Literature Review

The Functions of the BOD

It refers to the roles, responsibilities, and tasks assumed by the BOD. As the core of a corporate governance and the principal entity of corporate decision-making, the BOD usually serves monitoring and consulting function, and their basic goal is to create sustainably growing value for shareholders (Schmidt and Brauer, 2006). As for the monitoring function, Fama and Jensen (1983) put forth monitor hypothesis based on agency theory, which holds that the main function of the BOD is to monitor, including hiring & dismissal of managers and determining managers' compensation etc. Its purpose is to monitor the managers and protect the rights and interests of shareholders. As for the consulting function, the analyses based on resource dependence theory have revealed that the function of the BOD should be to provide advisory and suggestions to managers or to help establish connections with other organizations based on a comprehensive and in-depth understanding of the enterprise's operating conditions and strategic positioning (Hillman and Dalziel, 2003), ultimately reducing the uncertainty of the external environment and improving the success rate of the company's strategy implementation (Salancik and Pfeffer, 1978).

Since the functions of the BOD are largely invisible (Carter and Lorsch, 2003), most existing studies focus on the organization characteristics of the BOD and exploring whether certain characteristics effectively stimulates specific function. To reduce self-interested behavior of managers, the studies mainly examine the relationship between board structure, behavior requirements, incentive characteristics, and monitoring function. To improve consulting function of the BOD, the studies primarily focus on board members' industry expertise, business background, and professional knowledge etc.

The above researches are beneficial for understanding the functions of the BOD. Different characteristics of the BOD are only external representations after all. Whether or how the functions of the BOD are effectively performed therefore remains unclear. As Golden and Zajac (2001) have pointed out, although people generally have high expectations to the BOD, it is still uncertain whether its functions are fulfilled. Taking this flaw as a breakthrough, relevant literature has further deepened and expanded mainly from two directions. First, some studies directly investigate the roles played by specific board members. For example, Liu et al. (2015) studied whether non-local independent directors play an advisory role in inter-province mergers and acquisitions. Zhu et al. (2021) examined the monitoring motives and its effects of non-controlling shareholder directors. Second, explore the functions of the BOD from the perspective of specific corporate practices. For example, Klarner et al. (2020) studied the functions of the

Abbreviations: CP, Corporate philanthropy; BOD, Board of directors; SOEs, State-owned enterprises.

BOD in corporate innovation. In more detail, there is also literature that specifically analyses the roles played by particular board members in a given corporate practice. For example, Lara et al. (2017) studied the monitoring function of female directors in the release of company accounting information.

Corporate Philanthropy

Many studies, whether considering CP as a dimension of CSR or focusing on the topic itself, have furnished fruitful and in-depth research on its antecedents (Gautier and Pache, 2015; Liket and Simaens, 2015; Cha and Rajadhyaksha, 2021).

Relevant research studied from four different perspectives. The first is analyzing the effect of CEO or other senior leaders on CP from the individual level. The main factors studied include gender, personality of the leader, professional background, social connections, discretion, and values (Campbell et al., 1999; Williams, 2003; Zhang et al., 2021). The second examines the factors that affect CP from the perspective of enterprise characteristics, which include corporate property rights, resources, size, debt ratio, advertising expenditure, geographic location, labor intensity, culture, R&D intensity and corporate history etc. (Zhang et al., 2010; Gao et al., 2011; Li et al., 2015a,b). The third explores from the perspective of corporate governance. The relevant literature mainly focuses on the composition of the BOD, remuneration, and incentives, the proportion of institutional investors and equity concentration etc. (Wang and Coffey, 1992; Su and Sauerwald, 2018). The fourth identifies the impact of macro environmental factors on CP, such as market system, taxation, and industry background (Brammer and Millington, 2004; Carroll and Joulfaian, 2005; Chih and Chen, 2009; Pan et al., 2017).

Summarizing the above two aspects of literature, we can find that fewer studies combine the functions of the BOD with CP, especially rarely examine the formation mechanism of CP from the functions of the BOD. Although some studies have tested the impact of the composition characteristics of the BOD on CP, there is still a long way to go before the functions of the BOD are clearly revealed. This is not only because the findings of many studies on the influence of board composition on CP remain inconsistent (Bolourian et al., 2021; Endrikat et al., 2021), but also because various structures and mechanisms of the BOD are only means serving the purpose of decision-making, which are not directly related to what function the BOD actually performs. Further, it provides an opportunity for this study to directly explore the functions of the BOD in CP.

Research Hypothesis

The Functions of the BOD in CP

What functions does the BOD perform in CP? As far as Chinese enterprises are concerned, the coexistence of enterprises with different property rights during the transformation period has determined that state-owned and private enterprises would be in the spotlight (Wang and Qian, 2011). In view of the heterogeneity of the two types enterprises in CP orientation, and as the BOD should serve CP orientation, this study suggests that the functions of their BOD in CP are significantly different.

First, regarding SOEs, we infer that the BOD would position themselves in a monitoring role based on realistic considerations. Specifically, on one hand, SOEs should bear more social responsibilities including philanthropy (Zhang, 2013; Pan et al., 2015). The reason lies in the principle that social responsibilities shouldered by enterprises should match their rights. SOEs have more rights to development and resource use (Jin et al., 2014; Li and Cheong, 2019), which are manifested at least in the following facts. In terms of development, most of them are monopolies, through which they gain excessive profits (Huang, 2006; Wang and Yung, 2011). In terms of resource use, many SOEs expand their business by using more scarce economic resources, such as relying on bank credit rather than their own funds, and obtaining more quotas to become listed while enjoying more preferential policies including financial subsidies, land supply, and tax incentives etc. (Luo and Liu, 2009; Xu and Zhang, 2015). As SOEs have enjoyed the above privileges, they should accordingly shoulder more responsibilities including philanthropy.

On the other hand, due to owner absence and the lack of capital personalization, the excessive principal-agent chains of SOEs makes management team to weak supervision (Zheng et al., 2014; Hong et al., 2021). Coupled with the problem of information asymmetry, members of management team have the motivation to benefit themselves by using resources of SOEs to do more charity work. Existing studies have also revealed that the manager of SOEs have a strong desire to polish their personal images through charitable donations to pursue political promotion (Dai et al., 2014; Zhang et al., 2015).

In sum, SOEs must engage in CP for their privileges and inevitably encounter principal-agent problems at the same time. To avoid the loss of state-owned assets caused by charity works, the BOD is obliged to actively perform the monitoring function or take this as the function orientation.

While the BOD of SOEs positions itself in a monitoring role, given that competitiveness of monitoring and consulting functions (Armstrong et al., 2010; Faleye et al., 2011; Masulis et al., 2012; Boivie et al., 2021), it is not feasible to expect the BOD to do much work related to the consulting function. In fact, as stakeholders generally expect SOEs to be charitable, by nature, philanthropic responsibilities of SOEs is just a social response to stakeholder claims. In others words, when SOEs are subject to extensive pressure, stakeholders have actually set a framework for their philanthropic acts (Tan and Tang, 2016). At this point, there is insufficient demand for the consulting function of the BOD. And what is needed is immediate action rather than advisory. Thus we propose the following hypothesis:

Hypothesis 1a: The BOD of SOEs mainly performs monitoring functions in CP.

Furthermore, for private enterprises to seek better development through donations, this study infers that the BOD will position themselves in a consulting role due to the practical needs of business operations. Specifically, although the private sector is a key component of Chinese economy, the implicit discrimination

and the constraints placed on private enterprises have not been fully eliminated (Allen et al., 2005; Poncet et al., 2010; Lu et al., 2012). No form of private economy was allowed before 1987, and private enterprises were once regarded as enemies that exploited the people (Hong, 2004). Although private enterprises have been given new economic roles since reform and opening up, the public's prejudices against private enterprises remains deep-seated. People believe that such enterprises are wealthy but uncharitable, think that all businessmen are dishonest, and believe that private enterprises have original sins. As a result, private enterprises have always come under harsh and suspicious scrutiny.

In order to enhance their legitimacy, it has become a natural and realistic choice for private enterprises to seek various kinds of social support. One option is to gain the favor of stakeholders by proactively fulfilling their social responsibilities. For example, they might establish political connections with the government through CP and then using the connections to reduce financing costs, obtain tax reliefs, obtain financial subsidies and other facilities (Zhong, 2007; Li et al., 2016). Li et al. (2015a,b) find that private enterprises may obtain debt financing by exchanging resources with the government through donations; the empirical study of Su and He (2010) also show that private enterprises obtain property rights protection through CP.

In summary, driven by interest, private enterprises in the transitional period will proactively allocate resources in donations. When private enterprises invest resources in charity, considering the complexity of the value effect of CP, they will inevitably enhance the effort of managing the philanthropic resources, such as brainstorming, weighing up the costs and benefits of charitable acts (Krulicky and Horak, 2021). To help CP achieve intended goals, as the core organization to facilitate enterprise development and operation management, the BOD has the responsibility to position itself in a consulting role.

Similarly, when the BOD of a private enterprise positions itself in the above-mentioned consulting role, given that the monitoring and consulting functions of the BOD are in competition (Armstrong et al., 2010; Faleye et al., 2011; Masulis et al., 2012; Boivie et al., 2021), it is less likely that the BOD will itself be in a monitoring role. In fact, as an important feature of the corporate organization, most private enterprises in China are family enterprises with blood relation (Gregory et al., 2000; Jiang et al., 2015). The interests of the owners and the manager are relatively consistent, and thus the principal-agent problem can be relieved to some extent. Moreover, different from owner absence of SOEs, the owner of a private enterprise can more easily exercise strict monitoring on external managers, which can restrain managers from seeking personal interests through philanthropy (Boateng et al., 2017). In short, the existence of the above conditions reduces the necessity of monitoring role played by the BOD in private enterprises. Hence, We formulate the following hypothesis.

Hypothesis 1b: The BOD of private enterprises mainly performs consulting functions in CP.

Factors Affecting the Functions of the BOD in CP: Extensive Analysis

The functions of the BOD in CP is subject to certain conditions. The factors that affect the functions of the BOD are further identified as follows.

External Factors: Environmental Dynamism

As an important part of environmental uncertainty, environmental dynamism refers to the rate of environmental change and the degree of instability, which reflects the volatility and unpredictability of the external environment. It is reflected in an enterprise's inaccurate perception of the changes in the behavior and needs of stakeholders. In a dynamic environment, the management work of an enterprise is more cumbersome, and there are high requirements for the processing of the decision-making information (Baum and Wally, 2003). This will potentially affect a series of corporate behaviors (Daft and Weick, 1984; Daft et al., 1988).

Specifically, the increase in environmental dynamism means that the BOD faces higher decision-making costs, should spend more energy on processing environmental information, and face greater difficulties in identifying the suitable programs, so the effect of the monitoring and consulting functions of the BOD will be greatly weakened. For SOEs, environmental dynamism facilitates managers to act for self-interest at the expense of enterprise resources. As an insider, managers have information advantages (Jensen and Meckling, 1976), and it is more difficult to monitor managers through the internal governance mechanism in this context. Accordingly, the consulting function of the BOD can also be constrained. For private enterprises, environmental dynamism weakens the capability of the BOD to make effective decisions based on adequate information. In the donation process, to achieve the goals of a private enterprise, careful arrangements must be made based on a large amount of environmental information. Such arrangements include consulting professional institutions, formulating donation plans, budgeting costs for donation before the implementation, managing the donation projects and controlling the costs during the process, and evaluating the donation projects after implementation (Zhong, 2007). Due to lack of or insufficient information, environmental dynamism makes it difficult for the BOD to make accurate judgments on the above issues, which will directly lead to difficulty in giving effective suggestions concerning donations. We thus propose the following hypotheses.

Hypothesis 2a: Environmental dynamism inhibits the monitoring function of the BOD of SOEs in CP.

Hypothesis 2b: Environmental dynamism inhibits the consulting function of the BOD of private enterprises in CP.

Internal Factors: Board Fault Lines

Although the previous sections have reasoned that the BOD plays a specific role in CP, in a strict sense, the BOD is not a solidified whole. When there are fault lines between the board members, the performance of its functions is bound to be affected. Fault lines refer to the invisible dividing lines between several

homogeneous subgroups based on the single or multiple characteristic attributes of group members (Lau and Murnighan, 1998, 2005). Usually, people identify the people with similar characteristics and communicate with them, which leads to the existence of fault lines. As a result, team members will become more identified with their respective subgroups rather than the entire team, which intensifies conflicts within the team and reduces the trust and respect among team members. And team's attention will ultimately turn from unified to splitting, weakening solidarity of the team (Li and Hambrick, 2005; Harrison and Klein, 2007; Bezrukova et al., 2009). Relevant evidences also show that, when fault lines exist in the BOD, the degree of engagement of the BOD will decrease (Zhou et al., 2015). The members will shorten the time of meeting and reduce the discussions on key issues of the company (Tuggle et al., 2010). All of these will result in weakening the willingness to monitor the company and provide resources (Xu et al., 2021), eventually lowering the performance of the directors in fulfilling the service functions of consultation and strategic decision-making (Crucke and Knockaert, 2016). In view of the above influence of the fault lines, we infer that the monitoring function of the BOD of SOEs and the consulting function of the BOD of private enterprises will be weakened in CP. Thus we propose the following hypotheses.

Hypothesis 3a: Board fault lines inhibit the monitoring function of the BOD of SOEs in CP.

Hypothesis 3b: Board fault lines inhibit the consulting function of the BOD of private enterprises in CP.

RESEARCH DESIGN

Data Sources and Research Samples

With reference to similar literature (Pan, 2018), the original samples are Chinese A-share listed firms on Shanghai and Shenzhen stock exchanges for the 2008–2019 period. The samples were screened according to the following rules: (1) excluding listed financial and insurance companies, (2) excluding ST and PT companies, (3) eliminating companies with severely incomplete data, and (4) excluding samples with obvious errors in donation data or with unidentifiable donation amount. The sample data come from the China Stock Market & Accounting Research Database (CSMAR). During the data collection process, if there were uncertain data need to be collected, professionals joined in the discussion to ensure reliability before finally determining the data value. After screening, our final sample of state-owned enterprises consists of 3,734 firm-years observations and that of private enterprises 3,535 firm-years observations. To reduce the influence of outliers on the research results, the continuous variables are winsorized at the 1 and 99% levels.

Model Setting and Variable Definitions

Empirically, it is difficult to identify whether the BOD performs a monitoring or consulting function in CP as this is information or action that is hidden from researchers. Although it is difficult to find direct evidence of monitoring or consulting of the BOD, it is possible to infer from obvious external characteristics

(Savova, 2021). By clarifying such external characteristics, the functions of the BOD can be inferred indirectly. Specifically, if the BOD does perform a certain function in CP, the economic value of donations should have been elevated as a result (Laing and Weir, 1999; Carter and Lorsch, 2003; Zhong, 2007). Based on the inference, this study constructs the following model to test Hypothesis 1:

$$ROA_{i,t} = \alpha_0 + \alpha_1 \times CP_{i,t-1} + \alpha_2 \times CP_{i,t-1} \times \text{Monitor}_{i,t-1} + \alpha_3 \times CP_{i,t-1} \times \text{Consult}_{i,t-1} + \alpha_4 \times \text{Control} + \varepsilon \quad (1)$$

Consistent with Wang et al. (2008), return on total assets (ROA) is used as the proxy variable of enterprise performance. Corporate charitable donation is used as the proxy variable of CP, which is calculated by the ratio of enterprise's total amount of donations to the main business revenue. With reference to the approach of Frye and Pham (2020), the discretionary accruals estimated by the modified Jones model are used as the indicator of the monitoring function (Monitor). The larger the value, the more obvious the monitoring function. Specifically, the calculation is done with the following model:

$$\frac{TA_{i,t}}{Asset_{i,t-1}} = \alpha_1 \frac{1}{Asset_{i,t-1}} + \alpha_2 \frac{\Delta REV_{i,t}}{Asset_{i,t-1}} + \alpha_3 \frac{PPE_{i,t}}{Asset_{i,t-1}} + \varepsilon_{i,t} \quad (2)$$

$$DA_{i,t} = \frac{TA_{i,t}}{Asset_{i,t-1}} - \left(\hat{\alpha}_1 \frac{1}{Asset_{i,t-1}} + \hat{\alpha}_2 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{Asset_{i,t-1}} + \hat{\alpha}_3 \frac{PPE_{i,t}}{Asset_{i,t-1}} \right) \quad (3)$$

Use Model (2) to run regressions by year and industry on the sample data, put the obtained regression coefficients into Formula (3), and then estimate discretionary accruals (DA). Among them, $TA_{i,t}$ is the total accrual of sample i at the end of period t , $Asset_{i,t-1}$ is the total assets of sample i at the end of period $t-1$, $\Delta REV_{i,t}$ is the change of the main business of sample i from period $t-1$ to period t . $PPE_{i,t}$ is the original value of fixed assets of sample i at the end of period t , and $\Delta REC_{i,t}$ is the change of the receivable account of sample i from period $t-1$ to period t .

With reference to the approaches of Kim et al. (2014), Richardson (2006), and Zhu et al. (2015), corporate inefficient investment is obtained with the Richardson model and is used as the proxy variable for the consulting function of the BOD. The smaller the value, the more obvious the consulting function of the BOD. The model is as flows.

$$\text{Invest}_{i,t} = \alpha_0 + \alpha_1 \times \text{Growth}_{i,t-1} + \alpha_2 \times \text{Lev}_{i,t-1} + \alpha_3 \times \text{Cash}_{i,t-1} + \alpha_4 \times \text{Age}_{i,t-1} + \alpha_5 \times \text{Asset}_{i,t-1} + \alpha_6 \times \text{Return}_{i,t-1} + \alpha_7 \times \text{Invest}_{i,t-1} + \varepsilon \quad (4)$$

In model (4), “Invest” is the new investment of sample i in the current year, which is calculated by $\text{Invest} = (\text{capital expenditure} + \text{M\&A costs} - \text{income from the sale of long-term assets} - \text{depreciation}) / \text{total assets}$. “Growth” is the growth rate of business revenue, “Cash” equals the enterprise’s cash and cash equivalents divided by total assets, “Age” is the enterprise’s age, “Asset” is the natural logarithm of the enterprise’s total assets at the end of the period, and “Return” is the annual stock return of the enterprise. Additionally, the year and industry effects are controlled in Model (4). The absolute residual obtained at the end is the indicator of the investment efficiency.

In addition, based on the existing literature (Wang et al., 2008; Choi and Wang, 2009; Lev et al., 2010; Wang and Qian, 2011; Brammer and Millington, 2015; Pan, 2018), control variables in the hypothesis testing model are employed as follows: (1) enterprise size (*Size*), defined as the natural logarithm of the company’s assets at the end of the period. (2) Enterprise debt ratio (*Lev*), defined as the ratio of the enterprise’s liabilities to assets. (3) Enterprise age (*Age*), defined as the natural logarithm of the enterprise’s years of age+1. (4) Enterprise growth opportunity (*Growth*), defined as the growth rate of the enterprise’s sales. (5) Enterprise risk (*Beta*), measured as the value of β . (6) Enterprise resources (*Res*), defined as the natural logarithm of the enterprise’s cash equivalents. (7) Advertisement (*AD*), defined

as the ratio of sales expenses to operating income. (8) The industry (*Industry*), classified according to the latest classification of the China Securities Regulatory Commission in 2012. (9) The year (*Year*).

EMPIRICAL RESULTS AND ANALYSIS

Descriptive Statistics

As shown in Tables 1, 2, the sample sizes of state-owned and private enterprises in this study are 3,743 and 3,535, respectively. The mean value of the returns on total assets (ROA) of the state-owned and private enterprises are 0.038 and 0.047, respectively. The performance of the private enterprises is slightly better than that of SOEs. In addition, CP of the private enterprises are greater than those of the SOEs with mean values of 0.277 and 0.190, respectively. Furthermore, the monitoring (Monitor) and consulting (Consult) function of the state-owned and private enterprises are relatively close. The monitoring function (Monitor) of the two are 0.008 and 0.010, respectively, and the consulting function of the two (Consult) are 0.033 and 0.038, respectively. For the control variables, our descriptive statistics are generally consistent with historical literature (Wang et al., 2008; Choi and Wang, 2009; Lev et al., 2010; Wang and Qian, 2011; Pan, 2018).

TABLE 1 | Descriptive statistics of the main variables (SOEs).

Variable	Mean	SD	Min	P25	P50	P75	Max	Size
Roa	0.038	0.036	-0.026	0.014	0.031	0.055	0.129	3,743
CP × Monitor	0.001	0.020	-0.111	-0.002	0.000	0.004	0.140	3,743
CP × Consult	0.007	0.014	0.000	0.001	0.002	0.007	0.131	3,743
CP	0.190	0.241	0.011	0.036	0.091	0.234	1.027	3,743
Monitor	0.008	0.060	-0.108	-0.031	0.007	0.042	0.136	3,743
Consult	0.033	0.032	0.002	0.011	0.023	0.043	0.127	3,743
Beta	1.156	0.232	0.713	1.004	1.153	1.302	1.630	3,743
Growth	0.130	0.226	-0.224	-0.015	0.101	0.237	0.724	3,743
Size	22.896	1.150	20.911	21.941	22.858	23.822	24.764	3,743
Lev	0.530	0.180	0.156	0.396	0.551	0.676	0.790	3,743
Ad	0.055	0.062	0.003	0.015	0.034	0.070	0.279	3,743
Res	20.716	1.207	18.451	19.785	20.712	21.623	22.703	3,743
Age	2.663	0.388	1.609	2.398	2.773	2.944	3.178	3,743

TABLE 2 | Descriptive statistics of the main variables (private enterprises).

Variable	Mean	SD	Min	P25	P50	P75	Max	Size
Roa	0.047	0.040	-0.026	0.018	0.042	0.072	0.129	3,535
CP × Monitor	0.003	0.026	-0.011	-0.004	0.001	0.007	0.140	3,535
CP × Consult	0.022	0.039	0.000	0.002	0.007	0.023	0.281	3,535
CP	0.277	0.293	0.011	0.068	0.160	0.371	1.027	3,535
Monitor	0.010	0.062	-0.108	-0.031	0.007	0.047	0.136	3,535
Consult	0.038	0.034	0.002	0.012	0.027	0.051	0.127	3,535
Beta	1.179	0.250	0.713	1.006	1.181	1.354	1.630	3,535
Growth	0.163	0.242	-0.224	0.004	0.128	0.280	0.724	3,535
Size	22.353	0.901	20.911	21.688	22.297	22.900	24.764	3,535
Lev	0.432	0.177	0.156	0.292	0.428	0.561	0.790	3,535
Ad	0.083	0.080	0.003	0.027	0.051	0.109	0.279	3,535
Res	20.124	1.018	18.451	19.385	20.088	20.810	22.703	3,535
Age	2.286	0.457	1.609	1.946	2.197	2.639	3.178	3,535

TABLE 3 | Regression results of the functions of the BOD in CP.

	State-owned enterprises				Private enterprises			
	1	2	3	4	5	6	7	8
Constant	-0.057*** (-2.941)	-0.059*** (-3.011)	-0.040** (-2.159)	-0.042** (-2.225)	-0.098*** (-3.698)	-0.097*** (-3.779)	-0.058** (-2.290)	-0.057** (-2.339)
Beta	-0.000 (-0.173)	-0.001 (-0.196)	-0.002 (-0.616)	-0.002 (-0.634)	-0.013*** (-4.925)	-0.013*** (-4.991)	-0.012*** (-4.698)	-0.012*** (-4.752)
Growth	0.031*** (14.940)	0.030*** (14.743)	0.033*** (16.079)	0.032*** (15.933)	0.037*** (14.814)	0.036*** (14.279)	0.037*** (15.507)	0.037*** (15.004)
Size	0.001 (0.598)	0.001 (0.590)	-0.001 (-0.810)	-0.001 (-0.811)	0.002 (1.461)	0.002 (1.402)	-0.001 (-0.599)	-0.001 (-0.707)
Lev	-0.110*** (-19.662)	-0.110*** (-19.653)	-0.100*** (-18.226)	-0.100*** (-18.189)	-0.102*** (-17.564)	-0.102*** (-17.822)	-0.088*** (-15.742)	-0.089*** (-16.020)
Ad	-0.033* (-1.806)	-0.035* (-1.877)	-0.025 (-1.387)	-0.026 (-1.443)	-0.011 (-0.659)	-0.008 (-0.475)	0.001 (0.071)	0.005 (0.296)
Res	0.006*** (5.145)	0.006*** (5.126)	0.007*** (6.090)	0.007*** (6.073)	0.007*** (6.757)	0.007*** (6.879)	0.008*** (7.758)	0.008*** (7.919)
Age	-0.002 (-1.057)	-0.002 (-0.964)	-0.001 (-0.653)	-0.001 (-0.570)	-0.002 (-0.907)	-0.002 (-0.794)	-0.000 (-0.185)	-0.000 (-0.065)
CP	0.014*** (4.650)	0.013*** (3.531)	0.012*** (4.381)	0.011*** (3.173)	0.008*** (3.736)	0.015*** (5.665)	0.007*** (3.208)	0.015*** (5.659)
Consult		0.042** (1.976)		0.032 (1.577)		0.053** (2.568)		0.056*** (2.860)
Monitor			0.082*** (7.738)	0.081*** (7.670)			0.082 (0.797)	0.067 (0.646)
CP×Consult		0.002 (0.032)		0.015 (0.250)		-0.101*** (-4.402)		-0.115*** (-5.364)
CP×Monitor			0.089*** (2.682)	0.090*** (2.703)			0.005 (0.618)	0.006 (0.786)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,743	3,743	3,743	3,743	3,535	3,535	3,535	3,535
R ²	0.418	0.418	0.470	0.470	0.333	0.352	0.398	0.420

*, **, *** represent significant at the 10, 5, and 1% significance level, respectively. *t*-values are provided in parentheses.

Regression Results

To ensure the reliability of the research results, after F, LM, and Hausman tests, the results indicate that a fixed effect model should be used. In the meantime, to reduce the deviation of the regression results, the standard errors are corrected by the Driscoll–Kraay method while cluster-robust standard error correction is carried out at the company level. During the test, the control variables are added first followed by the core variables. The regression results are shown in **Table 3**.

In the eight sets of regression results shown in **Table 3**, the regression coefficients of CP are all significantly positive, which indicates that CP can improve the enterprises' performance. For SOEs, when the interaction terms of CP×Consult and CP×Monitor are added, the regression coefficient of CP×Monitor is 0.089, which is significant at the 1% level, while the regression coefficient of CP×Consult is not. When the two are put into the regression

model at the same time, the regression coefficient of CP×Monitor is 0.090, which is still significant at the 1% level. Similarly, the regression coefficient of CP×Consult is still not significant. This shows that the performance of CP of SOEs has been improved under the influence of the monitoring function of the BOD. In other words, Hypothesis 1-a is empirically supported.

For private enterprises, when the interaction terms of CP×Consult and CP×Monitor are added, the regression coefficient of CP×Consult is -0.101, which is significant at the 1% level, while the regression coefficient of CP×Monitor is not. When the two are put into the regression model at the same time, the regression coefficient of CP×Consult is -0.115, which is still significant at the 1% level. Similarly, the regression coefficient of CP×Monitor is still not significant. This shows that the performance of CP of private enterprises has been improved under the influence of the monitoring

TABLE 4 | Regression results of the functions of the BOD in CP. (Heckman Second-stage).

	State-owned enterprises				Private enterprises			
	1	2	3	4	5	6	7	8
Constant	-0.088*** (-4.635)	-0.088*** (-4.650)	-0.062*** (-3.355)	-0.062*** (-3.368)	-0.127*** (-5.150)	-0.124*** (-5.096)	-0.103*** (-4.308)	-0.099*** (-4.199)
Beta	-0.010*** (-2.997)	-0.010*** (-2.974)	-0.012*** (-3.637)	-0.012*** (-3.609)	-0.017*** (-4.872)	-0.017*** (-4.812)	-0.016*** (-4.597)	-0.015*** (-4.528)
Growth	0.032*** (8.921)	0.032*** (8.683)	0.034*** (9.671)	0.033*** (9.389)	0.039*** (8.800)	0.038*** (8.476)	0.039*** (9.087)	0.037*** (8.735)
Size	0.003** (2.504)	0.003** (2.495)	0.001 (1.003)	0.001 (0.994)	-0.001 (-0.556)	-0.001 (-0.633)	-0.003* (-1.926)	-0.003** (-2.085)
Lev	-0.108*** (-21.916)	-0.109*** (-21.885)	-0.099*** (-20.252)	-0.099*** (-20.227)	-0.099*** (-16.797)	-0.100*** (-17.187)	-0.087*** (-15.167)	-0.089*** (-15.622)
Ad	-0.017 (-1.171)	-0.017 (-1.146)	-0.010 (-0.693)	-0.009 (-0.654)	0.011 (0.822)	0.011 (0.868)	0.019 (1.511)	0.020 (1.591)
Res	0.005*** (4.478)	0.005*** (4.469)	0.006*** (5.454)	0.006*** (5.440)	0.012*** (9.201)	0.012*** (9.203)	0.012*** (9.908)	0.012*** (9.959)
Age	-0.002 (-0.796)	-0.002 (-0.747)	-0.001 (-0.596)	-0.001 (-0.535)	-0.000 (-0.183)	-0.000 (-0.038)	0.001 (0.392)	0.001 (0.590)
CP	0.010*** (2.949)	0.008* (1.799)	0.008** (2.397)	0.005 (1.198)	0.010*** (3.535)	0.021*** (6.109)	0.011*** (3.681)	0.023*** (6.718)
λ		-0.008 (-0.947)	-0.009 (-0.975)	-0.010 (-1.168)	-	-0.000 (-0.030)	-0.002 (-0.188)	0.005 (0.548)
Consult		0.011 (0.406)		0.012 (0.433)		0.114*** (3.688)		0.130*** (4.393)
Monitor			0.095*** (6.787)	0.094*** (6.756)			0.129 (0.906)	0.085 (0.604)
CP × Consult		0.045 (0.631)		0.062 (0.894)		-0.165*** (-5.703)		-0.184*** (-6.627)
CP × Monitor			0.113*** (3.157)	0.116*** (3.225)			0.002 (0.153)	0.005 (0.495)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,179	3,179	3,179	3,179	2,977	2,977	2,977	2,977
R ²	0.418	0.418	0.470	0.470	0.333	0.352	0.398	0.420

function of the BOD. That is, Hypothesis 1-b is empirically supported.

Robustness Test

Sample Selection Bias Test

In the empirical analysis of this study, there may be sample selectivity bias. Specifically, (1) the research objects of this study are the enterprises that have participated in donations, however, not all enterprises have donated. It is also possible that some enterprises have donated but have not disclosed. The fact that only the companies participating in donations are selected for research could lead to sample selection bias. (2) Even for the enterprises that have participated in donations, some samples have been deleted due to missing data, which also causes sample selection bias. For the second case,

we compared the actual research sample with the initial sample and found that the kernel density distribution curves of corporate donations in the two samples basically overlap, which shows that the actual research sample can replace the initial sample.

For the first case, with reference to the approach of Pan et al. (2015), Heckman two-step estimation is adopted. In the first stage, run a probit regression, and its dependent variable is whether the enterprise has participated in donations in the previous year. After obtaining the inverse Mills ratio (denoted by λ), put it into Model (1) to alleviate the influence of sample selection bias. Table 4 presents the regression results. As shown in Table 4, after adding the λ variable, the signs and significance of the regression coefficients of CP × Consult and CP × Monitor, for both state-owned and

private enterprises, are the same as in **Table 3**, and the research conclusions remain unchanged. In addition, the regression coefficients of λ itself are not significant.

Other Robustness Tests

To ensure the reliability of the aforementioned research conclusions, other robustness tests have also been conducted.

First, the explanatory variables and the explained variable are measured by alternative method. It mainly includes: (1) The ratio of an enterprise's total donations to the total assets is used to measure the intensity of the enterprise's donations. (2) Adjust the focus variables of concern with the industry average on a yearly basis. (3) The three-year moving average of ROA is used as the proxy variable for corporate performance.

Second, re-test through changing the samples. It includes: (1) Considering that the levels of enterprise donations during major disasters are significantly higher than in other ordinary years, with reference to Du et al. and Pan et al., the observations in 2010 (Qinghai earthquake) and 2013 (Yushu earthquake) are eliminated from the sample (Du et al., 2014; Pan et al., 2017). (2) Only when corporate donations exceed a certain amount do they need the approval of the BOD or should they be submitted to the authority for approval. As requirements of listed companies and regulations of various government set the threshold of donations at 100,000 RMB, to highlight the enterprises' true willingness of donations, observations that donated less than 100,000 RMB are excluded. (3) The values of the continuous variables are winsorized at the 2–5% quantiles.

Third, consider the influence of more control variables. To further eliminate the interference of missing variable bias and overcome the endogenous problems caused by the effects of the individuals and the industries, high-dimensional fixed effect estimation is adopted. Specifically, the interaction terms of the enterprise's province and industry with the year are added in the regression model.

In the results of the above regression test, the signs of the core variables remain unchanged, and the significance level is at least 95%, which indicate that the aforementioned conclusions are robust.

EXTENSION ANALYSIS

To further identify the dependent conditions of the functions of the BOD in CP, further empirical test is conducted on the moderating effect of environmental dynamism and board fault lines.

Environmental Dynamism

To test hypotheses 2, the following regression model is established:

$$ROA_{i,t} = \alpha_0 + \alpha_1 \times CP_{i,t-1} + \alpha_2 \times CP_{i,t-1} \times Monitor_{i,t-1} \times ED + \alpha_3 \times CP_{i,t-1} \times Consult_{i,t-1} \times ED + \alpha_4 \times Control + \varepsilon \quad (5)$$

In Model (5), environmental dynamism (ED) is the moderator variable. With reference to the approach of Ghosh and Olsen (2009), ED is calculated by taking the company's sales revenue in years $t, t-1, t-2, t-3,$ and $t-4$ as the dependent variable and running autoregressions with 5, 4, 3, 2, and 1 as independent variables. The standard errors of the regression coefficients of the model are divided by the mean value of the company's 5-year sales, and the obtained value is taken as the proxy variable. The larger the value, the stronger the environmental dynamism. The regression results are shown in **Table 5**.

For SOE, environmental dynamism is taken as the moderator variable, and the test is conducted by using it to form interaction terms with $CP \times Monitor$ and $CP \times Consult$. In the results, the regression coefficients of $ED \times CP \times Monitor$ are -0.350 and -0.344 , respectively, and both are significant at the 5% level. Given that the monitoring function of the BOD of SOEs promotes the enterprise's performance, the results show that, when the effect of environmental dynamism is considered, its monitoring function is weakened, which validates Hypothesis 2-a. For private enterprises, when putting the interaction term of $ED \times CP \times Consult$ into the model, its regression coefficient is 0.493 and significant at the 1% level. After adding it together with $ED \times CP \times Monitor$, the regression coefficient of $DE \times CP \times Consult$ is 0.559 , which is still significant at the 1% level. Given that the consulting function of the BOD of private enterprises promotes the enterprise's performance, the results show that the effect of environmental dynamism inhibits its consulting function, which is consistent with the proposition of Hypothesis 2-b.

Based on the above results, we can conclude that environmental dynamism is a constraint condition for performing the functions of the BOD in CP.

Board Fault Lines

To test hypotheses 3, the following regression model is established:

$$ROA_{i,t} = \alpha_0 + \alpha_1 \times CP_{i,t-1} + \alpha_2 \times CP_{i,t-1} \times Monitor_{i,t-1} \times FL + \alpha_3 \times CP_{i,t-1} \times Consult_{i,t-1} \times FL + \alpha_4 \times Control + \varepsilon \quad (6)$$

In model (6), FL is board fault lines. With reference to the approaches of Tuggle and other studies, board fault lines are calculated with five indicators as the basis: gender, age, education background, independent director or not, and length of tenure (Tuggle et al., 2010). The method is as follows. According to the formula proposed by Thatcher et al., the ratio of the sums of squares of the subgroups' characteristics to that of the overall characteristics of the BOD is taken as the intensities of the fault lines (Thatcher et al., 2003). The calculation is done as below:

$$FL_g = \frac{\sum_{j=1}^q \sum_{k=1}^2 n_k^g (\bar{x}_{j,k} - \bar{x}_j)^2}{\sum_{j=1}^q \sum_{k=1}^2 \sum_{i=1}^{n_k^g} (x_{i,j,k} - \bar{x}_j)^2} \quad (7)$$

$$FL_{i,t} = \max(FL_g)$$

TABLE 5 | Regression results of the moderating impact of environmental dynamism.

	State-owned enterprises			Private enterprises		
	1	2	3	4	5	6
Constant	-0.037* (-1.863)	-0.019 (-1.007)	-0.021 (-1.125)	-0.053** (-2.116)	-0.020 (-0.813)	-0.025 (-1.023)
Beta	-0.001 (-0.199)	-0.002 (-0.611)	-0.002 (-0.625)	-0.013*** (-5.089)	-0.012*** (-4.830)	-0.012*** (-4.847)
Growth	0.022*** (11.310)	0.025*** (12.842)	0.024*** (12.707)	0.024*** (9.304)	0.027*** (11.055)	0.027*** (10.646)
Size	-0.000 (-0.237)	-0.002 (-1.574)	-0.002 (-1.499)	-0.001 (-0.462)	-0.003** (-2.181)	-0.003** (-2.197)
Lev	-0.110*** (-20.224)	-0.101*** (-18.760)	-0.101*** (-18.803)	-0.105*** (-18.797)	-0.092*** (-16.623)	-0.092*** (-16.860)
Ad	-0.026 (-1.418)	-0.018 (-0.982)	-0.018 (-1.011)	-0.001 (-0.055)	0.005 (0.325)	0.010 (0.629)
Res	0.005*** (4.753)	0.006*** (5.733)	0.006*** (5.663)	0.007*** (7.173)	0.008*** (7.811)	0.008*** (8.164)
Age	0.000 (0.007)	0.001 (0.270)	0.001 (0.322)	0.002 (1.070)	0.003 (1.523)	0.003 (1.480)
CP	0.012*** (3.182)	0.011*** (4.012)	0.010*** (2.930)	0.011*** (4.319)	0.006*** (2.866)	0.011*** (4.318)
ED	0.042*** (7.240)	0.042*** (8.167)	0.039*** (7.169)	0.056*** (10.061)	0.054*** (10.347)	0.045*** (8.266)
Consult	0.036* (1.730)		0.028 (1.380)	0.019 (0.943)		0.025 (1.276)
Monitor		0.076*** (7.295)	0.075*** (7.233)		0.059 (0.510)	0.029 (0.249)
CP × Consult	-0.073 (-0.916)		-0.066 (-0.884)	-0.115*** (-4.422)		-0.137*** (-5.508)
ED × CP × Consult	0.367 (1.390)		0.381 (1.546)	0.493*** (2.913)		0.559*** (3.368)
CP × Monitor		0.159*** (3.227)	0.160*** (3.248)		0.005 (0.595)	0.008 (0.892)
ED × CP × Monitor		-0.350** (-2.057)	-0.344** (-2.028)		0.032 (0.315)	-0.001 (-0.007)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	3,743	3,743	3,743	3,535	3,535	3,535
R ²	0.427	0.472	0.475	0.361	0.395	0.426

First, the sum of squares of a particular characteristic of a subgroup is calculated with Formula (7). Next, the sum of squares of the same characteristics of the BOD is calculated. Calculate the intensity of fault line for all characteristics of the subgroup in turn, and the maximum value among all subgroups is taken as the measured value of the board fault line intensity. Among them, FL_g denotes the fault line intensity under the g -th division method where g denotes the classification method, n denotes the number of board members, j denotes a certain characteristic of the board members, q denotes the total number of characteristics investigated, $x_{i,j,k}$ denotes the

value of characteristic j of director i in subgroup k , $\bar{x}_{j,k}$ denotes the mean value of characteristic j of subgroup k 's board, \bar{x}_j is the mean value of characteristic j of all members of the board, and n_k^g denotes the number of members in subgroup k of the BOD under classification method g . The value range of board fault line (FL) is [0, 1]. The closer the value is to 1, the higher the intensity of the fault line. The regression results are shown in **Table 6**.

For SOEs, board fault line (FL) is taken as the moderator variable, and the test is conducted by using it to form interaction terms with CP × Consult and CP × Monitor. In the regression results,

TABLE 6 | Regression results of the moderating impact of board fault lines.

	State-owned enterprises			Private enterprises		
	1	2	3	4	5	6
Constant	-0.047** (-2.234)	-0.028 (-1.411)	-0.031 (-1.543)	-0.082*** (-3.072)	-0.044* (-1.659)	-0.043* (-1.703)
Beta	-0.002 (-0.548)	-0.003 (-1.097)	-0.003 (-1.131)	-0.013*** (-4.791)	-0.012*** (-4.459)	-0.011*** (-4.432)
Growth	0.030*** (13.380)	0.034*** (15.038)	0.032*** (14.632)	0.035*** (13.457)	0.037*** (14.800)	0.035*** (13.958)
Size	-0.000 (-0.024)	-0.002 (-1.421)	-0.002 (-1.318)	0.003 (1.562)	-0.001 (-0.489)	-0.001 (-0.502)
Lev	-0.109*** (-18.545)	-0.099*** (-16.973)	-0.099*** (-17.205)	-0.102*** (-17.588)	-0.087*** (-15.015)	-0.089*** (-15.820)
Ad	-0.026 (-1.287)	-0.019 (-0.939)	-0.017 (-0.870)	-0.005 (-0.285)	0.001 (0.074)	0.008 (0.491)
Res	0.007*** (5.458)	0.008*** (6.376)	0.008*** (6.305)	0.007*** (6.346)	0.007*** (7.075)	0.008*** (7.270)
Age	-0.003 (-1.314)	-0.002 (-1.027)	-0.002 (-1.017)	-0.002 (-0.988)	-0.001 (-0.285)	-0.000 (-0.157)
CP	0.021*** (5.720)	0.012*** (3.903)	0.020*** (5.576)	0.009*** (2.858)	0.006*** (2.588)	0.008*** (2.781)
FL	-0.008** (-2.377)	-0.007** (-2.104)	-0.007** (-2.023)	-0.011*** (-2.613)	-0.007 (-1.634)	-0.011*** (-2.751)
Consult	0.087*** (3.891)		0.083*** (3.715)	-0.001 (-0.056)		0.000 (0.008)
Monitor		0.102*** (10.585)	0.102*** (10.720)		0.129*** (9.953)	0.131*** (10.343)
CP × Consult	-0.004* (-1.814)		-0.005** (-2.316)	-0.009*** (-6.875)		-0.010*** (-8.089)
FL × CP × Consult	-0.011 (-0.220)		-0.001 (-0.025)	0.454*** (5.593)		0.487*** (6.243)
CP × Monitor		1.072** (2.237)	1.079** (2.200)		0.038 (0.563)	-0.007 (-0.123)
FL × CP × Monitor		-1.133** (-2.285)	-1.133** (-2.236)		0.010 (0.308)	0.038 (1.292)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	3,060	3,060	3,060	3,326	3,326	3,326
R ²	0.434	0.489	0.497	0.372	0.393	0.439

the regression coefficients of FL × CP × Monitor are all valued -1.133 and are all significant at the 5% level. The results show that, when the effect of board fault line is considered, the monitoring function of the BOD of SOEs is weakened. For state-owned enterprises, using board fault line (FL) as the moderator variable again, the regression coefficients of FL × CP × Consult are 0.454 and 0.487, and both are significant at the 1% level. It can be judged that board fault line weakens the consulting function of private enterprises of the BOD in CP. The above empirical findings are all consistent with the previous inferences and thus the hypotheses

3-a and 3-b were all tested. And it is reasonable to believe that board fault lines hinders the function of the BOD in CP.

DISCUSSION

As CP becomes an important means for companies to fulfil their social responsibility in China, this paper argues that in order to better respond to stakeholders, the focus needs to be on the functions of the BOD.

Theoretical Contributions

While well-targeted discussions and tests of the function of the BOD are still lacking in CP research, this study has made up for such deficiencies.

The main contributions of this study are as follows. First, based on the empirical evidence from Chinese listed companies, this study clarifies the function orientation of the BOD in CP. This not only expands the understanding of the formation mechanism of corporate philanthropy, but also provides a theoretical reference for guiding enterprises to formulate appropriate philanthropy programs. Second, based on environmental dynamism and board fault lines, this study has identified the boundary conditions. This provides a clearer foundation for the actions to optimize or improve the function of the BOD in a more explicit approach and, in turn, to enhance the effectiveness of corporate philanthropic programs. Third, the study examines the heterogeneity of the functions of the BOD in CP between state-owned and private enterprises. It enriches the research on heterogeneity of CP and provides new insight for accurately grasping the qualitative characteristics of CP.

Managerial Contributions

Our findings have important implications for companies and policymakers. First, to improve the financial effect of CP, the BOD should include charitable donations in the key decision-making agenda, especially focusing on and consolidating the functions of the BOD. Second, to avoid the misalignment of the function of the BOD in CP, SOEs can focus on the monitoring function when improving the governance mechanism while private enterprises can focus on the consulting function. Third, special attention should be paid to the impact of environmental dynamics and board fault lines on the functions the BOD in CP. In order to reduce the impact of environmental dynamics, enterprises can make their donation work more detailed through refined management so as to provide information to support the accurate decision-making of the BOD. To reduce the impact of board fault lines, the diversity of members in terms of their functional backgrounds, educational levels, and other cognitive characteristics should be fully considered when appointing board members, so as to reduce differences and enhance communication between board members, and ultimately enhance the synergy of decision-making.

Limitation and Future Research

As with any other research, several limitations of this study could be improved. First, although the results from the sample provide meaningful insights into the functions of the BOD in CP, this

study includes only Chinese A-share listed companies, which have a unique institutional and cultural background. Future studies need to applicate the model in other contexts in order to enhance the efficacy of the model. Second, the study focuses only on corporate charitable donation. However, there are other forms of fulfilling CSR. Future studies could consider the functions of the board of directors in other forms of CSR.

CONCLUSION

To infer the functions of the BOD in CP, we started from the impact of the BOD on donation performance. Based on Chinese A-share listed companies that have participated in donations from 2008 to 2019 as the samples, the empirical findings show that the BOD of SOEs mainly perform monitoring function while that of private enterprises mainly perform consulting function. Furthermore, the extension analysis shows that the functions of the BOD is restricted by environmental dynamism and its own fault lines.

DATA AVAILABILITY STATEMENT

The data sets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/**Supplementary Material**.

AUTHOR CONTRIBUTIONS

QP: conceptualization, methodology, validation, writing-original draft preparation, and writing-review and editing. ZH: software, validation, and writing-review and editing. All authors contributed to the article and approved the submitted version.

FUNDING

This research was funded by “Zhejiang Province Philosophy and Social Science Program, grant number 20NDJC168YB”; “Zhejiang Province University Major Humanities and Social Sciences Research Projects, grant number 2021GH006.”

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.850980/full#supplementary-material>

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The Effect of Coronavirus Exposure on CEO Perceptions of Climate Change

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OPEN ACCESS

Edited by:

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Reviewed by:

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Spring Xia,
Huazhong Agricultural University,
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equally to this work

Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 14 May 2022

Accepted: 13 June 2022

Published: 29 June 2022

Citation:

Zhang J and Liu Y (2022) The
Effect of Coronavirus Exposure on
CEO Perceptions of Climate Change.
Front. Psychol. 13:943952.
doi: 10.3389/fpsyg.2022.943952

CEOs' personal experiences can influence their perceptions of climate change and their firms' pro-environmental behavior; a concept termed the experience-perception link. Thus, the experience of the recent COVID-19 pandemic may have caused a change in CEOs' perceptions of another global threat—climate change. We test this hypothesis by comparing survey measures of climate risk perceptions, self-efficacy, and pro-environmental behaviors among 605 randomly selected CEOs in Wuhan across three phases—(1) before, (2) after the COVID-19 outbreak in Wuhan, and (3) after the COVID-19 had been primarily controlled in Wuhan but was declared a pandemic by the WHO. Harnessing between- and within-subjects variation in COVID-19 exposure, we find a substantial increase in climate change beliefs and actions after the COVID-19 evolved from an epidemic to a pandemic, regardless of subjects' exposure to the pandemic. We also demonstrate that this change is due to the salience of the global crisis and the feeling of hope elicited by observing effective responses to the crisis, rather than personal experiences solely made from a local health crisis. Our results reveal unexpectedly positive side effects of the abrupt shifts in CEOs' beliefs and their firms' pro-environmental behaviors in response to the COVID-19 pandemic.

Keywords: COVID-19 pandemic, CEO climate risk perception, pro-environmental behaviour (PEB), global crisis, self-efficacy

INTRODUCTION

The outbreak of the COVID-19 pandemic has threatened not only human lives but also the global economy, highlighting the potential consequences of global crises. The pandemic may also have given individuals pause for thought about how the world can work together to address a global emergency more effectively. Although climate change and COVID-19 are two different challenges, they share many key elements, e.g., the global nature of a threat, public health concerns, changes in living standards and social norms, and significant consequences for future generations. These similarities lead us to question whether the COVID-19 pandemic has reduced “psychological distance” and shifted public beliefs and actions toward another global threat—climate change. This study aims to empirically examine whether CEOs' personal experiences, such as the COVID-19 pandemic, can influence their perceptions of climate change and their firms' pro-environmental behavior. We use a large-scale three-wave survey to answer this question by

comparing climate risk perceptions, self-efficacy (beliefs in one's capacity to affect change), and pro-environmental behaviors among 605 CEOs from 605 randomly selected SMEs (Small and medium-sized enterprises) in Wuhan, China¹.

Our survey spans three critical phases of the COVID-19 crisis²: before the first case of COVID-19 was identified (October 2019), shortly after the initial COVID-19 outbreak in Wuhan (March 2020), and after COVID-19 was elevated to pandemic status but new infections in Wuhan had slowed, and the city had begun to reopen (April 2020). This time variation allows us to (1) identify the within-subject effect of COVID-19 by comparing survey responses before and after the outbreak of COVID-19, and (2) measure effect heterogeneity as COVID-19 evolved from an epidemic to a pandemic, which allows us to differentiate between a local and a global health threat. Our sample consists of 605 CEOs in Wuhan, 569 of whom returned to their hometowns before survey Waves 2 and 3 for semester breaks and the Chinese Lunar New Year celebrations³. This provides quasi-random variation in exposure to the pandemic, which allows us to study the between-subject effect of exposure to COVID-19 based on the geographical variation.

We focus on three measures to examine the impact of COVID-19 on climate change activism. Two measurements capture climate change beliefs—climate risk perceptions and self-efficacy. The third assesses individuals' willingness to act in a way that addresses climate change—pro-environmental behaviors. We find that fear about a future global crisis plays a prominent role in changing subjects' climate risk perceptions. The change is systemic regardless of their exposure to the pandemic. Previous studies have shown that climate change awareness and risk perception can be influenced through effective affective stimuli and the associated emotional response (e.g., fear, worry and grief) (e.g., Herrnstadt and Muehlegger, 2014; Zaval et al., 2014; McDonald et al., 2015; van der Linden, 2015; Brügger et al., 2016; Lang and Ryder, 2016; Geiger et al., 2017; Curnock et al., 2019; Bu et al., 2021; Tian et al., 2022). However, elicited negative emotions such as fear may cause individuals to distance themselves or disengage and may negatively influence their beliefs in their ability to address climate change, a phenomenon termed the self-efficacy barrier (e.g., O'Neill et al., 2013; Barnett et al., 2016; Metag et al., 2016; Xue et al., 2020, 2021; Bu and Liao, 2021; Wan et al., 2021). Thus, affective experience-induced stimuli would increase not only the salience of the issue of climate change but also the sense of being able to do something—but few motivations, if any, seem to do both. Our Wave 3 survey was administered when the COVID-19 had been effectively controlled in Wuhan. This offers a unique setting for us to

test whether observing an effective response to the crisis can elicit an emotion of hope and consequently help individuals overcome the self-efficacy barrier. We find supportive evidence that subjects' self-efficacy increased after COVID-19 was under control in Wuhan. We also test whether the increased beliefs in climate change risk and self-efficacy translated into pro-environmental actions. Previous studies have documented a moderate relationship between climate change attitudes and pro-environmental behavior (e.g., Hines et al., 1987; Bamberg and Möser, 2007; O'Neill and Nicholson-Cole, 2009; Xie et al., 2019; Bu et al., 2020). Our findings contribute to the literature by showing that the COVID-19 pandemic has shifted not only individuals' beliefs in climate change risk but also their actions toward addressing it.

Our results offer an essential contribution to a large body of literature on raising CEOs' concern about and engagement with climate change. While our study is the first to examine how the worldwide COVID-19 pandemic has affected CEOs' climate change activism, we also provide novel findings showing that changes in climate change beliefs and actions are more linked to the salience of a global threat than to the belief that climate change was a cause of the COVID-19 pandemic. In general, our results contribute to the literature by documenting the impact of individual-level global crisis experiences on subsequent beliefs about and corporate actions toward climate change. Additionally, our results contribute to the literature that exploits the positive side of COVID-19 on human thoughts and behaviors.

METHODOLOGY

Sample Selection

Our sample consisted of 605 randomly selected CEOs in Wuhan. In this study, we partner with a Wuhan-based survey firm. The survey company initially sent invitations to 1,400 SMEs in Wuhan with more than five employees at random, and 605 of them consented to take part in the survey. 76 of the 605 SMEs in our sample are in the real estate sector, 35 in the factory sector, 48 in the construction sector, 102 in the tourism & hospitality sector, 53 in the vehicle services sector, 29 in the trade services sector, 72 in the personal service sector, 82 in the general services sector, 66 in the processing sector, 18 in the agricultural products sector, and 24 in the transportation sector.

Wuhan was ground zero of the COVID-19 outbreak and undoubtedly one of the most impacted places; the majority of infected cases in China were located in Wuhan. In Wave 1 of our survey, all subjects were located in the city of Wuhan. Then, winter break for the semester at WUST started on January 11, and most CEOs from other provinces were able to return to their homes as planned for the Chinese Lunar New Year celebrations. As the province of Hubei became quarantined and effectively locked down shortly thereafter, CEOs from other provinces were denied to return to Wuhan. Therefore, in Waves 2 and 3, 94% of the subjects (569) were located in cities outside of Wuhan in parts of China with substantially lower exposure to COVID-19. The surveys were administered by a survey company called Wenjuanxing in China.

¹The survey was initially set up prior to the COVID-19 outbreak to study individuals' risk preference, climate risk perceptions, self-efficacy and pro-environmental behaviors. Due to the unique location of the study, we decided to amend the study design once the World Health Organization (WHO) declared COVID-19 as a pandemic (World Health Organization [WHO], 2020).

²Details of the survey, sample, experiment design and regression analysis methods can be found in the *Methods* appendix.

³This survey was originally for another project on beliefs about luck and investment behaviors. We also asked questions regarding climate change beliefs and actions.

Experimental Design

We conducted a three-wave survey between October 2019 and April 2020. The first wave was from October 16, 2019, to October 18, 2019⁴. The survey consisted of several parts. First, CEOs' provided demographic information such as their age, sex, date of birth, and birth province. We then asked nine questions about climate risk perceptions following O'Connor et al.¹⁷ and Leiserowitz¹⁸, 1 question on self-efficacy following Metag et al.¹⁰, and 9 questions on pro-environmental behavioral intentions following Bernauer and McGrath¹⁹. The detailed survey questions are provided in the survey design section.

The second survey wave was conducted from February 28, 2020, to March 3, 2020.

By then, the city of Wuhan had entered lockdown (on January 23, 2020), and most CEOs in our sample from regions outside of Wuhan had left the city for the lunar new year holiday. We thus administered an online survey to the same subjects. The online survey tool allowed us to capture precise information about subjects' locations. We mapped the provided geolocation coordinates to cities and provinces across China. In addition to the questions from our baseline survey, we included one question assessing fear due to exposure to the virus and one question about why subjects thought COVID-19 could be linked with climate change. Details on these questions are provided in the survey design section.

The third wave of the survey was conducted from April 15, 2020, to April 22, 2020. On April 8, 2020, lockdown measures were set to be eased in Wuhan. The restrictions were eased following a reduction in the number of daily reported infected cases, with reports suggesting that Wuhan had had only two new confirmed cases in the previous two weeks. People were permitted to leave the city of Wuhan for the first time since the lockdown was imposed on Monday, January 27. Passenger trains began to depart the city, and highways were opened to outbound traffic. While travel restrictions have since eased even further in Wuhan, strict control measures continue nationwide, and residents are still being encouraged to remain within their neighborhoods and avoid travel outside of the city unless it is essential. Our sample of subjects remained in their hometown cities after the Wave 2 survey. We administered one more online follow-up survey round to the same subject pool as in our first and second wave surveys. In addition to the questions from our second wave survey, we included one more question about subjects' attitudes toward the lockdown measures, such as quarantine and social distancing, that were taken during the outbreak of the virus. Details on the question are provided in the survey design section.

Survey Design

For all questions listed below, we asked subjects to indicate their level of agreement/disagreement on a 5-point scale (1 = very strongly disagree; 5 = very strongly agree). We measured subjects' fear of COVID-19 in 1 question: (1) "Are you afraid of COVID-19?" To measure subjects' climate risk perceptions, we asked 1 question about their general concerns about climate change: (2) "How concerned are you about climate change?" We asked seven questions about their perceptions of the threat of

climate change during the next ten years as follows: (3) "Global warming is already a global threat," (4) "The world is seeing an increasing rate of environmental damage," (5) "People's living standards on earth will decrease," (6) "Worldwide water shortages will occur," (7) "Worldwide, we have seen increased rates of serious diseases," (8) "My standard of living will decrease," and (9) "My chances of getting a serious illness will increase." To measure subjects' beliefs in their ability to affect climate change (self-efficacy), we asked 1 question: (10) "I feel that I can do something about climate change. To measure subjects' pro-environmental behavioral intentions, we asked eight questions: (11) "I keep the pressure/flow of the shower at a rate lower than what I consider to be ideal for saving water," (12) "I limit the time I spend in the shower to reduce my water consumption," (13) "I set the air conditioner temperature relatively high in summer to save energy," (14) "When I boil water, I only boil as much as I need," (15) "I switch appliances off instead of leaving them on standby," (16) "I turn off the shower when I soap myself down," (17) "I switch off the appliances when they are not in use," and (18) "I always sort the waste." To measure subjects' opinions about the link between the COVID-19 crisis and climate change, we asked two questions: (19) "The COVID-19 outbreak was caused by damage to the natural environment" and (20) "Climate change is as serious a global crisis as COVID-19 is." To measure individual social responsibility, we asked one question: (21) "Quarantines and social distancing are effective measures to prevent the spread of COVID-19."

Regression Analysis

Our OLS regression analysis aimed to answer two questions: (1) How has COVID-19 impacted subjects' attitudes toward climate change, and how has that attitude evolved over different phases of the COVID-19 crisis? (2) What is the mechanism through which COVID-19 has influenced subjects' attitudes toward climate change? The dependent variables included (1) *climate risk perceptions*, which is the aggregate mean score of responses to the nine questions about subjects' climate risk perceptions; (2) *self-efficacy*, which is the score of responses to one question measuring subjects' beliefs in their ability to affect climate change; and (3) *pro-environmental behavioral intentions*, measured by the aggregate mean score of responses to the eight questions measuring subjects' pro-environmental actions. The explanatory variables were *Wuhan subjects*, an indicator variable taking the value of one if subjects were quarantined or stayed in Wuhan city during the Wave 2 and 3 surveys. *Wave two* and *Wave three* indicate March 2020, the time of our second survey wave, and April 2020, showing our third survey wave, respectively. The two survey wave variables and their interaction with the Wuhan location variable were the variables of interest. Robust standard errors were used.

EMPIRICAL FINDINGS

Emotional Responses to COVID-19

Emotional responses to an experienced threat can influence climate change awareness and beliefs. Thus, we tested whether the pandemic has evoked a feeling of fear using the question

“Are you afraid of COVID-19?” Responses ranged from 1 to 5, corresponding to “low” and “high” levels of fear. We find that after the outbreak of COVID-19 in Wuhan (Figure 1, Wave 2), subjects located in the city of Wuhan or in Hubei Province, where the crisis had been much more severe than in other places in China, reported a higher level of fear about COVID-19 in general. This suggests a significant increase in fear in response to COVID-19, particularly for those with greater exposure to the crisis. When the COVID-19 virus evolved into a worldwide pandemic, and the focus shifted away from Wuhan (quarantine conditions in China were eased) (Figure 1, Wave 3), subjects reported a lower level of fear about COVID-19 regardless of their exposure to the pandemic. This suggests that the effective control of the virus in its place of origin may have improved the confidence of the public and provided relief. These results are further supported by the summary statistics reported in Table 1, where the mean score of responses to the question decreased from 2.704 (Wave 2) to 2.403 (Wave 3), and the difference was significant at the 5% level (p -value = 0.000).

Climate Change Beliefs and Actions

We next examine whether the elicited fear influenced subjects' climate change beliefs and actions, including their climate risk perceptions, beliefs in their ability to do something about climate change (self-efficacy), and willingness to act to address climate change (pro-environmental behaviors). We measured climate risk perceptions using a single question that relates to the general concerns about climate change risk, “In general, how concerned

are you about global climate change?” and eight questions following O'Connor et al. (1999) and Leiserowitz (2006) (the detailed questions are provided in *Methods*). Responses to the questions were given on a scale of 1 to 5, corresponding to “strongly disagree” and “strongly agree.” We averaged the answers of 9 questions into an equally weighted scale ranging from 1 to 5, representing “low” and “high” climate risk perceptions, respectively. Compared to their responses from pre-outbreak times (Wave 1, left panel of Figure 2.), subjects' beliefs in climate risk increased significantly after COVID-19 was elevated to pandemic status (Wave 3, left panel of Figure 2.) but did not change after the initial outbreak of COVID-19 in Wuhan (Wave 2, left panel of Figure 2). Table 1 reports the average score of the nine questions, showing that the average score increased slightly, from 3.571 (Wave 1) to 3.898 in Wave 2 and jumped to 4.031 in Wave 3. The increase from Wave 1 to Wave 3 amounted to 0.46, which was statistically significant at the 5% level (p -value = 0.000) and economically substantial given the mean value of 3.571 in Wave 1. Multiple regression analysis further confirmed these results (Table 2), where the dependent variable was the average score of the nine questions, and Wave 2, Wave 3, and Wuhan were independent variables indicating the responses of subjects from Wave 2 and 3 surveys and the reactions of the subjects who were quarantined in Wuhan during the two surveys. We controlled for subjects' demographic characteristics, such as age and gender. The coefficient of Wave 3 was significant (i.e., coefficient = 0.462, $s.d.$ = 0.036), but the interaction term Wave 3*Wuhan was insignificant (i.e., coefficient = -0.009, $s.d.$ = 0.091), indicating that climate risk perceptions were positively shifted after the COVID-19 had spread globally, regardless of subjects' individual exposure to the virus.

We next investigated subjects' self-efficacy, i.e., their sense of being able to do something about climate change. Following Metag et al. (2016), we measured self-efficacy using the question, “I feel that I can do something about climate change. The answers ranged from 1 to 5, corresponding to “strongly disagree” and “strongly agree,” respectively. Compared with responses from normal times (Wave 1, middle panel of Figure 2), subjects, especially those who were quarantined in Wuhan, reported a slightly lower level of self-efficacy after the outbreak of COVID-19 in Wuhan (Wave 2, middle panel of Figure 2). However, these changes were insignificant (p -value = 0.909). A possible explanation is that witnessing the outbreak of a health crisis without seeing effective actions to address it may decrease people's sense of being able to do something about another threat, e.g., climate change. However, the indirect link between COVID-19 and climate change may have moderated the effect. In contrast, we observed that subjects' self-efficacy increased considerably after COVID-19 had spread globally. Still, the quarantine restrictions in Wuhan were eased, marking a milestone in gaining control over the virus (Wave 3, middle panel of Figure 2). These findings were confirmed by the results shown in Table 1, which show that the mean score of responses to the question increased from 3.696 (Wave 1) to 4.221 (Wave 3); this increase was statistically significant at the 5% level (p -value = 0.000). The results from regression analysis (Table 2) provide further evidence, where the coefficient of Wave 3 was significantly

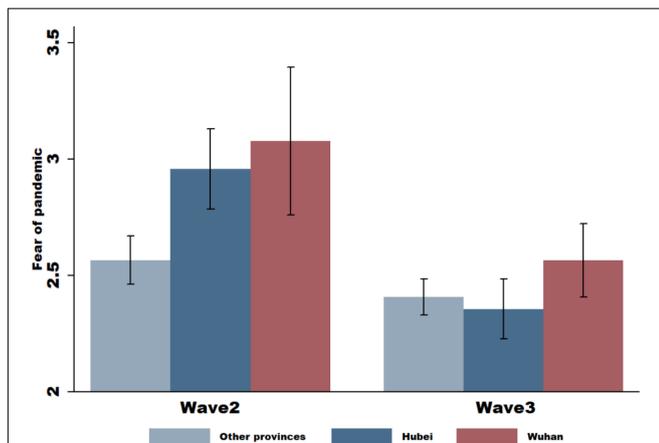


FIGURE 1 | Subjects' self-reported fear of COVID-19. In the following figure, we plot subjects' self-reported fear of COVID-19. We plot the responses by subjects who were quarantined in Wuhan, subjects who were quarantined in the province of Hubei (but outside of Wuhan), and subjects in different provinces in China. In Wave 2, we plot the mean values of responses to the question asking whether subjects were afraid of the COVID-19 pandemic during the COVID-19 outbreak in Wuhan when the city was under lockdown (our Wave 2 survey). In Wave 3, we plot the mean values of responses to the question asking whether subjects were afraid of COVID-19 when it was declared a pandemic and the Wuhan city lockdowns were eased (our Wave 3 survey). Responses were given on a scale between (1) and (5), corresponding to “not afraid at all” to “very afraid,” respectively, and 95% confidence intervals are displayed.

TABLE 1 | Summary statistics.

	Wave 1: mean (± s.e.m.)	Wave 2: mean (± s.e.m.)	Wave 3: mean (± s.e.m.)	Significance of changes from wave 1 to wave 2 (two-tailed)	Significance of changes from wave 1 to wave 3 (two-tailed)	Significance of changes from wave 2 to wave 3 (two-tailed)
Fear of COVID-19 (on a 5-point scale: 1 = lowest, 5 = highest)						
'Are you afraid of COVID-19?'		2.704 (1.096)	2.403 (0.791)			↓P = 0.000
Attitude towards climate change (on a 5-point scale: 1 = lowest, 5 = highest)						
(1) Perceived climate risk						
Average score of the 9 perceived climate change risk questions	3.571 (0.028)	3.633 (0.026)	4.031 (0.025)	↑ P = 0.054	↑ P = 0.000	
(2) Pro-environmental behaviors						
Average score of the 8 pro-environmental behavior questions	3.891 (0.026)	3.909 (0.0229)	4.111 (0.023)	↑ P = 0.308	↑ P = 0.000	
(3) Self-efficacy						
"I feel I can do something about climate change."	3.696 (0.039)	3.618 (0.042)	4.221 (0.035)	↓P = 0.909	↑P = 0.000	
Mechanism (on a 5-point scale: 1 = lowest, 5 = highest)						
(1) "The outbreak of COVID-19 was caused by damage to the natural environment."		3.390 (0.038)	3.238 (0.038)			↓P = 0.523
(2) "Climate change is as serious a global crisis as COVID-19 is."			3.967 (0.033)			

This table reports the summary statistics (mean and standard deviation in brackets) of subjects' responses to the survey questions. Part (a) reports the responses to 1 question about fear of COVID-19; part (b) shows the responses regarding attitudes toward climate change, including perceived climate change risk, self-efficacy, and pro-environmental behavior; and part (c) presents the responses relating to the perceived link between COVID-19 and climate change. The p-value shows the significance of the repeated-measures t-test (or paired two-sample t-test).

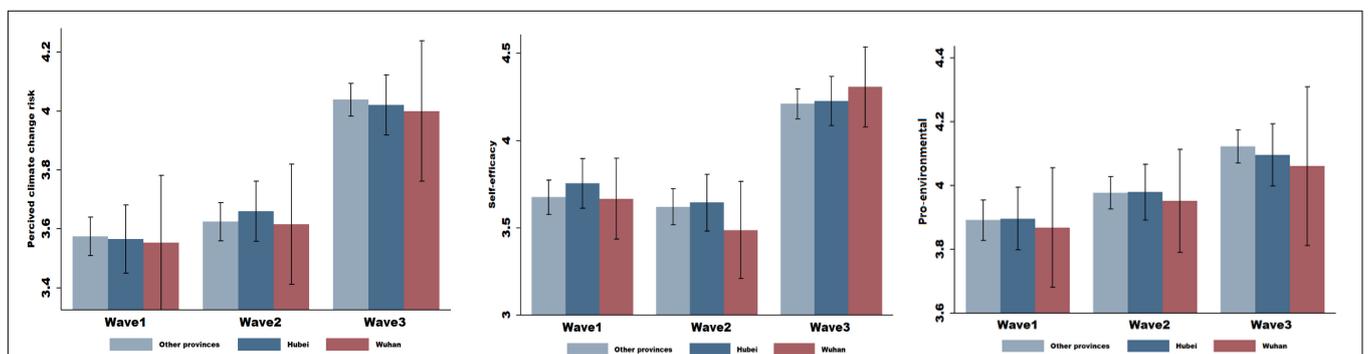


FIGURE 2 | Subjects' climate change beliefs and actions. In the following figure, we plot subjects' climate change beliefs and actions, including their perceived climate change risk, self-efficacy (belief in their ability to affect change), and pro-environmental behaviors. We plot responses by subjects who were quarantined in Wuhan, subjects who were quarantined in the province of Hubei (but outside of Wuhan), and subjects in different provinces in China. In Wave 1, we plot the mean values of responses to 9 questions about subjects' climate risk perceptions (perceived climate change risk), 1 question about subjects' belief in their capacity to address climate change (self-efficacy), and 8 questions about subjects' willingness to take action to address climate change (pro-environmental behaviors) before the outbreak of COVID-19. In Wave 2, we plot the mean values of responses to these questions after the COVID-19 outbreak in Wuhan, when the city was under lockdown. In Wave 3, we plot the mean values of responses to these questions when COVID-19 was declared a pandemic, but the Wuhan city lockdowns were set to be eased. Responses were given on a scale between (1) and (5), corresponding to "strongly disagree" and "strongly agree," respectively, and 95% confidence intervals are displayed.

TABLE 2 | Regression results.

	(1) Climate risk perceptions	(2) Self-efficacy	(3) Pro-environmental behaviors
Wave two	0.051 (0.041)	0.026 (0.032)	-0.066 (0.065)
Wave three	0.462*** (0.036)	0.228*** (0.042)	0.545*** (0.059)
Wuhan subjects	-0.009 (0.067)	0.007 (0.059)	0.079 (0.086)
Wave two*Wuhan subjects	0.050 (0.092)	-0.036 (0.078)	-0.046 (0.126)
Wave three*Wuhan subjects	-0.009 (0.091)	-0.020 (0.084)	-0.070 (0.120)
Control variables	Yes	Yes	Yes
R2	0.095	0.029	0.073
Observations	1,812	1,812	1,812

This table reports the regression analysis results. The dependent variable in Column (1) is climate risk perceptions, which is the aggregate mean score of responses to the 8 questions in part (b) of the survey. Column (2) is self-efficacy, which is the score of part (c) in the survey, and Column (3) is pro-environmental behaviors, measured by the aggregate mean score of responses to the 8 questions in part (d) of the survey. The explanatory variables are Wuhan subjects, an indicator variable that takes the value of one if the subject was quarantined or stayed in the city of Wuhan during the period of the Waves 2 and 3 surveys. Wave two and Wave three indicate March 2020 for our second survey wave and April 2020 for our third survey wave, respectively. The variables of interest are the two survey wave variables and their interaction with the Wuhan location variable. The robust standard errors used are reported in brackets. *** indicate significance at the 1% level, respectively.

positive (coefficient = 0.228, *s.d.* = 0.042) but that of Wave 2 was insignificant (coefficient = 0.026, *s.d.* = 0.032). Meanwhile, the interaction term Wave 3*Wuhan was insignificant (coefficient = -0.020, *p-value* = 0.084), suggesting that subjects' self-efficacy increased after they observed an effective response to the crisis in Wuhan and that this increase was independent of their exposure to the crisis.

Finally, we tested whether subjects' pro-environmental behaviors shifted in response to COVID-19. Following Bernauer and McGrath (2016), we measured pro-environmental behaviors using eight questions that presented a set of scenarios and asked about the willingness to act in environmentally friendly ways. The answers ranged from 1 to 5, corresponding to "strongly disagree" and "strongly agree," respectively (detailed questions are provided in *Methods*). We averaged the answers of the eight questions into an equally weighted scale ranging from 1 (low level of pro-environmental behaviors) to 5 (high level of pro-environmental behaviors). We found that after experiencing the local outbreak of COVID-19 in Wuhan (Wave 2, right panel of **Figure 2**), subjects stated a slightly higher level of willingness to act in pro-environment ways, confirmed by the mean scores reported in **Table 1**, which increased from 3.891 (Wave 1) to 3.976 (Wave 2). However, the increase was insignificant at the 5%

level (*p-value* = 0.308). When the health crisis evolved from the local to the global level, the mean score of answers to the eight questions further increased to 4.111; this increase was statistically and economically significant. The regression analysis further supported these results.

Overall, our results showed a significant increase in climate risk perceptions and self-efficacy, which translated into pro-environmental behaviors, from normal times before the COVID-19 outbreak to the time that it had evolved into a global health crisis. It is plausible that this effect was partially driven by a belief that there is a direct link between the COVID-19 pandemic and damage to the natural environment (potentially as a source of the pandemic), or an increase in fear about an analogous global crisis. Our findings of no significant changes after the local outbreak of COVID-19 in Wuhan can somewhat rule out the first explanation. We will further explore these two potential explanations in the following section.

Mechanism Analysis: A Next Global Crisis or a Source of the COVID-19

We attempted to disentangle the two aforementioned explanations by analyzing responses to the following two questions: "The COVID-19 outbreak was caused by damage to the natural environment," which was asked in both Wave 2 and Wave 3, and "Climate change is as serious a global crisis as COVID-19 is," which was asked only in Wave 3. The responses were given on a scale of 1 to 5, corresponding to "strongly disagree" and "strongly agree," respectively.

We found that fear about a future global crisis played the main role in changing subjects' climate change beliefs and actions. Subjects were more likely to agree that the COVID-19 pandemic is as much a global crisis as climate change is (**Figure 3**). While the mean score of the item "Climate change is as serious a global crisis as COVID-19 is" was 3.967, the mean score of the item "The COVID-19 outbreak was caused by damage to the natural environment" was only 3.238 (**Table 1**). The difference amounted to 0.729, accounting for 14.5% of the 5-point scale. Additionally, the responses to the two questions across subjects who were quarantined in Wuhan, quarantined in Hubei Province (outside of Wuhan), and quarantined in other provinces showed no significant difference, suggesting that subjects' perceived link between COVID-19 and climate change was not affected by their exposure to the virus.

Heterogeneity Analysis: Attitudes Toward Social Responsibility

Finally, we examined whether the shifts in climate change beliefs and actions due to COVID-19 varied across individuals. We focused on individuals' attitudes toward social responsibility and tested the hypothesis that larger shifts would happen among more socially responsible individuals. During the COVID-19 pandemic, most nations have enforced social distancing rules, quarantines, and/or lockdowns to contain the spread of the virus. These mobility restrictions require collective and unified action. We assumed that individuals' attitudes toward these collective actions might reflect their attitudes toward social

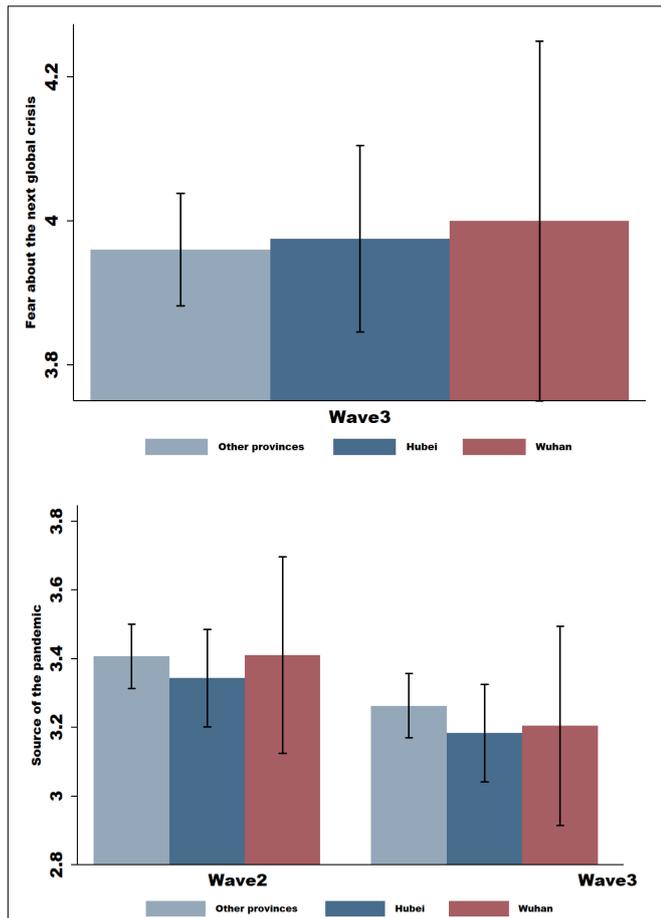


FIGURE 3 | Mechanism analysis: A next global crisis or a source of the COVID-19. In the following figure, we plot subjects' perceived link between COVID-19 and climate change. We plot the responses by subjects who were quarantined in Wuhan, subjects who were quarantined in the province of Hubei (but outside of Wuhan), and subjects in different provinces in China. In Wave 2, we plot the mean values of responses to the item "The COVID-19 outbreak was caused by damage to the natural environment" during the coronavirus outbreak in Wuhan when the city was under lockdown. For Wave 3, we plot the mean values of responses to the two items 'The COVID-19 outbreak was caused by damage to the natural environment' and "Climate change is as serious a global crisis as COVID-19 is" during the period when COVID-19 was declared a pandemic and the Wuhan city lockdown was being eased. Responses were given on a scale between (1) and (5), corresponding to "strongly disagree" and "strongly agree," respectively, and 95% confidence intervals are displayed.

responsibility. We thus measured individual social responsibility using responses to the question, "Quarantines and social distancing are effective measures to prevent the spread of COVID-19." Subjects answered this question on a scale of 1 to 5, corresponding to "strongly disagree" and "strongly agree," respectively. We sorted our subjects into three groups (representing low to high levels of social responsibility) and examined how shifts in climate change beliefs and actions (measured by the difference between the Waves 1 and 3 survey responses) varied across these groups. We aggregated the answers to all of the aforementioned questions into equally weighted

answers from 1 to 5. We found that the positive shift in climate change beliefs and actions monotonically increased from the low (mean score = 1.45) to high (mean score = 1.85) social responsibility groups, and the highest changes were observed in the subject group most in favor of quarantines or social distancing measures (Figure 4). Thus, we conclude that the COVID-19 pandemic has caused positive shifts in the public's climate change beliefs and actions, and the effect is more pronounced among people with high stated levels of social responsibility.

LIMITATIONS AND FUTURE RESEARCH

The study's design has several advantages, but it also comes with drawbacks. One limitation of this study is that participants were aware that they were participating in an experiment. This, of course, could impact their behavior, especially their attitude toward their social preference. However, because individuals in different treatment groups received identical questions, we could account for potential effects associated with the concept of monitoring. Although we randomly assigned participants into other treatment groups to account for potential monitoring effects, it would be interesting to observe if comparable results occur when individuals are unaware they are being monitored.

We also propose some future research directions in this study. The role of peer effects in decision making has been largely explored in many contexts, such as green product adoption, saving and borrowing decisions (Georgarakos et al., 2014;

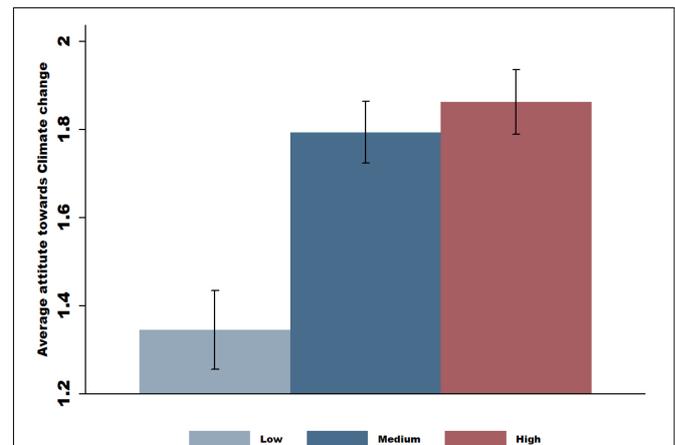


FIGURE 4 | Heterogeneity analysis: attitudes toward social responsibility. In the following figure, we examine whether the impact of COVID-19 on subjects' attitude toward climate change depended on their level of social responsibility. We measured individual social responsibility using the item "Quarantines and social distancing are effective measures for preventing the spread of COVID-19." Responses were given on a scale of 1 to 5, corresponding to "strongly disagree" and "strongly agree," respectively. We sorted our sample of subjects into three cohorts representing subject groups with low, medium and high levels of social responsibility. We then plotted the responses regarding the change in attitude toward climate change (the change in the mean score of responses to the 18 questions related to climate change) from Wave 2 to Wave 3 according to subjects in the low, medium and high social responsibility groups, and 95% confidence intervals are displayed.

Bu et al., 2021). It is well documented in those studies that people can learn from their friends' or colleagues' experiences and can be influenced by their choices (Hirshleifer, 2020). While peer impacts are believed to influence individuals' perceptions of climate change danger and pro-environmental action, little study has been conducted thus far. Additional research should be performed to ascertain whether and how an individual's enhanced pro-environmental behavior affects peers. Moreover, for future research, machine learning techniques could be used to assess treatment effects in this type of trial.

CONCLUSION

Our study examined how CEOs' climate change beliefs and corporate pro-environmental behavior evolved from before the COVID-19 outbreak to when it had become a global health crisis. We use repeated survey data from a large panel of subjects based in Wuhan, China. Our identification strategy exploited the fact that the COVID-19 outbreak evolved from an epidemic in Wuhan to a global pandemic. This variation allowed us to differentiate between local and global crisis perspectives. The sample size in our study is substantially greater than comparable studies. For example, Brügger et al. (2016) tested whether psychological distance from climate change predicted pro-environmental intentions with 252 subjects in their experiments. Metag et al. (2016) investigated whether expediting the COVID-19 pandemic causes greater risk-taking with only 231 subjects.

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The relatively larger sample size allows us to estimate the effect with a desired statistical power.

We found that while the CEOs showed an emotional response to COVID-19, as measured by higher levels of fear during the COVID-19 outbreak in Wuhan, this was not a constant determinant affecting their beliefs and corporate behavior toward climate change. However, when COVID-19 became a global pandemic, fear translated into a higher perception of climate risk, a more heightened sense of being able to do something about climate change, and a higher willingness to act to address climate change. We argue that this is mainly explained by subjects' belief in an analogous future global crisis after they observed the consequences of a global health crisis and felt hope after observing the effective responses to that crisis. At the same time, heterogeneity in exposure to COVID-19 did not differentially affect climate change beliefs and actions; instead, on average, all subjects surveyed showed a large and significant increase.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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Chief Executive Officer Collectivism and Corporate Pollution Abatement Behavior: Evidence From Industrial Firms in China

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This study examines the relationship between chief executive officers (CEOs)' collectivistic cultural background and corporate pollution abatement behavior among industrial firms in China. Using hand-collected data on birthplaces of CEOs of the industrial firms, we provided robust evidence that CEOs born in provinces with a higher level of collectivistic culture promote corporate pollution abatement performance. This study further shows that firms exhibit significant differences in their emission reduction behavior when firms are subjected to environmental regulation shocks: firms with collectivistic CEOs tend to reduce more pollution than firms with individualistic CEOs without sacrificing their firms' production.

Keywords: environmental regulation, climate change, financing constraints, pollution reduction, CEO collectivism

OPEN ACCESS

Edited by:

Haiyue Liu,
Sichuan University, China

Reviewed by:

Di Bu,
Macquarie University, Australia
Yin Liao,
Macquarie University, Australia

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 17 May 2022

Accepted: 13 June 2022

Published: 06 July 2022

Citation:

Wang S, Huang Y, Zhong C and
Li B (2022) Chief Executive Officer
Collectivism and Corporate Pollution
Abatement Behavior: Evidence From
Industrial Firms in China.
Front. Psychol. 13:946111.
doi: 10.3389/fpsyg.2022.946111

INTRODUCTION

The increased prominence of climate policy on government agendas worldwide has rekindled interest in the best design of large-scale environmental externality control. Climate change, also known as the “ultimate commons problem” (Stavins, 2011; Wan et al., 2021), is driven by anthropogenic greenhouse gas (GHG) emissions such as carbon dioxide (CO₂) and is projected to have severe ecological and economic effects (Kumar, 2007). Globally, the industrial sector is a major source of greenhouse gas emissions. The industrial sector and primary industry contribute to over 40% of global GHG emissions (OECD et al., 2010). In 2000, total carbon emissions from the industrial sector were expected to be 60.3 MtC. Command-and-control strategies have long been the most prevalent form of environmental regulation in the industrial sector. Economists have historically favored market-based mechanisms such as taxes and tradable permit systems because they are more efficient in both static and dynamic terms (e.g., Montgomery, 1972; Milliman and Prince, 1989; Tietenberg, 1990).

To curb industrial firms' pollution emissions in China, the Chinese government has been levying emission fees on these firms' pollution emissions since 2003. Along with reducing firms' pollutant emissions to a certain amount, the emission fee policy has brought certain negative consequences for firms and the whole economy. In the face of increasingly strict market regulation of emissions, such as the imposition of emission fees, firms typically have two options for reducing their emissions (Montero, 1998; Coria, 2009; Hatcher, 2012). The first strategy is pollution control, which reduces emissions. The second method is to reduce pollutant emissions by reducing firms' production directly. However, reducing emissions through

output reduction directly influences firms' production and operations, resulting in significant macroeconomic swings (Bu and Liao, 2014; Li et al., 2016; Liu et al., 2020). This study investigates which companies are more likely to cut their pollution emissions and which are more likely to lower their production in response to the emission fee policy.

According to research, the collectivistic and individualistic cultural backgrounds of chief executive officers (CEOs) are associated with their pro-environmental behavior. According to available research, collectivism (as opposed to individualism) is defined by an interdependent self (as opposed to an independent self) (Markus and Kitayama, 1991). Specifically, collectivists are concerned with group norms and collective harmony, and they place group aims above their own (Wagner and Moch, 1986; Strunk and Chang, 1999; Voronov and Singer, 2002). Individualists value human autonomy and uniqueness and prioritize personal aspirations over group objectives. In this research, we argued that collectivistic CEOs are more likely than individualistic CEOs to take measures to reduce business pollution while maintaining company production in response to the change in environmental policy. This presumption is supported by the following arguments. Individualist vs. collectivist orientations have been demonstrated to influence environmentally conscious behavior. Individuals with collectivistic tendencies are more likely than those with individualistic tendencies to engage in a variety of pro-environmental behaviors, such as resource conservation and green shopping. Moreover, according to a poll performed in New Zealand by Semenova (2015), the more ecologically engaged group (representing sustainable communities) had a more collectivistic value orientation than the less environmentally active group. Environmental activists were more likely to embrace self-transcendent values (similar to collectivism, e.g., universalism-concern), but non-activists were more likely to endorse self-interest values (similarly to individualism, e.g., self-direction). Therefore, when confronted with stringent environmental regulations, collectivistic CEOs are presumed to take actions to directly reduce their firms' pollution emissions without reducing production, whereas individualistic CEOs may choose to reduce production in order to reduce pollution emissions, resulting in the emission per unit of the product unchanged.

To investigate the effect of the CEO's collectivistic background on corporate emission behaviors, we manually collected birthplace data for 9,227 out of 29,751 CEOs of our sample industrial firms from 2004 to 2013, which are then matched with the pollution information from Chinese Industrial Firm Pollution Emission (CIFPE) Database. We conducted empirical research utilizing the difference-in-difference method with the CEO birthplace information and the pollution data from industrial companies from 2004 to 2013 in response to the exogenous policy shock of the 2007 emission charge increase. Our primary measure of corporate pollution emissions is the annual emissions of both CO₂ and sulfur dioxide (SO₂) in tones. We found that CEOs born in provinces with a stronger collectivistic culture tend to reduce emissions. When controlling for firm characteristics, firms managed by such CEOs lower their

pollution emissions and retain their production levels following an increase in the emission fee. While firms led by individualistic CEOs also lowered their total emissions after the rise in emission fees, the decreased emissions were accomplished by cutting production. On average, the emission per unit of output was reduced by 12.6% more for firms led by collectivistic CEOs than those led by individualistic CEOs.

This study makes the following three contributions to the existing literature. First, we complemented and broadened an emerging body of research that links culture to corporate behaviors and economic outcomes (e.g., Hilary and Hui, 2009; Ahern et al., 2015; DeBacker et al., 2015; Nguyen et al., 2018; Fitzgerald and Liu, 2020). Our study shows that CEOs' individualistic cultural values from their hometowns shape corporate pollution abatement behaviors. Second, existing literature has examined the effects of pollution emission regulation on air pollution (Henderson, 1996; Greenstone, 2004), industrial activity (Becker and Henderson, 2000; Greenstone, 2002), plant births and deaths (Henderson, 1996; Levinson, 1996; List et al., 2003), plant productivity (Berman and Bui, 2001; Bu and Liao, 2021), and market structure (Bu et al., 2021). This is the first study to systematically evaluate the implementation of China's emission fee policy change on industrial firms' pollution control. Third, this study used a micro-matching sample at the firm level, which combined the Chinese Industrial Firm (CIF) and the Chinese Industrial Firm Pollution Emission (CIFPE) databases. The sample contained firm-related economic and financial indicators and a series of various pollutant emission indicators at the firm level. This provides the basis for reliable evidence for our study.

The subsequent sections of this study are organized as follows: the "Institutional Background" section and the "Hypothesis Development" section introduce the background of the emission fee policy and the agricultural root of collectivism in China and develop research hypotheses. The "Data" section and the "Empirical Analysis" section introduce the dataset and empirical analysis. The "Heterogeneous Analysis" section presents the heterogeneous analysis. The "Conclusion and Policy Implication" section concludes the whole study and makes policy implications.

INSTITUTIONAL BACKGROUND

Emission Fee Policy

In the early 1970s, the pollution levy system was initially implemented in OECD nations. China first introduced the idea of a pollution levy system in 1978, after learning from the environmental management practices of Western countries. Subsequently, in 1979, the "Environmental Protection Law of the People's Republic of China (Trial)" mandated that pollutant emissions in excess of the nationally established levels would incur fees based on their quantity and concentration. It also offers a legal foundation for the pollution levy system. In February 1982, the State Council issued comprehensive regulations on the pollution levy's objective, scope, criteria, extra and reduced conditions, and charge administration. In July 1982, the pollution levy system was formally formed and applied nationwide. In

2003, the total pollutant emission became the basis for the pollution levy system. The pollution levy standards for SO₂ were increased to 0.63 yuan per kilogram on 1 July 2005. In May 2007, in response to a severe environmental situation, the Chinese central government proposed a binding target of a 10% reduction in the total emissions of major pollutants during the 11th Five-Year Plan period and mandated that the pollution levy standards for SO₂ be increased from 0.63 yuan per kilogram to 1.26 yuan per kilogram. In reaction to this policy, a number of Chinese provinces have successively modified their pollution levy regulations (refer to **Table 1** for more details). The province of Jiangsu assumed the lead on 1 July 2007. In 2008, the provinces of Anhui, Hebei, Shandong, and Inner Mongolia Autonomous all upped their pollution levy standards. In total, 15 provinces in China have upped their pollution charge standards to 1.26 yuan per kilogram as of the end of 2014, with the exception of Beijing, which raised the threshold to 10 yuan per kilogram.

Agricultural Root of Collectivism/Individualism in China

Why are some communities collectivistic and others individualistic? The literature on cross-cultural psychology contends that the origins of individualism and collectivism are ecological (Vandello and Cohen, 1999; Nisbett, 2003; Talhelm et al., 2014). Rice-growing regions typically have relatively longer crop-growing seasons, allowing them to double their crop production. Rice responds well to substantial irrigation, dredging, planting, weeding, transplanting, and rigor field leveling. Traditional rice growers met the labor requirements by establishing labor exchanges. Therefore, a history of rice production produces collectivism and increased societal responsibility.

Compared with rice, wheat needs more rainfall and less irrigation. The duration of the wheat-growing season is shorter than the rice-growing season. With additional time, efforts might be dedicated to other endeavors, such

as advancing agricultural techniques. Throughout history, women cultivated wheat while men reared livestock. Seasonally, the home men may require to procure water and grass for the herd in remote areas (Moran, 1982; Ang and Fredriksson, 2017). The lower labor input needs also indicate that wheat producers can tend to their own plots with less assistance from other people than rice farmers. Individualists, therefore, embrace human individuality and uniqueness and place a premium on personal ambitions over community goals. In conclusion, wheat production promotes higher individualism, correlated with diminished social responsibility.

HYPOTHESIS DEVELOPMENT

On the one hand, environmental regulation can help companies reduce pollution. On the other hand, as environmental regulations (e.g., environmental taxes and carbon taxes) increase the cost of environmental resources while reducing pollution emissions, firm productivity is frequently impacted negatively. More precisely, when enterprises are subjected to harsh environmental regulations, such as a considerable increase in emission costs, the marginal cost of firm production exceeds the marginal benefit. Controlling firm pollution, in particular, necessitates massive corporate environmental investment. Corporate environmental investments, such as green technology R&D innovation, process improvement, or equipment installation, are typically characterized by lengthy lead times, low upfront returns, and high risk, making it costly for firms to reduce their pollution through pollution abatement investment. Some firms then choose to reduce pollutant emissions by reducing firm production directly.

Individualist vs. collectivist orientations have been demonstrated to influence environmentally conscious behavior. Individuals with collectivistic tendencies are more likely than those with individualistic tendencies to engage in a variety of pro-environmental behaviors, such as resource conservation and green shopping. Moreover, according to a poll performed in New Zealand by Semenova (2015), the more ecologically engaged group (representing sustainable communities) had a more collectivistic value orientation than the less environmentally active group. Environmental activists were more likely to embrace self-transcendent values (similar to collectivism, for example, universalism-concern). Still, non-activists were more likely to endorse self-interest values (similar to individualism, e.g., self-direction). Based on the above theoretical analysis, this study proposes the following research hypothesis:

H1: *Firms' pollution emissions decreased dramatically as a result of the increase in emission fees.*

H2: *Collectivistic CEOs are more likely than individualistic CEOs to take measures to reduce business pollution while maintaining company production in response to the change in environmental policy.*

TABLE 1 | Information on the change of emission fee by regions 2007–2013.

Pilot provinces	Policy change date	Pollution levy rate
Jiangsu	1/07/2007	1.26 yuan/ton
Anhui	1/01/2008	1.26 yuan/ton
Hebei	1/07/2008	1.26 yuan/ton
Shandong	1/07/2008	1.26 yuan/ton
Inner Mongolia	10/07/2008	1.26 yuan/ton
Guangxi	1/01/2009	1.26 yuan/ton
Shanghai	1/01/2009	1.26 yuan/ton
Yunnan	1/01/2009	1.26 yuan/ton
Guangdong	1/04/2010	1.26 yuan/ton
Liaoning	1/08/2010	1.26 yuan/ton
Tianjin	20/12/2010	1.26 yuan/ton
Xinjiang	1/08/2012	1.26 yuan/ton
Beijing	1/01/2014	10 yuan/ton
Ningxia	1/03/2014	1.26 yuan/ton
Ningxia	1/04/2014	1.26 yuan/ton

DATA

We employed four sources of data in our analysis: the Chinese Industrial Firm (CIF) database, the Chinese Industrial Firm Pollution Emission (CIFPE) database, the China Statistical Yearbook, and the Global Agro-Ecological Zones (GAEZ) database. The CIFPE database includes industrial firms that account for 85% of the total emissions of major pollutants in China and comprises information on industrial output, energy input, and pollution emissions. To ensure the integrity and accuracy of these data, they are reported by polluting firms independently, collected by local environmental protection departments, and finally monitored and irregularly checked by environmental protection departments at the county level. The database is considered to hold the most comprehensive and reliable micro-firm pollution emission data in China. The CIF database includes information on all state- and non-state-owned industrial firms that are “above-designated scale” (i.e., output value over 5 million yuan). The total output value of all firms accounts for more than 90% of China’s total industrial output value (Cui et al., 2020). The volume of this database is huge, and it contains rich information on firms.

Based on the method of Brandt et al. (2012), we matched the CIF database and the CIFPE database. First, the two databases were matched year by year, according to the firms’ code; the datasets that had not been matched successfully were matched again according to the firm name. Second, we identified and checked whether the firm in different years is the same firm according to the legal representative’s name, address, postcode, telephone, industry code, main products, and other information. Finally, we processed the data as follows: (1) We eliminated samples that did not meet the Chinese General Accepted Accounting Principles. The deleted samples mainly included firms with fewer than eight employees; samples with total assets less than current assets or net fixed assets; samples with negative current assets, fixed assets, net fixed assets, total sales, or total output; and samples with negative pollutant emissions.

(2) The industry code was revised twice, in 2002 and 2011 during the sample period, and it was unified according to the 2002 standard in this study. (3) Due to the inconsistent dates provided for the establishment of some firms, we used the information in the enterprise search¹ and Baidu search² websites to make corrections.

Culture is typically characterized as the transmission of largely unchanging beliefs and values from one generation to the next by ethnic, religious, and social groups (Guiso et al., 2006). According to Bisin and Verdier (2011), the transmission of cultural values from parents to children is essential in determining an individual’s cultural values. Although individuals may relocate in the future, they carry with them the cultural views and values inherited from their parents or, more generally, from their hometowns. In this way, we measured the collectivism of CEOs based on where they were born. In this study, we defined the collectivism of CEOs using province-level agroecological suitability indices for rice and wheat obtained from agricultural suitability data. The information is derived from the Global Agro-Ecological Zones (GAEZ) database, which was established collaboratively by the International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization (FAO). Under the assumption that agroecological conditions vary slowly over time, we followed Nunn and Qian (2010) and employed an intermediate level of inputs for the period 1961–2000. The provinces with more rice cultivation area than wheat cultivation area are categorized as collectivistic culturally dominated regions instead of individualistic culturally dominated regions. We then matched the birthplace of our sample CEOs to the agroecological suitability indexes to determine their collectivism. A CEO is considered collectivistic if he or she was born in a collectivistic culturally dominant province.

Finally, this study generates a merged panel dataset at the company level for 2004–2013, which includes data on CEO’s

¹<https://www.qcc.com/>

²<https://www.baidu.com/>

TABLE 2 | Definition of variables and descriptive statistics.

Variable	Variable definition	Unit	Mean	SD
Panel A: Pollution measure				
SO ₂	Annual SO ₂ emissions	Ton	150.391	727.212
PI	SO ₂ emission intensity: emissions per unit of output	Tons/million \$	1.230	2.973
COD	Annual COD emissions	Ton	52.058	163.547
Panel B: Firm characteristics				
Output	Total industrial output	Million dollars	374.583	859.468
Employee	Number of persons employed by the firm at the end of the year	Number of employees	561.203	859.921
Year	Age of firm	Year	13.484	11.987
FixedAsset	Corporate fixed assets	Million dollars	120.716	321.533
Gearratio	Gearing ratio: total liabilities/total assets	–	0.5981	0.3041
Debt	Credit borrowing: total liability accounts payable	Million dollars	155.430	405.364
IE	Interest expenses	Ten thousand dollars	207.566	888.820
Panel C: CEO characteristics				
Collectivism			0.683	0.857
Gender			0.836	0.9563

Table reports variable definitions and summary statistics of the main variables used in the regression analysis. We winsorized the main variables at the 1 and 99 percentiles to mitigate any undue influences of outliers.

TABLE 3 | Policy effects of emission fee increases.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>
<i>Treat_p × Post_t</i>	-0.0836* (-1.72)	-0.0337* (-1.69)	-0.0871 (-1.48)	-0.0927* (-1.62)	-0.0431** (-2.14)	-0.0732 (-1.55)
<i>lnOutput</i>			-0.6131*** (-16.63)			-0.8262*** (-16.16)
<i>Firm control</i>	No	No	No	Yes	Yes	Yes
<i>Firm fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Province control</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	161,939	173,954	161,939	161,939	173,954	161,939
<i>R²</i>	0.732	0.812	0.725	0.793	0.886	0.829

*Firm control variables include the number of employees, age, and squared terms; province control variables include GDP per capita, industrial SO₂ emission intensity, and share of investment in exhaust gas treatment by the province in 2007. Significance: *10%; **5%; ***1%. t-values in parentheses, and they are clustered at the city level.*

birthplace, firms’ identifying features, manufacturing processes, financial state, and numerous pollutant emissions. We eliminated firms from the final sample if they (1) do not adhere to accounting standards; or (2) have missing or zero pollution emissions during the sample period. Our final sample consists of 9,227 firms and 63,954 observations spanning the years 2004–2013. To minimize the effect of outliers, all variables in this study were winsorized at the 1% level. **Table 2** contains a list of the major variables utilized in this study, together with descriptive statistical information about them.

EMPIRICAL ANALYSIS

Baseline Results

Since 2007, some provinces in China have gradually increased their emission fees, while others have maintained their current rate. Due to China’s staggered implementation of increased emission fees across provinces and over time, we could utilize the difference-in-difference methodology to determine the causal effect of increased emission fees on corporate pollution reduction.

We can determine the policy effect of an increase in emission charges by comparing the difference between emissions in areas where emission charges were increased before and after the policies in areas where emission charges stayed unchanged. To test the effect of the increased emission fees on corporate pollution reduction, we estimated the following regression model:

$$Y_{jt} = \alpha + \beta Treat_p \times Post_t + \lambda Control_{jt} + \mu_t + \gamma_i + \epsilon_{jt} \tag{1}$$

Where Y_{jt} are the outcome variables, including pollutant emissions, emission intensity, and gross enterprise product, presented in logarithmic form; j denotes firm j , p denotes province p , and t denotes year t ; the indicator variable $Treat_p \times Post_t$ equals one if province p has increased their emission fees in year t ; otherwise, it is zero. Thus, the coefficient of $Treat_p \times Post_t$ provides the difference-in-difference estimate, stating the difference in Y_{jt} between the provinces that raised and not raised the emission fees. Given the sample period of 2004–2013, the regions where emission fees were increased throughout that time period are selected to be in the treatment group, as illustrated in **Table 1**, which includes 12 provinces and cities. The control group, which includes 18 provinces and cities, is comprised of places where emission fees were not changed during the sample period of 2004–2013. $Control_{jt}$ contain firm control variables, which include basic firm information (number of employees and year) and firm operating characteristics (labor productivity, capital-labor ratio, and gearing ratio). In addition, the control variables also include provincial control variables. In the regressions, we also included fixed effects (γ_i) and year fixed effects (μ_t). ϵ_{jt} is error term. To address the concerns of autocorrelation among observations associated with a given firm, we clustered standard errors at the city level.

Table 3 represents the estimated results of SO₂ emissions and production of firms affected by the increase in emission fees in regression (1), where columns (1)–(3) do not account for firm characteristics, but columns (4)–(6) do. From columns (4) to (6), it is evident that increasing emission fees significantly reduced SO₂ emissions and firm output by 9.14 and 4.43%, respectively; however, the results also show that firms’ SO₂ emissions per unit of output did not significantly decrease. The

TABLE 4 | Chief executive officer (CEO) collectivism and corporate pollution behavior after the policy change.

	(1)	(2)	(3)
	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>
<i>Treat_p × Post_t</i>	-0.0532* (-1.38)	-0.0207* (-1.42)	-0.0368 (-1.21)
<i>Treat_p × Post_t × Collectivism_{it}</i>	-0.112*** (3.87)	0.087*** (0.985)	0.133*** (6.98)
<i>Firm control</i>	Yes	Yes	Yes
<i>Firm fixed effects</i>	Yes	Yes	Yes
<i>Province control</i>	Yes	Yes	Yes
<i>Year fixed effects</i>	Yes	Yes	Yes
<i>N</i>	63,954	63,954	63,954
<i>R²</i>	0.657	0.717	0.702

*Firm control variables include the number of employees, age, and squared terms; province control variables include GDP per capita, industrial SO₂ emission intensity, and share of investment in exhaust gas treatment by the province in 2007. Significance: *10%; ***1%. t-values in parentheses, and they are clustered at the city level.*

findings reveal that enterprises choose to minimize emissions by simply cutting production rather than implementing more environmentally friendly manufacturing practices in reaction to the higher cost of emissions. The results are consistent with the first hypothesis.

Chief Executive Officer Collectivism and Corporate Pollution Behavior

To examine the relationship between CEO’s collectivistic background and corporate pollution behavior after the pollution policy change, we estimated the following OLS regressions:

$$Y_{jt} = \alpha + \beta Treat_p \times Post_t + \theta Treat_p \times Post_t \times Collectivism_{jt} + \lambda Control_{jt} + \mu_t + \gamma_i + \epsilon_{jt} \tag{2}$$

The main explanatory variable is *Collectivism*, which is measured by the CEO’s birthplace. Collectivism is a dummy

variable that equals one if the CEO was born in a province dominated by rice cultivation and zero if otherwise.

Table 4 reports the regression results for both the collectivist CEO and individualistic CEO firm samples. There is significant heterogeneity in the change of emission fee policy effects after the pollution policy change between collectivistic CEO and individualistic CEO firms. The coefficient of the interaction term $Treat_p \times Post_t \times Collectivism_{jt}$ in the regression shows a significant difference between the two types of firms. Comparing firms with collectivistic CEOs to those with individualistic CEOs, the results indicate a significant drop in SO_2 emissions and SO_2 emissions per corporate output unit. In contrast to the firms with collectivist CEOs, the output of the firms with individualistic CEOs decreased significantly after the policy change. Taken together, our results support the second hypothesis that collectivistic CEOs are more likely than individualistic CEOs to implement strategies to minimize corporate pollution

TABLE 5 | Heterogeneity of policy effects between large and small firms.

	(1)	(2)	(3)	(4)	(5)	(6)
	Large firms			Small firms		
	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>
<i>Treat_p × Post_t</i>	−0.0462* (−1.43)	−0.0221* (−1.46)	−0.0329 (−1.26)	−0.0482 (−1.41)	−0.0223** (−1.57)	−0.0316 (−1.24)
<i>Treat_p × Post_t × Collectivism_{jt}</i>	−0.122*** (3.34)	0.072*** (0.839)	0.137*** (6.35)	−0.111*** (3.12)	0.077*** (0.881)	0.131*** (6.13)
<i>Firm control</i>	YES	YES	YES	YES	YES	YES
<i>Firm fixed effects</i>	YES	YES	YES	YES	YES	YES
<i>Province control</i>	YES	YES	YES	YES	YES	YES
<i>Year fixed effects</i>	YES	YES	YES	YES	YES	YES
<i>N</i>	31,692	31,692	31,692	32,681	32,681	32,681
<i>R²</i>	0.612	0.703	0.682	0.631	0.702	0.691

Table reports the regression results of the effect of the emission fee increase on corporate emission behavior for both large and small firms. Columns (1)–(3) are the regression results for the large firm sample, while columns (4)–(6) are the regression results for the small firm sample. Firm control variables include the number of employees, age, and squared terms; province control variables include GDP per capita, industrial SO_2 emission intensity, and share of investment in exhaust gas treatment by the province in 2007. Significance: *10%; **5%; ***1%. *t*-values in parentheses, and they are clustered at the city level.

TABLE 6 | Heterogeneity of policy effects between high emission and low emission firms.

	(1)	(2)	(3)	(4)	(5)	(6)
	High pollution firms			Low pollution firms		
	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>	<i>lnSO₂</i>	<i>lnOutput</i>	<i>lnPI</i>
<i>Treat_p × Post_t</i>	−0.0418* (−1.49)	−0.0283* (−1.31)	−0.0391 (−1.42)	−0.0521 (−1.62)	−0.0207** (−1.38)	−0.0342 (−1.22)
<i>Treat_p × Post_t × Collectivism_{jt}</i>	−0.137*** (3.19)	0.078*** (0.792)	0.128*** (6.72)	−0.125*** (2.92)	0.071*** (0.827)	0.119*** (6.37)
<i>Firm control</i>	YES	YES	YES	YES	YES	YES
<i>Firm fixed effects</i>	YES	YES	YES	YES	YES	YES
<i>Province control</i>	YES	YES	YES	YES	YES	YES
<i>Year fixed effects</i>	YES	YES	YES	YES	YES	YES
<i>N</i>	31,533	31,533	31,533	32,927	32,927	32,927
<i>R²</i>	0.634	0.685	0.648	0.642	0.711	0.636

Table reports the regression results of the effect of the emission fee increase on corporate emission behavior for both large and small firms. Columns (1)–(3) are the regression results for the high pollution firm sample, while columns (4)–(6) are the regression results for the low pollution firm sample. Firm control variables include the number of employees, age, and squared terms; province control variables include GDP per capita, industrial SO_2 emission intensity, and share of investment in exhaust gas treatment by the province in 2007. Significance: *10%; **5%; ***1%. *t*-values in parentheses, and they are clustered at the city level.

while maintaining firm output in response to a shift in environmental regulation.

HETEROGENEOUS ANALYSIS

In the heterogeneous analysis, we explored whether the effect of a CEO's collectivism is consistent across different types of firms to ensure that the results are not sensitive to sample selection and research design. We split the sample by firm size and firm pollution emission. First, a firm is defined as small if the total assets are below the median for the sample. We then defined a firm as having low pollution emission if its pollution emission is below the median of the sample firms.

Table 5 reports the regression results for the large and small firm samples. The coefficient on $Treat_p \times Post_t \times Collectivism_{jt}$ in large firms is not significantly different from that of small firms, suggesting that the results are not sensitive to sample selection based on size. When the sample is divided by pollution emission, the coefficients of $Treat_p \times Post_t \times Collectivism_{jt}$ stay comparable in both samples of firms with high and low pollution emissions as shown in **Table 6**.

CONCLUSION AND POLICY IMPLICATION

Climate change, commonly described as the “ultimate commons problem,” is caused by anthropogenic glasshouse gas (GHG) emissions such as CO₂ and is anticipated to have severe ecological and economic consequences. The industrial sector is a major contributor to global glasshouse gas emissions. Together with primary industries, the industrial sector is responsible for roughly 40% of worldwide glasshouse gas emissions. In this study, we evaluated the impact of the CEO's collectivistic background on the firm's pollution abatement behavior using the agricultural root of the CEO's birthplace as a measure of collectivism. We

found that as a result of the increased emission prices, firms' pollutant emissions reduced considerably. We also found that, in reaction to a change in environmental policy, collectivistic CEOs are more likely than individualistic CEOs to take action to reduce company pollution while maintaining firm production. The results are unaffected by the sample firms' size or pollutant emission volume.

Overall, our research adds to the knowledge of the value of a CEO's intrinsic characteristics by shedding fresh light on the relationship between personality traits and corporate pollution abatement behavior. More crucially, we showed that corporate pollution abatement behavior is heavily influenced by culture. Our research highlights the importance of culture and has significant implications for future research into the relationship between culture and corporate behavior.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: The Chinese Industrial Firm (CIF) Database, the Chinese Industrial Firm Pollution Emission (CIFPE) Database.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

FUNDING

This research was funded by the Science and Technology Research Project of Chongqing Education Commission: Graduate Innovation Project of Chongqing Technology and Business University (CYB21223).

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Does Corporate Social Responsibility Heterogeneity Affect Corporate Financial Performance Through Technological Innovation? The Moderating Effects of Advertising Intensity

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OPEN ACCESS

Edited by:

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 17 December 2021

Accepted: 27 May 2022

Published: 08 July 2022

Citation:

Niu M and Ma W (2022) Does Corporate Social Responsibility Heterogeneity Affect Corporate Financial Performance Through Technological Innovation? The Moderating Effects of Advertising Intensity. *Front. Psychol.* 13:837967. doi: 10.3389/fpsyg.2022.837967

In this study, we examine the effects of firms' corporate social responsibility (CSR), technological innovation, and advertising intensity on corporate financial performance (CFP). Prior research has shown mixed findings for the CSR–CFP relationship. To provide additional evidence and alternative explanations for these mixed findings, we built a moderated mediating model by combining the knowledge-based view with the stakeholder theory. We use this model to examine whether CSR influences CFP by affecting technological innovation, and whether such mediating effects are moderated by advertising intensity. We classify heterogeneous CSR activities into technical and institutional activities. Using data from 2010 to 2018 on Chinese listed firms, we find that superior technical CSR performance can enhance CFP by promoting technological innovation and that it promotes technological innovation to a greater extent when advertising intensity is higher. However, institutional CSR does not affect technological innovation or CFP. The findings suggest that to improve the firm's financial position, its resources should be allocated effectively to technical CSR activities as well as to innovation and advertising.

Keywords: technical CSR, institutional CSR, corporate financial performance, advertising intensity, technological innovation

INTRODUCTION

The term corporate social responsibility (CSR) refers to the efforts of firms to consider social and environmental concerns, and the benefits to their stakeholders, when pursuing business interests (United Nations Industrial Development Organization, 2022). CSR has been a long-standing, yet still crucial, topic in the business world since Bowen (1953) first defined this concept. A firm's financial performance can be influenced by its market and nonmarket strategies (Baron, 2003). CSR, as a major element of such nonmarket strategies, is becoming an instrumental approach to building firms' competitiveness and obtaining resources for their long-term growth (Frynas and Yamahaki, 2016).

Another long-standing discussion, along with that about CSR topics, is whether or not CSR engagement influences corporate financial performance (CFP). Firms consider financial goals their top priority, whereas they often overlook nonfinancial aspirations (e.g., CSR) because conducting CSR activities can incur significant monetary costs, which sometimes draw scarce resources away from their core business activities. Although a stream of literature has examined whether CSR influences CFP, these studies have not arrived at a consensus on this relationship (Waddock and Graves, 1997; Margolis et al., 2009). The CSR–CFP association can be positive (Orlitzky et al., 2003), negative (Wang and Bansal, 2012), absent (Surroca et al., 2010), asymmetric (Van der Laan et al., 2008; Jayachandran et al., 2013), or U-shaped (Barnett and Salomon, 2012), in specific contexts.

The inconsistent findings on the CSR–CFP relationship indicate that further studies need to be conducted to investigate how (mechanisms) and when (contingencies) CSR affects CFP, instead of focusing on the empirical relationship between CSR and CFP alone (McWilliams and Siegel, 2000; Lev et al., 2009). Motivated by this view, in this study, we add technological innovation and advertising intensity, which have largely been overlooked in prior studies, into the CSR–CFP model. Specifically, we examine whether CSR influences CFP through its effects on technological innovation, which is reflected by the investment level for research and development (R&D), and whether such mediating effects are moderated by advertising intensity, which is reflected by the firm's total advertising expenditure. We also take CSR heterogeneity into consideration by separating the integrated CSR performance into the related performance for two specific domains: technical CSR (TCSR) and institutional CSR (ICSR).

Through these analyses, our study makes three main contributions. First, we extend the CSR–CFP literature by providing additional evidence that superior technical CSR performance improves CFP by promoting technological innovation and that this effect tends to be more pronounced as advertising intensity increases (Luo and Du, 2015; Zhao and Murrell, 2016). Further, our analysis results provide mixed findings for the CSR–CFP relationship with an alternative explanation: the effect of CSR performance on CFP also depends on the interaction between the technological innovation and the advertising intensity of firms. Thus, this study responds to the call of Aguinis and Glavas (2012) for deeper insight into the mechanism underlying the CSR–CFP relationship in order to identify effective mediators and moderators.

Second, we distinguish the effects of TCSR from ICSR on technological innovation and CFP. Specifically, we document that only superior TCSR performance can improve CFP by promoting firms' technological innovation. Prior studies generally examine firms' CSR performance by integrating heterogeneous CSR activities into one single construct (Godfrey et al., 2009). However, given that CSR is an "all embracing" idea that includes a wide range of activities related to various stakeholders (Jenkins, 2006, p. 245), the power of tests conducted by combining all CSR-related activities may be limited (Entine, 2003). Our classification of CSR activities allows us to specify how CFP is affected differently

by the firm's CSR activities related to its different groups of stakeholders.

Lastly, our study can enhance managers' understanding of the economic consequences of specific CSR activities and the related mechanisms. Our findings indicate to managers that to improve firms' financial position through CSR, they should spend more resources on the activities related to creditors, consumers, shareholders, employees, suppliers, and the government, and that it is critical to promote technological innovation and advertising accordingly.

The remainder of this paper is structured as follows: in the next section, we review a body of relevant literature on the CSR–CFP relationship and on heterogeneous CSR. Thereafter, we develop our hypotheses in Section Hypotheses Development and present our research design in Section Research Design. We describe our sample and report our empirical findings in Section Empirical Results. In Section Conclusion and Discussion, we conclude the study and discuss the findings. Last, in Section Implications and Limitations, we provide this study's theoretical and practical implications and limitations.

THEORETICAL BACKGROUND

Corporate Social Responsibility and Corporate Financial Performance

In extending the pioneering research regarding the CSR–CFP relationship by Moskowitz (1972), a stream of literature has attempted to identify a clear relationship between CSR performance and CFP. Although the CSR–CFP relationship is inherently a critical strategic topic (Grewatsch and Kleindienst, 2017), to date, this literature has not arrived at a consensus on this relationship. For instance, in a review of more than 170 empirical studies about the CSR–CFP relationship, Rivoli and Waddock (2011) find that these studies have provided mixed findings. Overall, these empirical studies have examined three sets of temporal relationships: positive, negative, and natural CSR–CFP relationships.

In this regard, most studies have supported that CSR can enhance CFP (Dowell et al., 2000; Hillman and Keim, 2001; Orlitzky et al., 2003; Blanco et al., 2013; Servaes and Tamayo, 2013; Wang and Choi, 2013). The positive CSR–CFP relationship is well explained by the stakeholder theory (Freeman, 1984), which emphasizes the importance of fulfilling multilateral stakeholders' expectations, rather than focusing only on bilateral stakeholders' profit maximization aspirations and organizational value creation (Donaldson and Preston, 1995; Jones, 1995). Indeed, CSR promotes rather than limits capital (Hussain et al., 2020), and CSR engagement benefits firms in many ways. For instance, engaging in CSR activities has positive effects on the expansion of firms' market opportunities (King and Lenox, 2009; Pil and Rothenberg, 2009) and their formation of product differentiation (Jones, 1999). CSR engagement can also improve the satisfaction (Edmans, 2012), attraction, retention (Memon et al., 2021), and conscientiousness of employees (Zeng et al., 2020; Yan et al., 2021). Successful CSR engagement is related to positive abnormal returns (Dimson et al., 2015),

financial constraint alleviation (Cheng et al., 2014), and increased customer awareness (Servaes and Tamayo, 2013). More broadly, firms that address society's needs benefit because this act builds a favorable reputation and yields them a competitive advantage (Frynas and Yamahaki, 2016).

In contrast, studies that suggest a negative CSR–CFP relationship argue that CSR activities may distract managerial attention and draw resources away from the firm's core business, because managers cannot balance social and financial performance improvement at the same time (Klassen and Whybark, 1999). Schreck (2011) finds no relationship between CSR and CFP. In addition, an asymmetric relationship (Jayachandran et al., 2013) and a U-shaped relationship (Barnett and Salomon, 2012) have been found.

Although the process of exploring empirical relationships is of vital importance for enhancing the understanding and the awareness of CSR, there is still debate and controversy surrounding the ways in which CSR influences CFP (Luo et al., 2015). Given the omitted variable bias (McWilliams and Siegel, 2000), the CSR–CFP relationship is complex and is perhaps more than a direct causal relationship (Margolis and Walsh, 2003). Grewatsch and Kleindienst (2017), who reviewed 32 prominent studies, conclude that the CSR–CFP relationship should be investigated from a contingency perspective. Thus, it is necessary to specify CSR activities and to investigate the mechanism within a specific context to gain additional evidence about the CSR–CFP relationship and to identify practical ways to balance societal concerns and firms' profit-generating activities (Hull and Rothenberg, 2008).

Corporate Social Responsibility Heterogeneity

The stakeholder concept is an umbrella term for strategic management (Freeman, 1984). As Freeman's metaphor goes, the firm is the hub of a wheel and its stakeholders are at the ends of the spokes around the wheel. Stakeholders who can affect or are affected by the achievement of a firm's purpose (Freeman, 1984) are bound tightly with the firm to achieve a better and more equitable society.

However, the stakeholder concept is a general concept that can be classified into various organizational stakeholder categories. The earliest stakeholder differentiation can be traced back to the period of the depression of the 1930s, for which four main stakeholder groups—shareholders, employees, customers, and the public—have been identified (Preston and Sapienza, 1990). Similarly, shareholders, employees, customers, and managers are included in the strictly business stakeholder group (Clarkson, 1995). Some regular stakeholders, for instance, shareholders, consumers, employees, the community, unions, competitors, suppliers, the government, and the mass media, have also been identified (Freeman, 1984; Sirgy, 2002; Tang and Tang, 2016). In addition, stakeholders are grouped into internal stakeholders (e.g., employees, and business units), lateral stakeholders (e.g., competitors, and the government) (Sirgy, 2002), and external stakeholders (e.g., community, and mass media) (Sirgy, 2002; Tang and Tang, 2018) according to whether they have the

same claims and interests, and by the research-specific context. However, the stakeholder groups categorized into primary and secondary stakeholders by Freeman (1984) are more widely discussed (Goodpaster, 1991; Clarkson, 1995; Godfrey et al., 2009). The term primary stakeholders refers to those who possess both the power and the urgency to press their legitimate claims on firms, whereas the term secondary stakeholders refers to those who also have legitimate claims but lack the urgency and the power to enforce their claims (Mitchell et al., 1997; Godfrey et al., 2009). The primary and the secondary stakeholders are also called strategic and moral stakeholders, respectively (Goodpaster, 1991). In a similar vein, Mattingly and Berman (2006) are the first to differentiate CSR activities into TCSR and ICSR, which are aimed at firms' primary and secondary stakeholders, respectively. Godfrey et al. (2009) maintain the idea that CSR includes heterogeneous actions aimed at the different stakeholder recipients of CSR behaviors, and they too classify CSR into TCSR and ICSR.

In line with this literature, we classify CSR into TCSR and ICSR. In our analysis, TCSR is targeted at firms' primary stakeholders, who are essential to business operations and can make legitimate claims on firms since they have both the urgency and the power to enforce those claims. ICSR refers to actions oriented toward secondary stakeholders, who lack the power and the urgency to lodge a claim for CSR activities.

HYPOTHESES DEVELOPMENT

Corporate Social Responsibility Heterogeneity and Financial Performance

Given the classification in the previous section, we hold the view that heterogeneous CSR activities may influence CFP through different mechanisms. First, we expect that TCSR is positively associated with CFP. Examples of TCSR activities include improving firms' product quality, employee welfare, or corporate governance, which are somehow a part of firms' normal operational activities that they undertake toward enhancing profitability (Godfrey et al., 2009). TCSR activities involve primary stakeholders, such as customers, creditors, and shareholders. Primary stakeholders can exert strong influence on the firm's operations because their power is utilitarian, coercive, and normative (Mitchell et al., 1997). For example, shareholders can enforce or incentivize management to act in their best interests through management contracts that are decided by the board of directors. Creditors can share information on the creditworthiness of firms, which influences the future financial performance of firms. The exchange capitals of firms are generated by effectively and immediately reacting to the legitimate and urgent claims of primary stakeholders on the firms (Chang et al., 2014). The exchange capitals are reflected in the explicit contracts or the direct exchanges between firms and their stakeholders, such as attracting more high-quality employees, selling more products, reducing material costs, or acquiring more investments (Van der Laan et al., 2008). Therefore, we argue that because primary stakeholders can reward a firm directly by providing financial benefit in exchange for the firm addressing

their legitimate and urgent claims, CFP will increase as the firm builds a good relationship with these stakeholders through TCSR activities. Thus, our first hypothesis is as follows:

H1: TCSR is positively related to CFP.

Second, we expect that ICSR is also positively related to CFP. ICSR is associated with the legitimate claims by secondary stakeholders who are not directly involved in the firms' operations. ICSR activities include charitable donations and environmental protection activities, which do not align with firms' profit-making interests and are thus unlikely to generate short-term exchange capital to promote CFP, unlike TCSR (Godfrey et al., 2009). Instead, ICSR can increase CFP by creating intangible value, such as a favorable firm reputation.

ICSR allows firms to build a reputation for caring about the well-being of others (Du et al., 2013). Although the reputation *per se* has no cash value, it can generate economic value by influencing the decision-making of these firms' stakeholders because they may perceive that they will also be treated kindly by these firms and thus tend to make decisions that are favorable for the firms. Thus, ICSR activities have been found to improve employee commitment (Brammer and Millington, 2005), firms' attractiveness to high-quality employees (Jones et al., 2014), and customer satisfaction with the brand (Lee et al., 2009). Consequently, CFP will increase with the increase in productivity and sales. Thus, our second hypothesis is as follows:

H2: ICSR is positively related to CFP

Technological Innovation

The knowledge-based view sheds light on the importance of knowledge in firms. The knowledge that is created, stored, and exploited within firms can be regarded as an important strategic resource to drive business development (Grant, 1996). Hakanson (2010) argues that as social entities, firms should pay more attention to their in-house knowledge storage and application, which are the determinants for the survival and the future development of firms.

The acquisition and application of firm knowledge, in the form of technological innovation, can improve CFP because technological innovation facilitates product and process renewal, which, in turn, improves productivity (McWilliams and Siegel, 2000). Technological innovation, as a part of firms' core capabilities, also allows firms to meet dynamic market requirements by developing products of superior quality and thus improve their profitability (Cassiman and Veugelers, 2006).

Meanwhile, according to the knowledge-based view, technological innovation can be promoted by stakeholder-oriented CSR activities (Luo and Du, 2015). Favorable stakeholder relationships boost firms' access to valuable information (Harrison et al., 2010; Desai, 2018). Effective knowledge transformation and mutual learning with stakeholders facilitate knowledge recombination and the access to resources needed for firms' innovation success (Jiang et al., 2020).

Taken together, we argue that technological innovation can be a key channel for CSR to create business value. Stakeholders are more likely to share their knowledge with firms who broaden and

deepen their relationships with the stakeholders through CSR engagement (Luo and Du, 2015). Compared with the existing knowledge of firms, the incremental knowledge they can acquire from stakeholders is quite novel. This novel knowledge as well as the resources and the support from stakeholders facilitates innovation and thus ultimately improves CFP (Jiang et al., 2020).

Moreover, Hull and Rothenberg (2008) highlight that heterogeneous CSR activities may lead to different CSR–CFP relationships, and the interactions between differentiated CSR activities and technological innovation can also vary. Therefore, it is worth exploring the CSR–CFP relationship according to the different mechanisms between CSR heterogeneity and technological innovation. In this study, we deepen our analysis by identifying the comprehensive relationship between CSR heterogeneity, technological innovation, and CFP. In general, although we infer that TCSR and ICSR activities may both improve CFP, TCSR and ICSR activities play different roles in driving technological innovation and CFP. Specifically, we predict that the mediating effect of technological innovation in the CSR–CFP relationship can be valid only when firms care for their primary stakeholders; that is, technological innovation mediates only the TCSR–CFP relationship and not the ICSR–CSP relationship. TCSR activities target the primary stakeholders, whereas ICSR activities target the secondary ones. Unlike secondary stakeholders, primary stakeholders can involve themselves in firms' economic transactions directly, and hence, their claims are more authoritative, legitimate, and urgent than those of the secondary stakeholders. Moreover, firms find it easier to build extensive and close networks with their primary stakeholders. Knowledge exchanges are thus more likely to be conducted in the interactions between firms and their primary stakeholders. As Thompson and Heron (2006) indicate, the relationships between firms and their primary stakeholders can be regarded as a certain relational capital, and the quality of this capital significantly affects firms' innovative abilities. By contrast, the secondary stakeholders' claims on firms always lack adequate support, because they hardly contribute any human capital or other valuable resources to firms but lead the firms to bear the risks in business operations alone (Mitchell et al., 1997). Hence, it is difficult for a firm to establish stable relationships with its secondary stakeholders, and the firm cannot foster technological innovation through knowledge exchange with them. Therefore, we propose that TCSR and ICSR can influence CFP differently:

H3: Technological innovation mediates the relationship between TCSR and CFP; that is, TCSR improves CFP through technological innovation.

H4: Technological innovation does not mediate the relationship between ICSR and CFP; that is, ICSR cannot improve CFP through technological innovation.

Advertising Intensity

Advertising, which is a strategic marketing lever and a market-based maker of intangible assets, is widely applied in business competition (Luo and Bhattacharya, 2009). The term advertising intensity refers to the total advertising expenditure relative to a firm's overall resources (Huang and Wei, 2012). Advertising

intensity provides a firm-specific context in examining the CSR–CFP relationship (McWilliams and Siegel, 2000). First, more effective advertising tactics and more advertising expenditure improve firm product differentiation (Bain, 1956). Incumbent firms can take advantage of advertising to establish and maintain a monopoly and thus erect competitive barriers and create competitiveness in business, which helps these firms to overcome potential risks in competing with new entrants (McGee, 1988). For new entrants, increased advertising investments can assist them to offset a disadvantage, namely, that the incumbent firms have already gained brand recognition among customers (Robinson and McDougall, 2001). Second, advertising intensity leads to a mitigation of information asymmetry (Rahman et al., 2017). Sufficient product information facilitates customer decision-making as regards purchasing those products (Nelson, 1991). Advertising is used to implement a competitive strategy against the firm's competitors. Advertising is a means of business competitive strategy among firm competitors (Scherer and Ross, 1990) because firms can use advertising not only to promote products and services but also to persuade customers that the advertised product is superior to its counterparts. A high level of advertising investment by a firm makes it easier for customers to obtain a unique image of this firm, which effectively mitigates reputation asymmetries between firms and their target customers (Shamsie, 2003). In addition, advertising can increase the potential demand for firm products by reducing the search costs of those latent customers; thus, advertising is a critical tool in gathering externality (Stahl, 1982).

CSR makes an impact by delivering the information that is expected to differentiate firms upward from their competitors (Schuler and Cording, 2006; Mackey et al., 2007). For example, customers are more willing to purchase products from socially reputable firms (Rahman et al., 2017) because CSR information highlights firm' organization-based self-esteem and creates positive moral capital. Advertising intensity can significantly increase the overall amount of information available to stakeholders, which may either positively or negatively impress them (Servaes and Tamayo, 2013). Taken together, we argue that CSR promotes technological innovation by impressing stakeholders with positive information, whereas the information from other sources, such as advertising, may positively or negatively moderate the impact of CSR-related information (Schuler and Cording, 2006).

In line with the knowledge-based view, one possible inference is that advertising intensity and TCSR have a synergistic effect in the relationship between TCSR and technological innovation. Advertising intensity may strengthen the positive relationship between TCSR and technological innovation because a good reputation generated from high advertising intensity strengthens knowledge sharing between primary stakeholders and firms, and, in turn, improves firms' technological innovation.

However, there may be a substitutional relationship between advertising intensity and TCSR in that advertising intensity may weaken the positive relationship between TCSR and technological innovation. Advertising significantly influences the accumulation process of firm reputation and brand loyalty. The high uncertainty, high asset specificity, and high sunk costs of the

process exacerbate the significant constraints, which are caused by scale economy, resource erosion, and time compression diseconomies, on knowledge acquisition through CSR activities. For example, offensive advertising may impress stakeholders negatively, or too much advertising may distract stakeholder attention from the firm's CSR-related information. Therefore, we develop two competing hypotheses:

H5a: There is a synergistic interaction between advertising intensity and TCSR. Specifically, the higher the advertising intensity is, the stronger is the positive impact on TCSR and technological innovation relationship.

H5b: There is a substitutional interaction between advertising intensity and TCSR. Specifically, the higher the advertising intensity is, the weaker is the positive impact on TCSR and technological innovation relationship.

As discussed thus far and as shown in **Figure 1**, we assume that technological innovation mediates the TCSR–CFP relationship and that advertising intensity strengthens or weakens the impact of TCSR on technological innovation. According to these hypotheses, we further infer that the higher the advertising intensity is, the stronger (or weaker) is the indirect impact on the TCSR–CFP relationship through technological innovation; that is, when the advertising intensity increases, the mediating impact on technological innovation in the TCSR–CFP relationship is stronger (or weaker). Thus, we develop two competing hypotheses as follows:

H6a: The higher the advertising intensity is, the stronger is the mediating effect of technological innovation in the TCSR–CFP relationship.

H6b: The higher the advertising intensity is, the weaker is the mediating effect of technological innovation in the TCSR–CFP relationship.

RESEARCH DESIGN

The overarching goal of our research is to reveal the mechanism through which CSR affects CFP. The regression model we adopt to examine our primary hypothesis about the association between CSR and CFP is as follows:

$$TQ_t = \beta_0 + \beta_1 TCSR_t (ICSR_t) + \beta_2 Controls_t + \varepsilon_t \quad (1)$$

The dependent variable of our study is CFP. In this study, we measure CFP using the long-term financial performance of firms (i.e., Tobin's Q). The accounting measurements of CFP, such as earnings or returns on asset, focus on retrospective short-term performance, and managers are likely to manipulate those accounting numbers through their discretion in accounting policies (Hillman and Keim, 2001). In contrast, Tobin's Q, which is a proxy for firm valuation, can more effectively measure CFP in the long run because the incremental value of a firm does not only present its current financial position but also reflects the positive reactions of the financial market on the prospects of the firm's intangible assets (Dowell et al., 2000). Therefore, we follow Surroca et al. (2010) to use Tobin's Q as the proxy of CFP.

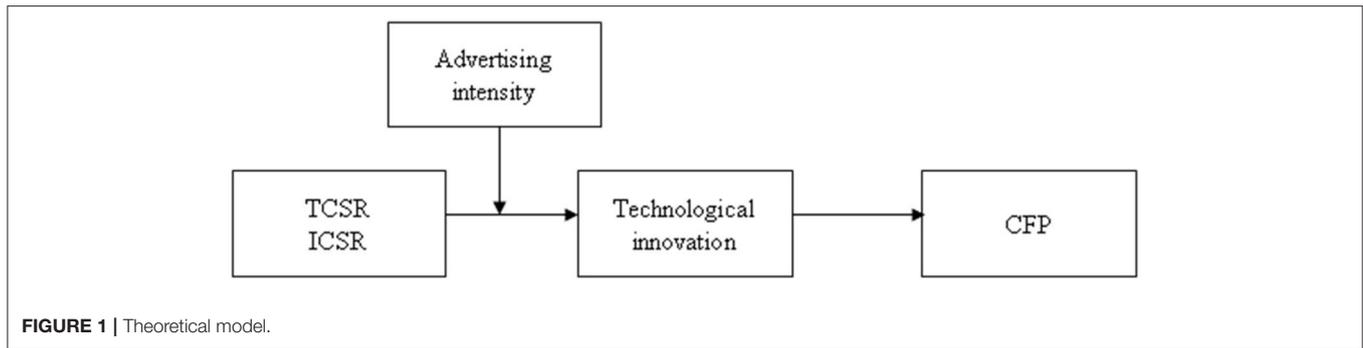


FIGURE 1 | Theoretical model.

Given the difficulty in obtaining data on the replacement value of assets, we measure Tobin's Q (TQ_t) as the ratio of market value to total assets, computed as the number of outstanding shares multiplied by the closing price at the end of the fiscal year, divided by total assets.

Then, to assess the firms' CSR performance, we use the Reactive–Defensive–Accommodative–Proactive Scale developed by Clarkson (1995) and the stakeholder theory, to construct a model with seven groups of the related stakeholders that benefit from firms' CSR behaviors: creditors, consumers, shareholders, employees, suppliers, the government, and society. For each group, we adopt one or two variables as proxies to conduct a factor analysis. To be more specific, we use the current ratio (CR_t), measured as current assets divided by current liabilities, and the inverse of the leverage ratio (LEV_t), measured as total assets divided by total liabilities (times negative one) as proxy for the responsibilities taken on for creditors, because a high level of liability is often associated with a high default risk (Cathcart et al., 2020). We use the growth rate of operational expenses and sales revenues ($CSGR_t$ and IRR_t) as proxy for responsibilities taken on consumers, where managing operation expenses and sales revenues of firms efficiently can lead customers to obtain value at a lower cost (Chun and Ovchinnikov, 2019). We use the earnings per share (EPS_t), measured as the net profit divided by the number of outstanding shares, and the net asset per share ($NAPS_t$), measured as net assets divided by the number of outstanding shares, as proxy for responsibilities taken on shareholders because these measures indicate the actual value, rather than the market price of the shares held by shareholders. We use employee benefits (EBL_t), measured as cash paid to (for) employees scaled by sales revenue, as proxy for responsibilities taken by employees. We use operation expenses divided by accounts payables to measure the accounts payable turnover rate ($APTR_t$) as the proxy for responsibilities taken on suppliers because a high level of accounts payable leads to high risks and uncertainty in the cashflow of suppliers (Nam and Uchida, 2019). Considering that the government always has to handle the serious problem of unemployment and tax is an essential source of government revenue, we use jobs created (ER_t , measured as the number of employees, scaled by net assets) and tax responsibility (ATR_t , measured as tax paid minus tax rebates received, scaled by net assets) as proxy for responsibilities taken on by the government. Last, we use the expenditure on donations (DIR_t)

as proxy for the responsibilities taken by society because the donation is a channel for firms to help people in society who experience poverty and natural disasters (Wang et al., 2015). To address the concerns about the skewed distribution of variables (Martikainen et al., 1995) and multicollinearity, we standardize the variables included before we conduct factor analysis.

Table 1 reports the outcome of factor analysis. Panel A presents the results of the Kaiser–Meyer–Olkin and Bartlett's tests. The sampling adequacy is 0.527 (significance = 0.000 < 0.05), which is higher than 0.5, showing that factor analysis is appropriate for our model. We then adopt the principal component analysis method to extract seven components. Panel B presents the total variance explained by each component. The total accumulative variance contribution after rotation is 91.376%, which implies the components extracted cover the overall information well. We compute the weight of each component as its variance contribution, divided by the total accumulative variance contribution (91.376%). Further, Panel C presents the rotated component matrix. We define the component proxying each group based on its highest factor loadings. For example, CR_t and LEV_t have the highest two factor loadings in component 1, which implies the score of component 1 measures the performance of CSR regarding creditors. Accordingly, the scores of component 2 to component 7 measure the performance of CSR regarding consumers, shareholders, the government, employees, society, and suppliers. Last, following Mattingly and Berman (2006) and Godfrey et al. (2009), we extract data for the score of each component and define institutional CSR ($ICSR_t$) as the weighted score of component 6 (for society), and technical CSR ($TCSR_t$) as the weighted sum of the remaining six components' scores.

In addition to the variables for CFP and CSR performance, our model includes firm size ($SIZE_t$), firm age (AGE_t), state ownership ($STATE_t$), and the specific characteristics (IT_t) of the internet technology (IT) industry (i.e., a significant level of intangible assets) as our control variables. Further, large firms have more resources to pursue long-term benefits (Akram et al., 2020). Hence, we measure $SIZE_t$ as the natural logarithm of total assets. Next, mature firms are more experienced in seeking additional investment opportunities, such as CSR activities, to promote their valuation (Wang et al., 2015). Therefore, we measure AGE_t as the time gap between the current year and the foundation year of the firm. Moreover, state-owned

TABLE 1 | Factor analysis: measuring firm CSR performance.

Panel A KMO and Bartlett's tests						
Kaiser-Meyer-Olkin measure of sampling adequacy				Sampling adequacy	0.527	
Bartlett's test of sphericity				Approx. chi-square	56884.995	
				df	55.000	
				Sig.	0.000	

	Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
Panel B total variance explained						
1	2.241	20.369	20.369	1.929	17.532	17.532
2	1.928	17.523	37.892	1.812	16.476	34.008
3	1.576	14.326	52.219	1.727	15.697	49.704
4	1.409	12.811	65.029	1.583	14.392	64.096
5	1.001	9.096	74.125	1.001	9.098	73.194
6	1.000	9.086	83.211	1.000	9.091	82.285
7	0.898	8.165	91.376	1.000	9.091	91.376

	1	2	3	4	5	6	7
Panel C rotated component matrix							
CR_t	0.974	-0.007	0.086	-0.016	0.061	-0.003	0.005
LEV_t	0.972	-0.010	0.087	-0.025	0.078	-0.004	0.002
IRR_t	-0.006	0.949	0.070	-0.001	-0.002	0.000	0.000
$CSGR_t$	-0.011	0.948	0.079	-0.001	-0.022	-0.001	0.000
EPS_t	0.034	0.053	0.929	0.000	-0.056	0.004	-0.007
$NAPS_t$	0.135	0.096	0.914	-0.020	0.004	-0.003	0.002
EBL_t	0.119	-0.021	-0.048	0.016	0.989	0.002	0.001
$APTR_t$	0.006	0.000	-0.005	0.001	0.001	0.000	1.000
ER_t	-0.017	0.005	-0.016	0.888	0.074	-0.004	-0.001
ATR_t	-0.019	-0.007	-0.002	0.891	-0.057	0.005	0.002
DIR_t	-0.005	-0.001	0.001	0.001	0.002	1.000	0.000

Bold values indicate the highest factor loading of each variable.

firms often underperform in financial markets because of their less effective corporate governance (Lazzarini and Musacchio, 2018). Hence, we compute $STATE_t$ as the number of shares held by the state, divided by the number of total shares. Last, because IT firms are often better priced in the financial market because of their valuable intangible assets (Banker et al., 2019), we create an indicator for the internet technology industry classified based on the *Guidance for Industry Classification of Listed Companies* (2012 revised edition) of the China Securities Regulatory Commission.

To examine the mediating role of innovation, we adopt a regression model for the relationship between CSR performance and innovation. We measure technological innovation with R&D spending ($R\&D_t$), measured as R&D expenses scaled by total assets. We use Models (1), (2), and (3) to jointly examine whether firms' CSR performance influences their CFP by affecting technological innovation:

$$R\&D_t = \beta_0 + \beta_1 TCSR_t (ICSR_t) + \beta_3 Controls_t + \varepsilon_t \quad (2)$$

$$TQ_t = \beta_0 + \beta_1 R\&D_t + \beta_2 TCSR_t (ICSR_t) + \beta_3 Controls_t + \varepsilon_t \quad (3)$$

Last, we investigate whether the mediating effects of technological innovation are moderated by advertising intensity. We measure our moderating variable, ADI_t , as the sales expense, scaled by sales revenue. To address collinearity concerns, before we interact ADI_t with our variable of interest, $TCSR_t$, we decentralize the data for those two variables. We adopt a structural equation model, shown in Models (4) and (5), to test whether ADI_t moderates the mediation models of technological innovation:

$$R\&D_t = \beta_0 + \beta_1 TCSR_t + \beta_2 ADI_t + \beta_3 TCSR_t \times ADI_t + \beta_4 Controls_t + \varepsilon_t \quad (4)$$

$$TQ_t = \beta_0 + \beta_1 R\&D_t + \beta_2 TCSR_t + \beta_3 ADI_t + \beta_4 TCSR_t \times ADI_t + \beta_5 Controls_t + \varepsilon_t \quad (5)$$

EMPIRICAL RESULTS

Sample and Data

Our sample covers the firm-year observations listed in China's A-share market from 2007 to 2018. The starting year is 2007 because data on R&D expenses are available from this

TABLE 2 | Descriptive statistics, correlation matrix, and VIF analysis.

Variable	Mean	SD	Min	Median	Max					
Panel A descriptive statistics										
TQ_t	2.454	2.535	0.083	1.837	128.438					
$TCSR_t$	0.000	0.379	-4.609	-0.070	16.885					
$ICSR_t$	0.000	0.099	-0.033	-0.003	7.678					
$R\&D_t$	0.044	0.061	0.000	0.034	2.516					
AD_t	0.075	0.084	0.000	0.047	1.116					
$SIZE_t$	22.022	1.286	17.806	21.820	28.509					
AGE_t	2.717	0.394	0.693	21.820	3.932					
$STATE_t$	0.038	0.120	0.000	0.000	0.875					
IT_t	0.086	0.280	0.000	0.000	1.000					
CR_t	2.824	4.535	0.075	1.721	190.869					
LEV_t	3.835	4.666	0.125	2.517	132.956					
IRR_t	0.509	17.829	-0.949	0.120	1880.750					
$CSGR_t$	0.341	5.166	-0.894	0.128	317.029					
EPS_t	0.668	1.289	-11.055	0.384	31.387					
$NAPS_t$	8.587	8.943	-9.652	5.860	199.041					
EBL_t	0.034	0.025	-0.044	0.028	0.337					
$APTR_t$	23.015	1110.664	0.278	6.299	127301.600					
ER_t	0.000	0.000	0.000	0.000	0.001					
ATR_t	0.014	0.048	-2.050	0.010	2.429					
DIR_t	0.000	0.015	0.000	0.000	1.186					
	1	2	3	4	5	6	7	8	9	VIF
Panel B correlation matrix										
TQ_t	1.000									
$TCSR_t$	0.157	1.000								1.178
$ICSR_t$	-0.011	0.000	1.000							1.153
$R\&D_t$	0.211	0.213	-0.008	1.000						1.110
AD_t	0.180	0.155	0.008	0.183	1.000					1.087
$SIZE_t$	-0.423	-0.145	0.029	-0.195	-0.180	1.000				1.078
AGE_t	-0.042	-0.107	0.014	-0.089	-0.013	0.218	1.000			1.065
$STATE_t$	-0.069	0.034	0.008	-0.064	-0.091	0.162	-0.039	1.000		1.043
IT_t	0.181	0.129	-0.007	0.296	0.109	-0.138	-0.037	-0.038	1.000	1.001

year onward. In addition, we follow the prior literature and exclude firms from the financial industry because of the significant differences in their financial characteristics (Cho and Lee, 2019). We obtain all the data from the China Stock Market & Accounting Research Database. Thus, we obtain 13,384 firm-year observations for 2,552 unique firms.

Panel A of **Table 2** presents the summary statistics of all the variables included in our study. Overall, the market value of firms in our sample is around 2.454 times the book value of their total assets. Their TCSR performance scores range from -4.509 to 16.885, and their ICSR scores range from -0.003 to 7.678. On average, these firms spend 4.4% of their sales revenue on R&D, and 7.5% on advertising. The average firm age is approximately 3 years, the average state ownership is 3.8%, and 8.6% of the firms in the sample compete in the internet technology industry.

We report the correlation matrix and the results of the variance inflation factor (VIF) tests in Panel B. The correlation matrix shows that TCSR performance and technological innovation are positively related to Tobin's Q, which primarily supports our hypotheses on TCSR. In addition, ICSR negatively relates to Tobin's Q, which implies that the different types of CSR performance may have different effects on CFP. All the correlations are less than 0.500, and the VIF statistics for all variables are about 1, less than the recommended cut-off of 10 (Hair, 2009), which indicates that multicollinearity is not a serious issue in our empirical model.

Regression Results

To address how CSR performance, innovation, and CFP interact with each other, we first adopt the hierarchical regression method (Baron and Kenny, 1986) to run the regression models for the relationship between CSR and CFP, between CSR and

TABLE 3 | CSR performance and CFP: The mediating effects of innovation.

Dependent variable:	The effects of TCSR			The effects of ICSR		
	TQ (1)	R&D (2)	TQ (3)	TQ (4)	R&D (5)	TQ (6)
Panel A regression results						
$R\&D_t$			4.035*** (0.342)			4.566*** (0.339)
$TCSR_t$	0.600*** (0.053)	0.026*** (0.001)	0.495*** (0.053)			
$ICSR_t$				0.029 (0.198)	0.000 (0.005)	0.030 (0.196)
$SIZE_t$	-0.803*** (0.016)	-0.006*** (0.000)	-0.779*** (0.016)	-0.824*** (0.016)	-0.007*** (0.000)	-0.794*** (0.016)
AGE_t	0.389*** (0.051)	-0.006*** (0.001)	0.413*** (0.051)	0.346*** (0.051)	-0.008*** (0.001)	0.382*** (0.051)
$STATE_t$	0.023 (0.167)	-0.021*** (0.004)	0.110 (0.166)	0.127 (0.167)	-0.017*** (0.004)	0.204 (0.166)
IT_t	1.046*** (0.071)	0.056*** (0.002)	0.821*** (0.073)	1.136*** (0.071)	0.060*** (0.002)	0.864*** (0.073)
F-statistics	687.59***	433.78***	602.03***	655.40***	347.37***	583.82***
R ²	0.204	0.140	0.213	0.197	0.115	0.208
Adj.R ²	0.204	0.139	0.212	0.197	0.115	0.207
Panel B bootstrap: Sobel-Goodman mediation tests						
Indirect effects		0.105*** (0.031)			-0.001 (0.013)	
Direct effects		0.495*** (0.162)			0.030 (0.141)	
Replication		5,000			5,000	

The table presents the regression results of examinations on the relationship between CSR performance and financial performance, and the mediating effects of innovation on this relationship. Panel A presents the regression results. The results in Column 1 (4) reports the association among technological (institutional) CSR performance and financial performance; the results in Column 2 (5) reports the association among technological (institutional) CSR performance and R&D expenses; and the results in Column 3 (6) reports the mediating effects of R&D expenses on the association among technological (institutional) CSR performance and financial performance. Panel B presents the results of Sobel-Goodman mediation tests replicating 5000 times with bootstrap method. Detailed definitions of variables are reported in the **Appendix A**. Standard errors are reported in brackets. Significance at the 1% level is denoted by ***.

technological innovation, and between CSR and CFP, after controlling for technological innovation. Panel A of **Table 3** reports the regressions results for Models (1), (2), and (3), which examine the associations between CSR performance, technological innovation, and CFP, respectively. In Column (1), the estimated coefficient on $TCSR_t$ is positive and significant ($\beta = 0.600, p < 0.01$), which implies that the TCSR performance is positively related to CFP; thus, H1 is supported. In addition, we find that older firms and IT firms have a better valuation in the financial market, and state ownership does not influence CFP. The estimated coefficient on $TCSR_t$ in Column (2) is 0.026 ($p < 0.01$), suggesting that as firms perform better in TCSR, their spending on R&D increases. Older firms and state-owned firms are found to spend less on R&D than non-state-owned firms, whereas IT firms spend more on R&D than firms in other industries. In Column (3), the estimated coefficient on $R\&D_t$ is 4.035 ($p < 0.01$), which supports the positive impact of

innovation on promoting CFP. After controlling for the effects of $R\&D_t$, the estimated coefficient of $TCSR_t$ remains significant and positive ($\beta = 0.495, p < 0.01$), primarily showing that technological innovation plays a partial mediating role in the association between TCSR performance and CFP. Therefore, these results support H3.

Moreover, we adopt the bootstrap resampling method to test the mediating effects of technological innovation, which is suggested to have the strongest test power on mediation effects compared with all other methods, including the hierarchical regression method (MacKinnon et al., 2004). Panel B presents the results of Sobel-Goodman mediation tests replicated 5,000 times with the bootstrap resampling method. We find that while TCSR also positively affects CFP directly ($\beta = 0.495, p < 0.01$), it also has positive indirect effects on CFP through technological innovation ($\beta = 0.105, p < 0.01$). The results are consistent with our primary findings for H3.

By contrast, the estimated coefficients on $ICSR_t$ in Columns (4), (5), and (6) are not significant ($p > 0.10$), which together with the nonsignificant results of the bootstrap resampling test, imply that ICSR performance is not related to innovation spending or to CFP. The findings support H4 but do not support H2. A potential explanation is that unlike US firms, under the Chinese system, firms cannot extract direct financial benefits, such as tax benefits, through charitable donations, given that only about 3% of all the charity organizations in China are exempt from tax (Su and He, 2010).

Next, we examine whether the mediating effects of technological innovation are moderated by advertising intensity. **Table 4** reports the regression results of tests on the moderating effects of advertising intensity on the association between TCSR performance and technological innovation, and a structural equation for the relationships between TCSR, technological innovation as a mediator moderated by advertising intensity, and CFP. In Column (1), the results show that the interaction term of TCSR and technological innovation ($TCSR_t \times ADI_t$) positively relates to technological innovation spending ($\beta = 0.179$, $p < 0.01$), suggesting that advertising intensity has positive incremental effects on the positive impact of TCSR on technological innovation. The results support H5a but do not support H5b.

After uncovering the moderating effects of advertising intensity on the positive relationship between TCSR and technological innovation, we follow Edwards and Lambert (2007) and adopt a structural equation to test whether advertising intensity moderates the role of technological innovation as a mediator. In Column (2) of **Table 4**, the results for the first stage of the structural equation are consistent with our findings in Column (1), where the interaction term is positively associated with technological innovation ($\beta = 0.242$, $p < 0.01$). At the second stage of the structural equation, the estimated coefficient of interaction in Column (3) is not significant ($\beta = 0.519$, $p > 0.10$), which implies that advertising intensity does not moderate the direct effects of TCSR on CFP. Thus, the results of the two stages of the structural equation jointly support H6a that advertising intensity positively moderates the mediating role of technological innovation in the relationship between TCSR and CFP. Last, we replicate the structural equation 5,000 times using the bootstrap resampling method. The results show that on taking the mean minus one standard deviation, the mean, and the mean plus one standard deviation of sales expenses scaled by sales revenue as the value of ADI_t , the mediating effects of technological innovation show a trend of growth from 0.225 ($p < 0.01$) to 0.503 ($p < 0.01$), which is consistent with our primary findings for H6a.

CONCLUSION AND DISCUSSION

Our study, which combines the stakeholder theory and the knowledge-based view, uncovers that technological innovation is the key mechanism bridging CSR heterogeneity and CFP. Using the main effect model, we also prove that advertising intensity, as a critical market differentiation strategy, plays the role of

TABLE 4 | TCSR and CFP: The mediating effects of innovation moderated by advertising.

Dependent variable:	R&D (1)	R&D (2)	TQ (3)
Panel A regression results			
$R\&D_t$			6.797*** (0.359)
$TCSR_t$	0.027*** (0.001)	0.036*** (0.001)	0.687*** (0.060)
ADI_t	0.059*** (0.006)	0.082*** (0.006)	3.980*** (0.270)
$TCSR_t \times ADI_t$	0.179*** (0.017)	0.242*** (0.018)	0.519 (0.757)
$SIZE_t$	-0.005*** (0.000)		
AGE_t	-0.006*** (0.001)		
$STATE_t$	-0.017*** (0.004)		
IT_t	0.052*** (0.002)		
F-statistics	357.54***	407.58***	191.14***
R ²	0.158	0.084	0.054
Adj.R ²	0.157	0.083	0.054

Panel B bootstrap: Moderated mediation tests based on structural equation model

$R\&D_{mean-sd}$	0.225*** (0.052)
$R\&D_{mean}$	0.364*** (0.068)
$R\&D_{mean+sd}$	0.503*** (0.098)
Replication	5,000

The table presents the regression results of examinations on the moderating effects of advertising intensity on the mediating role of innovation playing in the relationship between TCSR performance and financial performance. Panel A presents the regression results. The results in Column 1 reports the association among TCSR performance and R&D expenses moderated by advertising expenses, including the control variables; the results in Column 2 reports the first stage of structural equation model for the association among TCSR performance and R&D expenses moderated by advertising expenses; and the results in Column 3 reports the second stage of structural equation model for the mediating effects of R&D expenses moderated by advertising expenses, on the association among TCSR performance and financial performance. Panel B presents the results of structural equation replicating 5000 times with bootstrap method for R&D expenses with the value of mean minus standard deviation, mean, and mean plus standard deviation, respectively. Detailed definitions of variables are reported in the **Appendix A**. Standard errors are reported in brackets. Significance at the 1% level is denoted by ***.

moderator in the entire relationship between CSR heterogeneity and CFP. Therefore, we reach the following conclusions.

First, by considering the various stakeholder recipients of firms, we differentiate CSR activities into TCSR and ICSR, which refer to socially responsible initiatives that target the primary stakeholders and the secondary stakeholders of a firm, respectively. We argue that TCSR can enhance CFP significantly

whereas ICSR engagement may not lead to CFP improvement. TCSR can drive profit gaining through firms' technological innovation; that is, the mediating effect of technological innovation can be valid only in the TCSR–CFP relationship and not in the ICSR–CFP relationship. These results on the nonsignificant impact on the ICSR–CFP relationship may lead to the reconsideration of the relationship between charitable giving and corporate financial goals. Charitable behaviors reflect the “concern-for-others” corporate philosophy, and the purpose of firms' kindness is to acquire and accumulate reputational capital and boost corporate prosperity. Reputational capital is of great value to firms for business development—for instance, to help alleviate resource restraints, create differentiated advantages, improve customer loyalty, and reduce the employee turnover rate. From the other side, philanthropic actions may impair CFP in light of the principal–agent relationship between the manager and the firm. This effect occurs because the firm's generosity may improve only its managers' reputation or translate to their private social capital, and these social advantages generated by charitable behaviors would not be passed on to the firm level and facilitate CFP (Haley, 1991). In this study, our results show that there is a positive but nonsignificant correlation between ICSR and CFP, which may be attributable to the latent negative impact on the correlation between charitable donation behaviors and CFP. Moreover, we argue that it is difficult for firms to apply ICSR strategies directly to their core business competencies, and the result is consistent with the views of Madsen and Rodgers (2015). These authors also suggest that CSR activities targeted to the secondary stakeholders cannot contribute directly to their welfare, and thus, firms cannot obtain any immediate benefits and rewards from these stakeholders.

Second, we proposed two competing hypotheses to test whether the relationship between advertising intensity and TCSR is synergistic or substitutional. We conclude that there is a synergistic interaction between advertising intensity and TCSR, which means advertising can strengthen the linkage between TCSR and technological innovation. This finding confirms the view that a good reputation generated from high advertising intensity reinforces the knowledge exchange between the primary stakeholders and corporations, and consequently drives technological innovation improvement. Moreover, this finding further illustrates that advertising intensity and TCSR have different roles in ensuring product differentiation from competitors and reducing the information asymmetry between goods and customers. In other words, firms' decision-makers need not regard advertising as the only key to creating product varieties and decreasing information asymmetry, and TCSR is another efficient approach to help build technology innovation capabilities. Furthermore, from a long-term perspective, the synergetic relationship between TCSR and advertising intensity emphasizes the importance of prioritizing stakeholders' interests and maintaining stakeholder relationships for long-term business growth. Otherwise, managers would blindly focus on short-term profits and pay too much attention to market strategies such that they myopically overlook stakeholders' requirements.

Third, advertising intensity also moderates the mediated relationship of TCSR with CFP such that higher advertising

intensity strengthens the mediating effect of technological innovation on the TCSR–CFP relationship. This finding reveals that firms with large advertising investments can maximize their profits not only by relying on the customer loyalty generated through their advertising strategy, but also by focusing on their main value creation mechanism in business. This study recommends that managers in these firms should avoid depending on high advertising intensity and indulging in earning quick profits. Therefore, firms with advertising advantages should be outstandingly competent in the aspects of product prices, product quality, and innovation. Only their outperformance in both advertising and technological innovation will enable businesses to thrive in a sustainable manner.

IMPLICATIONS AND LIMITATIONS

This study has several theoretical and practical implications. Theoretically, first, the theoretical model incorporates the knowledge-based view into the stakeholder theory, which provides the causal relationship between CSR and CFP explained by the stakeholder theory with additional evidence that superior CSR performance can enhance CFP by promoting technological innovation. Second, this study responds to the calls in the literature for further research to identify the mechanism underlying the CSR–CFP relationship in the specific context. In this study, we include technological innovation and advertising intensity as contingent factors in examining the CSR–CFP relationship. Third, we distinguish CSR into TCSR and ICSR activities, which echoes the prior suggestion that since CSR involves heterogeneous activities, the different factors in CSR should not be integrated into a single variable.

This study also has some managerial implications. First, we provide robust evidence that TCSR can help achieve firms' financial goals through technological innovation, which could be the clue for firms' decision-makers to integrate TCSR strategies with the core business competency for profit maximization. In a rebuttal to those who have suggested that participating in CSR activities is a diversion of limited resources and managerial efforts from the core business, this study recommends that investment in TCSR activities should be regarded as a valuable capital investment rather than an operational cost. Second, combining the CSR strategy with other traditional core strategies, such as technological innovation and advertising market strategy in order to impel innovation strategy, would result in significant efficiency. In addition, given the synergistic interaction between TCSR and advertising intensity, to prevent a shortsighted focus on profit-making, firms with high advertising intensity should concentrate on building an innovative and responsibility-oriented corporate culture. Meanwhile, efforts should be made to strengthen the synergistic effect of the two strategies in promoting technological innovation, which would allow firms to run their operations in a benign development mode. Further, an aspect that cannot be neglected is the supportive policies provided by institutions. We suggest the government should encourage firms to participate in CSR activities and become

involved in creative activities with adequate corresponding policy assurance. Last, from the knowledge-based view, firms need to raise awareness of CSR among their different stakeholder groups and enhance knowledge exchange in their knowledge networks through their CSR communication with their stakeholders (or stakeholder groups).

This study does have some limitations. First, it relies entirely on secondary data, and although archival databases are objective and reliable, these do not provide access to the perceptions and other subjective factors that influence managerial decisions. Second, given that R&D expenditure is a voluntary disclosure rather than mandatory in the annual reports of listed firms in China, we cannot obtain R&D information for every listed company, which may lead to some deviations. Third, we fail to disentangle the technological innovation concept into different dimensions. Thus, in a future study, we intend to consider different types of innovation, such as exploratory innovation and exploitative innovation to conduct a more comprehensive, in-depth analysis.

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DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: China Stock Market & Accounting Research Database (CSMAR), available at <https://www.gtarsc.com>.

AUTHOR CONTRIBUTIONS

MN presented the idea and wrote the theoretical part of the manuscript. WM built the structure of the article, wrote empirical analysis of the manuscript, and revamped the parts requested during peer review throughout the whole manuscript. Both authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by National Natural Science Foundation of China (71732004).

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APPENDIX I

Table A1 | Variables definitions.

Variable	Definition
$TCSR_t$	Technical CSR performance, measured as the weighted sum of scores of components proxying responsibilities to creditors, consumers, shareholders, employees, suppliers, and government, extracted from factor analysis. Details are introduced in Section 3.2
$ICSR_t$	Institutional CSR performance, measured as the weighted score of the component proxying responsibilities to society. Details are introduced in Section 3.2
TQ_t	Tobin's Q, measured as the number of outstanding shares multiplies annual closing price, divided by total asset.
$R\&D_t$	R&D expense, scaled by sales revenue.
AD_t	Advertising level, measured as sales expenses scaled by sales revenue.
$SIZE_t$	Firm size, measured as the natural logarithm of total asset.
AGE_t	Firm age, measured as current year minus the foundation year of the firm.
$STATE_t$	State ownership, measured as the number of shares state held, divided by the number of total shares.
IT_t	Indicator variable, equals one if the firm competes in internet technology industry, classified based on the Guidance for Industry Classification of Listed Companies (2012 revised edition) of CSRC.

Variable	Related parties	Definition
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The variables used in factor analysis to compute CSR performance score

CR_t	Creditors	Current ratio, computed as current asset divided by current liability
LEV_t		Inverse of leverage ratio, computed as total asset divided by total liability
$CSGR_t$	Consumers	Growth rate of operation expense, computed as the changes in operation expense, divided by lagged operation expense.
IRR_t		Growth rate of sales revenue, computed as the changes in sales revenue, divided by lagged sales revenue.
EPS_t	Shareholders	Earnings per share, computed as net profit divided by the number of outstanding shares.
$NAPS_t$		Net asset per share, computed as net asset divided by the number of outstanding shares.
EBL_t	Employees	Employee benefits, measured as cash paid to employees and cash paid for employees, scaled by sales revenue.
$APTR_t$	Suppliers	Account payable turnover rate, computed as operation expenses, divided by account payable.
ER_t	Government	Jobs created, measured as the number of employees, scaled by net asset.
ATR_t		Tax responsibility, measured as tax paid minus Tax rebates received, scaled by net asset.
DIR_t	Society	Donations, scaled by sales revenue.



Corporate Co-Agglomeration and Green Economy Efficiency in China

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This paper uses panel OLS, IV, and system GMM methods to empirically study the effects of manufacturing and producer service corporate co-agglomeration on green economy efficiency (GEE) in China. Chinese panel data from 2000 to 2019 are collected to assess the GEE and co-agglomeration degrees. The regression results show that there is an “inverted U-shaped” relationship between co-agglomeration and GEE. However, regional heterogeneity is found in the effects of corporate co-agglomeration on GEE. The mediating analysis indicates that corporate co-agglomeration could increase GEE through business entrepreneurship and innovation entrepreneurship. Variables such as transportation infrastructure, human capital, foreign direct investment, and environmental regulations are also found to have an elevating effect on GEE, whereas local fiscal expenditure on environmental protection has little effect. The findings in this paper indicate that entrepreneurship plays an important role in the process of co-agglomeration impacting GEE which differs in different regions and thus provide references for corporate and regional sustainable development.

Keywords: corporate, co-agglomeration, green economy efficiency, manufacturing, producer services

OPEN ACCESS

Edited by:

Rui Xue,
Macquarie University, Australia

Reviewed by:

Longguang Yu,
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Economics, China
Xiaotong Yang,
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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 05 March 2022

Accepted: 18 May 2022

Published: 08 July 2022

Citation:

Zhu X, Zhang Y and Yang W (2022)
Corporate Co-Agglomeration and
Green Economy Efficiency in China.
Front. Psychol. 13:890214.
doi: 10.3389/fpsyg.2022.890214

INTRODUCTION

Agglomeration refers to the corporate geographical proximity, that is, the co-location of corporations (Marshall, 1916). Manufacturing enterprises that produce the same products and upstream and downstream enterprises that produce related products tend to be geographically co-located, which is known as co-agglomeration (Ellison and Glaeser, 1997). Studies have shown that the location of a producer services sector is a function of the manufacturing sector location, that is manufacturing and associated producer service corporations are more likely to be closely located because producer services is an important input sector in manufacturing (Andersson, 2006). Producer services are intermediate industries that can be used in the further production of goods and services (Greenfield, 1966). Unlike the traditional service industries, which are consumer-oriented, producer services are producer-oriented. It includes finance, insurance, business services, and other knowledge-intensive industries (Browning and Singelmann, 1975). Producer services can directly or indirectly provide intermediate services to the manufacturing production process and link the various stages of production.

Therefore, manufacturing and producer service corporate co-agglomeration can enhance the core competitiveness of the manufacturing industries, cultivate a modern industrial organization system, and achieve a high level of development (Wang et al., 2022a). Accordingly, the co-agglomeration in this paper refers to the corporate co-agglomeration of producer services and manufacturing.

Co-agglomeration generates externalities, such as lower production costs (Fan and Scott, 2003), improved infrastructure, the promotion of competition, knowledge spillovers, and technological innovation (Marshall, 1916; Jacobs, 1969; Krugman, 1991; Porter, 1998). Co-agglomeration, through the above-mentioned externalities, can lead to higher productivity, which can drive economic growth (Lanaspa et al., 2016; Klein and Crafts, 2020), enhance the emissions reduction effects, and reduce environmental pollution (Zhuang et al., 2021; Wang et al., 2022b).

However, the co-location of many firms in a region can also lead to problems, such as traffic congestion, rising production factor prices, and insufficient market carrying capacities (Henderson, 1986; Brakman et al., 1996), all of which might inhibit productivity (Paci and Usai, 2000; Sbergami, 2002). Co-agglomeration can also result in high resource consumption and emissions, which could pollute the environment (Pandey and Seto, 2015; Lu et al., 2021).

Entrepreneurship, one of the externalities of co-agglomeration (Kemper et al., 2011; Wu et al., 2021), can also influence economic growth and the ecological environment (Glaeser and Kerr, 2009). Entrepreneurs can make better use of social capital, build corporate social relationships and mobilize employees, improve corporate productivity, and drive economic growth (Dastourian et al., 2017; Lafuente et al., 2020). Entrepreneurs also encourage firms to take greater social responsibility (Ahmad et al., 2021; Wei et al., 2021). Consequently, when regulated by social responsibility, companies will seek to achieve advances in clean energy technologies, which in turn can reduce environmental pollution (Zeng and Zhao, 2009; Otsuka et al., 2014).

Overall, co-agglomeration has been found to be highly correlated with economic growth and ecological environment (Rosenthal and Strange, 2020); however, in China, the effects of co-agglomeration on the two are not clear and widely debated (Lin and Tan, 2019). Therefore, this paper uses green economy efficiency (GEE) to represent the economic and environmental outputs (Qian and Liu, 2013; Naseer et al., 2021) to empirically verify the relationship between co-agglomeration and GEE in China and whether entrepreneurship plays a role in it.

This paper makes two main contributions. First, in the process of co-agglomeration affecting GEE, the role of entrepreneurship is studied. We verify that co-agglomeration enhances entrepreneurship, which boosts GEE by deploying social capital and assuming social responsibility. This provides a supplement to the study of regional green economy development. Second, geographic heterogeneity is taken into consideration in this paper. We find that the effects of co-agglomeration on GEE differ in different regions, which provides practical implications for regions to adjust the level of co-agglomeration and enhance GEE according to local conditions.

The remainder of this paper is organized as follows. Section Literature Review reviews the relevant literature on the impacts of manufacturing and producer service co-agglomeration on GEE, Section Empirical Analysis details the empirical study and variables, data and models are introduced, Section Empirical

Results discusses the empirical results, assesses the regional heterogeneity, and analyzes the effects and mechanisms of co-agglomeration on GEE, and Section Conclusion gives the main conclusions.

LITERATURE REVIEW

Corporate Co-Agglomeration

Agglomeration, which is closely related to the development and evolution of industrial organizations, has been an important characteristic of economic development (Ellison et al., 2010; Chen and Chen, 2014). The essence of corporate co-agglomeration is the coordination of spatial locations and a geographic and spatial dimensional “synergetic clustering” (Jacobs et al., 2013; Gaubert, 2018). The co-agglomeration of corporates in manufacturing and producer services compresses the spatial industrial integration distances and allows for more interactive relationships between the two through mutual interaction and integration (Mansour and Kanso, 2017; Taghizadeh-Hesary et al., 2020).

Even though they have strong mutual needs, manufacturing and producer services can gradually become divided (Marshall, 1982). However, because producer services provide intermediate input factors, they have been increasingly integrated into manufacturing industries and all aspects of the manufacturing production chain (Lanaspa et al., 2016; Yang et al., 2018). This manufacturing and producer service co-agglomeration engenders closer cooperation and the product production process smoother. The industrial organization structure is also improved with the co-agglomeration of the two (Ganvir and Jain, 2021). Therefore, the corporate co-agglomeration between industries is a good way to build a new system of modern industrial organization, which benefits both economy and environment.

Green Economy Efficiency

Whereas, rapid economic growth has led to increased regional spatial agglomeration, it has also resulted in more severe urban environmental problems (Zhang and Qin, 2018). Therefore, to establish a better ecological civilization and ensure a harmonious coexistence between people and nature, economic development needs to shift to a growth pattern that integrates economic growth, environmental protection, and resource conservation, that is, the “green economy” (Lin and Tan, 2019). The term “green economy” was first proposed by Pearce (1996) and is defined as an “affordable economy” in which the pursuit of economic growth does not lead to ecological crises.

The green economy is an economy that considers both the needs of society and the needs of the environment. However, a suitable index is required to effectively study the “green economy.” Many methods have been suggested to express the green economy, with the GEE being one of the most popular, and have been widely used, as it considers both the desirable and undesirable production outputs (Sahoo and Tone, 2008; Mendelová, 2022) and comprehensively considers both the resource and environmental costs. Therefore, the GEE is chosen to assess the state of the green economy.

Co-Agglomeration and Green Economy Efficiency

The impact of co-agglomeration on GEE has been widely examined, but its exact effects remain controversial. There are three types of opinions on the co-agglomeration GEE relationship.

Some studies have found that manufacturing and producer service co-agglomeration can improve GEE (Ehrenfeld, 2003) in four main areas: economic growth efficiency, economic growth stability, economic structure optimization, and green development (Guo and Huang, 2020; Liu, 2021; Ren et al., 2021). Some scholars, however, have disagreed with these conclusions. They argue that industries sometimes agglomerate inefficiently and create problems such as insufficient resources and environmental carrying capacity, which have negative effects on GEE (Virkanen, 1998; Helsley and Strange, 2014; Huang, 2021). The third opinion type holds that the agglomeration impact on environmental pollution is diverse. Some studies have found that the impact of co-agglomeration on GEE has an “inverted U” curve (Wang and Sun, 2020; Ren et al., 2021), whereas others have found that the relationship between agglomeration and GEE was “U-shaped” (Yue et al., 2015; Zeng et al., 2021).

If the positive externality of co-agglomeration is greater than the negative externality, co-agglomeration behaves as promoting GEE, and vice versa, it behaves as inhibiting GEE. That is, the effect of co-agglomeration on GEE is related to the level of co-agglomeration, based on which, this study proposes the following hypothesis:

Hypothesis 1: The impact of corporate co-agglomeration on GEE is inverted U-shaped in China.

Co-agglomeration affects GEE through externalities, and one of the important externalities is that co-agglomeration promotes entrepreneurship, which influences economic growth and ecological environment by deploying social capital and assuming social responsibility (Omrane, 2015; Silvestri and Veltri, 2020).

Entrepreneurship is the sum of the entrepreneurs' abilities to identify potential opportunities, acquire resources, innovate, and implement actions that can drive enterprise development (Wennekers and Thurik, 1999). Agglomeration can promote entrepreneurship (Mason and Gos, 2014) because it provides entrepreneurs with the information needed to identify opportunities and establish social relationships (Audia and Rider, 2005; Kemper et al., 2011). Entrepreneurship enables companies to better deploy social capital, including trust, team effectiveness, and social relationships (Becchetti et al., 2022; Schlak, 2022). Entrepreneurial actions can improve mutual trust between members of the organization, the organizational actions become more efficient (Kacperska and Łukasiewicz, 2020; Sedrine et al., 2020). In addition, through their social network relationships, entrepreneurs can also overcome resource constraints and gain access to more resources and information (Bauernschuster et al., 2010), which leads to knowledge spillovers and collective learning between the agglomerated enterprises (Crespo et al., 2022), reduces the cost of technological innovation, and further improves productivity and boosts economic growth

(Xu et al., 2021). Entrepreneurship also enables enterprises to take greater social responsibility (Chen et al., 2021; Biggeri et al., 2022). Entrepreneurs are the shapers of corporate culture and the leaders of corporate development (Mudrack, 2007). A great entrepreneur can lead by, for example, influence corporate culture, guide enterprises to achieve sustainable development, raise awareness of environmental protection, and contribute to economic transformation and social development (Branco and Rodrigues, 2006). A rising sense of social responsibility influences corporate decisions and disciplines company behavior, which in turn can motivate clean energy technology innovation, reduce pollution emissions, and protect the environment (Agudelo et al., 2020). Based on this logic, the second hypothesis is proposed to analyze the role of entrepreneurship in the impact process of co-agglomeration on GEE.

Hypothesis 2: Co-agglomeration can promote GEE through its spillover effects on entrepreneurship.

EMPIRICAL ANALYSIS

Data Description

This paper selects 2000 to 2019 Chinese panel data¹ as the research samples. The original data for the variables are extracted from the National Bureau of Statistics of China, China Statistical Yearbooks, China Labor Statistical Yearbooks, Provincial statistical Yearbooks, CEIC China Premium Database. To ensure the accuracy of the empirical results and weaken the dimensional differences, foreign direct investment (fdi), environmental regulations (er), and local fiscal expenditure on environmental protection (efe) are logarithmized.

Variables Descriptions

Explained Variable: GEE

The GEE measures the overall output for both the economy and the environment and reflects green output environmental pollution costs. Specifically, the GEE measures the desirable output efficiency per unit of input costs and the environmental production process costs (Qian and Liu, 2013; Ohene-Asare and Turkson, 2019). This paper measures the GEE under constant scale conditions using the super-efficient SBM model (Tone, 2004; Lee, 2020), a method that appraises the relative efficiencies of multiple inputs and outputs (Kutty et al., 2022).

The measurement indicators are inputs, desirable outputs, and undesirable outputs, with the desirable outputs representing the desirable economic efficiencies, and the undesirable outputs representing the undesirable environmental efficiencies. The input factors are capital, labor, and energy inputs. The fixed asset investments, which are determined using the perpetual deposit method, are used to evaluate the capital stock and represent capital investment (Xie and Pan, 2011). The number of employees at the end of the year represents the labor, and the total energy consumption in each region is adopted to represent the energy input. The desirable output is the GDP in each

¹Tibet is not included because of the lack of data. Taiwan, Hong Kong, and Macao are excluded because their statistical systems differ from the mainland's.

region, and the undesirable output is the waste emissions. As most environmental pollution comes from the manufacturing sector, the undesirable outputs are represented by industrial wastewater, waste gas, and solid waste discharges, with the SO₂ industry emissions being used to indicate the industrial waste gas discharges.

Explanatory Variable: Co-Agglomeration Index for the Corporations in Manufacturing and Producer Services² Sector (Coaggl)

The co-agglomeration concept was proposed by Glaeser and Eillson. Based on an industrial geographic concentration measurement, Glaeser and Eillson constructed an E-G modified index to formulate a co-agglomeration index for two industries, which has consequently been widely used to assess co-agglomeration levels. In reference to the ideas proposed in Devereux et al. (2003) and Jiang and Xi (2014), this paper adopted the E-G correction index, which is calculated by incorporating the Herfindahl index and assigning weights, the formula for which is as follows:

$$r_{ij} = \frac{H_{ij} - (H_i \times w_i^2 + H_j \times w_j^2)}{1 - (w_i^2 + w_j^2)}$$

where w_i and w_j are the weight index, which is the proportion of employees in a single industry to the sum of employees in two industries, H_i , H_j , and H_{ij} , respectively, represent the geographic concentration formed by industry i , industry j , and two industries; the larger the value of r_{ij} , the higher the agglomeration degree between the industries.

The geographic concentration is generally expressed using the Herfindahl index, for which the employment data from the various regions are adopted for the calculation, the formula for which is as follows:

$$HHI = \sum_{k=1}^n S_k^2 - \frac{1}{n}$$

where S_k is the proportion of industrial employees in the entire region k , and n is the number of regions.

Control Variables

The first control variable is transportation infrastructure ($tinfr$) as convenient transportation can ease factor production constraints and increase productivity (Cedillo-Campos et al., 2022), for which the ratio of road kilometers to city area is used.

The second control variable is the industrial structure (is), which is measured based on the share of secondary sector output in total output. Generally speaking, the higher the secondary industry share, the more serious the pollution, and the greater the adverse effect on GEE (Muhammad et al., 2022).

²There is no specific statistical data for producer services. We refer to the Statistical Classification of producer services (2019) and the categories of Statistical Yearbook, and select transportation, warehousing and postal services, information transmission, software and information technology services, financial services, leasing and business services, scientific research and technical services, and real estate to represent producer services sector.

The third control variable is the human capital level (hc). The greater the human capital improvement, the more efficient the knowledge dissemination, which is conducive to GEE improvements (Aljuboori et al., 2021; Martinidis et al., 2021). Therefore, the average education per capita is chosen to represent the labor quality in each region.

The fourth control variable is foreign direct investment (fdi) as this can affect regional innovative development and improve environmental quality (He, 2005; Ali et al., 2022) or can have a “pollution haven” effect [it refers to the tendency of companies in the industry to establish themselves in countries or regions where environmental standards are relatively low] (List and Co, 1999; Nguyen, 2021).

The fifth control variable is environmental regulations (er). Implemented government policies and regulations affect the environmental impacts on GEE. Moderate regulations can stimulate innovation and increase GEE (Lanoie et al., 2008; Thiel et al., 2016); however, excessive regulations can increase enterprise costs, which is not conducive to GEE improvement (Leiter and Winner, 2010; Saltari and Travaglini, 2011). Therefore, the proportion of corporate investment in pollution treatment to GDP is selected to represent the environmental regulations indicator.

The sixth control variable is the local fiscal expenditure on environmental protection (efe). The government can improve the environment by increasing its fiscal expenditure on corporations, which may lower corporate costs and motivate enterprises to improve their GEE.

Research Design

To analyze the relationships between corporate co-agglomeration and GEE, a regression model with quadratic terms is established, as follows:

$$GEE_{it} = \beta_0 + \beta_1 Coaggl_{it} + \beta_2 Coaggl_{it}^2 + \beta_3 Control_{it} + \varepsilon_{it}$$

where GEE_{it} is the GEE in province i in year t , $Coaggl_{it}$ is the co-agglomeration index in province i in year t , $Coaggl_{it}^2$ is the quadratic term for the co-agglomeration index, $Control_{it}$ represents the control variables, and ε_{it} is a random error term.

EMPIRICAL RESULTS

Basic Regression

Descriptive Statistics

The descriptive data statistics for the regression analysis for the models in this paper are shown in **Table 1**.

Main Results

This paper first uses the panel OLS method to determine the impact of the manufacturing and producer service co-agglomeration on GEE in China, the results for which are shown in **Table 2**. The Hausman test find that the $Prob > \chi^2$ for the four models are 0.0007, 0.0055, 0.0000, and 0.0000, respectively. As they all strongly reject the original hypothesis, the fixed effects model is chosen. The regression results in **Table 2** show that the manufacturing and producer service co-agglomeration is conducive to the regional GEE improvements, and there is an

TABLE 1 | Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
GEE	600	0.8261264	0.2875783	0.2446396	1.262708
Coaggl	600	0.0529276	0.0116251	0.0144741	0.0955337
is	600	0.4287704	0.0804929	0.1598923	0.6196027
tinfr	600	0.0039737	0.0034247	0.0001219	0.0128906
hc	600	8.544943	1.091863	5.43834	12.782
fdi	600	55.61867	68.24681	0.0446	357.5956
er	600	0.0017699	0.0018004	7.45E-06	0.0185728
efe	600	77.86628	91.4546	0.06067	747.44
IE	600	7.688906	12.77725	0.1447019	88.22828
BE	600	0.0091846	0.0108836	0.000381	0.0813382

TABLE 2 | Main results.

	(1) GEE	(2) GEE	(3) GEE	(4) GEE
Coaggl	4.113*** (2.968)	12.451*** (3.022)	5.046*** (3.601)	12.828*** (3.210)
Coaggl ²		-72.817*** (-2.148)		-69.368*** (-2.078)
tinfr			46.145*** (5.013)	45.817*** (4.991)
is			-0.347** (-1.684)	-0.383** (-1.858)
hc			0.013 (0.377)	0.025 (0.716)
logfdi			0.024*** (2.120)	0.024*** (2.096)
er			8.563** (1.862)	7.611** (1.652)
logefe			-0.038*** (-2.905)	-0.037*** (-2.827)
_cons	0.755*** (10.332)	0.522*** (3.998)	0.513** (1.897)	0.234 (0.777)
Hausman test	14.44***	12.64***	44.47***	44.47***
P	0.0007	0.0055	0.0000	0.0000
Area fixed	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
N	600	600	600	600

t statistics in parentheses **p* < 0.2, ****p* < 0.05.

“inverted U-shaped” relationship between the co-agglomeration and GEE. That is, the above empirical results indicate that hypothesis 1 of this paper is tested.

When the co-agglomeration level is within a proper range, competition and cooperation coexist, and agglomeration will generate externalities, such as increased cross-industry talent exchange, expanded knowledge, and technological spillover dissemination, and the innovative vitality of the enterprises is enhanced, thus leading to the enhancement of GEE (Chen and Hu, 2008; Liu and Rui, 2012). When the co-agglomeration level exceeds the range, its increase has an adverse impact on

GEE because at this point, the market is overcrowded and threatens the carrying capacity of the region. The negative externalities outweigh the positive ones, and the economic aggregates are expressed as an increase in resource consumption and environmental pollution (Dou and Liu, 2016; Lin and Tan, 2019).

After adding the control variables, the co-agglomeration coefficient becomes larger, which indicates that the control variable selections are valid. Transportation infrastructure (tinfr) facilitates GEE as it can reduce circulation costs, optimize resource allocations, and promote talent and technology spillovers (Ghosh and Dinda, 2022). The secondary sector share depresses GEE because it generates greater pollution. Human capital (hc) can boost GEE, and industrial co-agglomeration provides conditions for the accumulation of human capital (Ji et al., 2021). As high-quality human capital represents knowledge, technology, and experience, it is more beneficial to knowledge and innovation spillovers (Yuan and Gao, 2020), which can elevate GEE. The foreign direct investment (fdi) coefficient is positive, which is inconsistent with the “pollution haven” hypothesis (Zeng and Zhao, 2009), and indicates that the benefits of foreign direct investment are greater than the drawbacks in China and can offer a better environment and conditions for regional GEE improvements. The environmental regulation coefficient is also positive, indicating that environmental regulations can have a positive adjustment effect on GEE, that is, environmental regulations regulate corporate behavior, reduce pollution emissions, and promote green technology innovation (Hamamoto, 2005; Telle and Larsson, 2006). The local government’s fiscal expenditure on environmental protection significantly inhibits GEE improvements, which indicates that fiscal expenditure is an inefficient way to protect the environment as it weakens the incentive for enterprises to regulate themselves and improve the environment.

Endogeneity Test

However, as there may have been an endogenous relationship between the co-agglomeration and the GEE, to deal with the endogeneity and ensure greater results reliability, this paper selects the instrumental variable method and redoes the estimation for which a lag of 1 is added to the co-agglomeration and a lag of 1 is added to the squared term as the instrumental variables. As shown in **Table 3**, the instrumental variables pass both the weak instrumental variable test and the non-identification test (Stock and Yogo, 2005); therefore, as the relationship between the co-agglomeration and GEE is still in an “inverted U-shape,” the instrumental variables are valid and the regression results are proven to be reliable.

Heterogeneity Analysis

A heterogeneity analysis is conducted using group regression (Li and Song, 2008; Yang and Wang, 2014), the results for which are shown in **Table 4**. The suest test *p*-values show that the coefficients of variation between the regions

TABLE 3 | Instrumental variable regression.

	Coaggl	Coaggl ²	GEE
Coaggl			11.243*** (2.795)
Coaggl ²			-60.043** (-1.811)
is			-0.327* (-1.558)
tinfr			45.521*** (5.040)
hc			0.024 (0.685)
logfdi			0.027*** (2.289)
er			5.467 (1.061)
logefe			-0.035*** (-2.656)
IV1	1.011*** (12.78)		
IV2		0.8542*** (10.78)	
Kleibergen-Paap rk LM statistic			52.77
P			0
Cragg-Donald Wald F statistic			1,553.70
Kleibergen-Paaprk Wald F statistic			280.97
N			570

t statistics in parentheses **p* < 0.2, ***p* < 0.1, ****p* < 0.05.

are significant, indicating that there is heterogeneity between the regions³.

As shown in **Table 4**, the influence of co-agglomeration on GEE in the eastern, western, and northeastern regions has an “inverted U-shaped” curve. The difference is that the influence of co-agglomeration on GEE in the central region has a “U-shaped” curve, which is because in the central region, when the co-agglomeration is at a lower level, the negative externality generated by agglomeration is greater than the positive externality, resulting in lower GEE. However, as the level of co-agglomeration continues to rise, the GEE will increase.

Currently, individual provinces in the eastern region have had excessively high co-agglomeration in the recent years, which has inhibited the GEE. The corporate co-agglomeration in most other provinces and cities is still promoting GEE. The industrial co-agglomeration in the central regions is at

³Eastern region, central region, western region and northeastern region in the Yearbook are divided as following:

Eastern 10 provinces (municipalities) include: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan; Central 6 provinces include: Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan; Western 12 provinces (autonomous regions and municipalities) include: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet(Not included in this article due to missing data), Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang; Northeastern 3 provinces include: Liaoning, Jilin and Heilongjiang.

TABLE 4 | Heterogeneity test.

Heterogeneity test	Eastern region GEE	Central region GEE	Western region GEE	Northeast region GEE
Coaggl	14.441*** (3.086)	-39.265 (-1.132)	104.766*** (2.959)	46.512* (1.354)
Coaggl ²	-124.183*** (-3.149)	369.889 (1.106)	-862.152*** (-2.889)	-242.827 (-0.867)
tinfr	87.734 (0.950)	42.150 (1.096)	51.020*** (4.649)	-17.178 (-0.755)
is	-2.763*** (-5.574)	1.487*** (2.558)	0.811* (1.408)	0.875*** (4.463)
hc	0.154*** (2.569)	-0.012 (-0.128)	-0.015 (-0.262)	0.011 (0.156)
logfdi	0.123*** (3.190)	-0.059* (-1.396)	0.003 (0.167)	-0.004 (-0.258)
er	-5.389 (-0.779)	-27.441* (-1.388)	12.992* (1.642)	4.003 (0.592)
logefe	0.095*** (2.429)	-0.280*** (-2.637)	-0.047* (-1.359)	-0.003 (-0.118)
_cons	-1.721*** (-2.884)	1.236* (1.109)	-2.825*** (-2.408)	-1.190 (-0.954)
N	200	100	210	60
Area fixed	Yes	Yes	Yes	Yes
Year fixed	Yes	Yes	Yes	Yes
Suest test Eastern region P-value	1	-	-	-
Central region	0.1417*	1	-	-
Western region	0.0044***	0.0028***	1	-
Northeastern region	0.1127*	0.0389***	0.1185*	1

t statistics in parentheses **p* < 0.2, ****p* < 0.05.

the bottom of the “U-shaped” curve and indicates that the current co-agglomeration does not adequately contribute to the GEE. The industrial co-agglomeration in the western region has crossed to the left side of the “inverted U-shaped” curve, which is not conducive to GEE improvements. In the northeastern region, the co-agglomeration level is at the top of the “inverted U” curve, which will inhibit GEE if it continues to grow.

In addition, the co-agglomeration in the central, western, and northeastern regions has a greater impact on GEE than in the eastern region. In other words, for every 1% point change in the co-agglomeration index, the degree of change in the GEE in the central, western, and northeastern regions is greater than in the eastern region. This is because the eastern region has a better economic and industrial structure than the central, western, and northeastern regions, which weakens the marginal promotion effect of co-agglomeration on GEE. However, the central, western, and northeastern regions have a larger marginal effect because of the larger optimization space.

TABLE 5 | Robust test.

	(1) GMM method GEE	(2) Changing the samples GEE
Coaggl	14.490*** (2.984)	16.627*** (3.216)
Coaggl ²	-83.606** (-1.882)	-102.687*** (-2.145)
is	-0.325** (-1.705)	-0.281* (-1.433)
tinfr	45.349*** (6.375)	46.896*** (6.180)
hc	0.027 (0.836)	0.018 (0.551)
logfdi	0.027*** (2.178)	0.020* (1.590)
er	5.463 (0.874)	4.285 (0.689)
logefe	-0.035*** (-2.776)	-0.032*** (-2.542)
_cons	0.175 (0.494)	0.174 (0.489)
AR	1	-
Hansen test P	0.980	-
Area fixed	Yes	Yes
Year fixed	Yes	Yes
N	570	540

t statistics in parentheses **p* < 0.2, ***p* < 0.1, ****p* < 0.05.

Robust Test

To verify the robustness of the above results, the sample is changed and another method is adopted to re-estimate the model. First, system GMM is chosen as the new estimation method because system GMM can deal with heteroscedasticity problems and weaken endogeneity. Second, to lessen the effects of the sample time span and extreme data, the 2019 sample was excluded⁴ and the explanatory variables are cut by 1% up and down. As shown in **Table 5**: (1) the conclusion that industry co-agglomeration promotes regional GEE is still proven; (2) the “inverted U-shaped” curve is still significant; and (3) the coefficients for the other variables remain unchanged. Therefore, the above conclusions are proven to be robust.

Mechanism Test

To further investigate whether entrepreneurship is the transmission mechanism for co-agglomeration on GEE, the mediating effect model proposed by Baron and Kenny (1986) is consulted to test. Considering the importance of the many connotations of entrepreneurship and the availability of data,

⁴In 2019, the National Development and Reform Commission issued a directory of industrial restructuring, guiding the focus on promoting a new development concept and promoting the high-quality transformation of the manufacturing industry; therefore, these data were removed for the robustness to reduce the impact of the sample time span.

TABLE 6 | Mechanism test.

	(1) GEE	(2) IE	(3) GEE	(4) BE	(5) GEE
Coaggl	5.474*** (3.871)	61.499* (1.342)	5.321*** (3.766)	0.234*** (6.558)	4.543*** (3.123)
tinfr	46.145*** (5.013)	488.032* (1.672)	45.370*** (4.917)	0.762*** (3.251)	44.508*** (4.791)
is	-0.347* (-1.684)	-46.514*** (-7.121)	-0.273 (-1.267)	-0.040*** (-7.550)	-0.262 (-1.209)
hc	0.021 (0.584)	7.578*** (6.644)	0.002 (0.047)	0.005*** (5.146)	0.003 (0.093)
logfdi	0.016* (1.347)	-0.302 (-0.805)	0.016* (1.414)	0.000 (0.733)	0.024** (2.080)
er	9.958*** (2.121)	329.616*** (2.166)	9.138** (1.943)	0.197* (1.681)	8.140* (1.766)
logefe	-0.050*** (-4.143)	-1.067*** (-2.738)	-0.047*** (-3.905)	0.000 (1.273)	-0.039*** (-2.972)
IE/BE			0.00249** (1.888)		2.774** (1.73)
_cons	0.495* (1.919)	-56.716*** (-6.788)	0.636** (2.374)	-0.030*** (-4.312)	0.577** (2.099)
N	600	600	600	600	600

t statistics in parentheses **p* < 0.2, ***p* < 0.1, ****p* < 0.05.

this paper draws on the approach of Hébert and Link (1989) to classify entrepreneurship into business entrepreneurship (BE) and innovation entrepreneurship (IE).

The total number of manufacturing and producer service patents granted in each region is divided by the annual population of the region to obtain the number of granted patents per 10,000 people, which is then used to represent the innovation entrepreneurship (IE) (Wong et al., 2005; Li et al., 2009; Song and Chen, 2020). The number of private firms in manufacturing and producer services per 10,000 people is taken to represent business entrepreneurship (BE) (Beugelsdijk and Noorderhaven, 2004; Glaeser, 2007; Ovaska and Takashima, 2021).

Referring to the mediating effects test model (Wen et al., 2004), **Table 6** is generated, which shows the results of the mechanism test for innovation entrepreneurship and business entrepreneurship.

In **Table 6**, it can be seen that the test results of columns (2) and (4) are significantly positive, indicating that the positive contribution of co-agglomeration to entrepreneurship is significant. The test results of columns (3) and (5) are also significantly positive, indicating that the mediating effect of entrepreneurship is significant. Among them, the mediating effect of IE is 2.8% and the mediating effect of BE is 11.9%. That is, co-agglomeration can spill over to entrepreneurship, and entrepreneurship promotes GEE. Entrepreneurship, as one of the externalities of co-agglomeration, optimizes the efficiency of resource allocation within enterprises and strengthens knowledge spillover and technological innovation. Meanwhile, excellent entrepreneurs guide enterprises to pursue efficient and sustainable development by enhancing their sense of

responsibility and mission. Therefore, co-agglomeration can promote GEE through its spillover effects on entrepreneurship, and hypothesis 2 of this paper is tested.

CONCLUSION

Using 2000–2019 panel data from China, this paper measures GEE and corporate co-agglomeration level and empirically investigates the effects of co-agglomeration on GEE, from which the following are discovered. First, the manufacturing and producer service corporate co-agglomeration is significantly conducive to enhancing GEE in China, with the corporate co-agglomeration showing an “inverted U-shaped” relationship with the GEE. Second, there is regional heterogeneity in the effects of corporate co-agglomeration on GEE. In the central region, the corporate co-agglomeration does not contribute sufficiently to the GEE. The co-agglomeration in the western and northeastern regions and some developed eastern provinces is found to be too high. Finally, entrepreneurship plays a mediating role in the effect of corporate co-agglomeration on GEE.

The findings in this paper indicate that the level of co-agglomeration needs to be controlled to better promote GEE and entrepreneurship is an important factor in this process. Therefore, local policies should be carefully designed to have a guiding effect on corporate location decisions. Green industrial parks and tax incentive policies should be established to support

the co-agglomeration of corporates. Meanwhile, by taking the carrying capacity of local infrastructure and resources into consideration, focusing on the quality of FDI, and exerting the constraining effect of environmental regulations, the local government could avoid the negative effects of excessive co-agglomeration. In addition, institutions and policies that facilitate the exercise of entrepreneurship should be formulated. Practical measures such as improving the financial system, providing funding support, and lowering the threshold for business startups could be taken to encourage the exertion of entrepreneurship.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

AUTHOR CONTRIBUTIONS

XZ, YZ, and WY contributed to the conception and design of the study. YZ organized the database and performed the statistical analysis. All authors wrote the first draft of the manuscript together, contributed to manuscript revision, read, and approved the submitted version.

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The Impact of Partnerships and Information Sharing on Corporate Sustainable Performance: A Mediation Model Moderated by Government Support

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OPEN ACCESS

Edited by:

Rui Xue,
Macquarie University, Australia

Reviewed by:

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Chongqing University, China
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and Economics, China
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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 12 May 2022

Accepted: 13 June 2022

Published: 11 July 2022

Citation:

Yue L, Ye M and Chen Q (2022)
The Impact of Partnerships
and Information Sharing on Corporate
Sustainable Performance:
A Mediation Model Moderated by
Government Support.
Front. Psychol. 13:942279.
doi: 10.3389/fpsyg.2022.942279

Based on the theory of strategic alliances and social networks, this article empirically studies the relationship between partnership, information sharing, and sustainable performance through a questionnaire survey of Chinese sports equipment manufacturers. The findings show that partnerships have a positive impact on sustainable performance; that information sharing plays a role in mediating the relationships between trust, cooperation, and sustainable performance; and that government support can positively impact the effect of partnerships on sustainable performance. Through empirical research, this article proves the mechanism of the impact of partnership on alliance performance, further expands the theoretical basis for enterprises' establishment of strategic alliances, and has important enlightening significance for enterprises within alliances aiming to rationally use the networks inside and outside their alliances to obtain knowledge and resources and improve their sustainable performance.

Keywords: partnerships, information sharing, sustainable performance, government support, cooperation, trust

INTRODUCTION

The global pandemic of COVID-19 has cast a shadow over the development prospects of the world sports industry (Ratten et al., 2021). The epidemic has brought serious threats to life and health, and has caused tremendous psychological shock. More people realize that in the face of the epidemic, medical care can only cure the symptoms, and only physical fitness can cure the root cause (Leguizamo et al., 2021). Psychological changes are manifested in behavioral improvements in sports participation and more emphasis on individual sports behaviors. The change of concept will give birth to a new consumption pattern of sports products. For example, people pay more attention to the consumption of personal sporting goods, such as sportswear, fitness equipment, wearable fitness equipment, etc. Many scholars predict that in the post-epidemic era, the sports market will usher in retaliatory consumption and the sports industry will recover (Schnitzer et al., 2020).

In the past, the sports industry continued to maintain rapid growth and still has a large room for growth in the future. It is of great significance to adhere to sustainable development in the growth process of the sports industry (Huang and Chen, 2022). The sporting goods manufacturing industry has strong industrial relevance. Its upstream and downstream industrial chain is not only related

to agricultural production such as cotton in the primary industry; it is also related to industrial production such as textiles, rubber, steel, and construction in the secondary industry; it is even related to modern services such as warehousing, logistics, sales, and packaging in the tertiary industry. This also means that the production process and production method of the sporting goods manufacturing industry must consume a large amount of natural resources, energy and industrial water, and at the same time generate a large amount of solid waste and greenhouse gases. In addition, due to the mismatch between supply and demand, a large number of primary sporting goods are often left unused or disposed of at low prices, resulting in a waste of resources. To promote the sustainable development of the sporting goods manufacturing industry, it is impossible to rely on a single sporting goods manufacturing enterprise. Alliances must be formed in the overall sporting goods manufacturing industry chain. The enterprise alliance balances the economic interests, environmental benefits and social responsibilities of enterprises internally, and externally drives the upstream and downstream industrial chains to explore and jointly promote green manufacturing and green production.

Early business managers were influenced by the “economic man” hypothesis, believing that the driving force of the survival and development of enterprises was the continuous acquisition of economic benefits and maximization of shareholder profits; indeed, it was not until the birth of stakeholder theory and social responsibility theory that entrepreneurs began to focus on the balance between economic and social interests (Roscoe et al., 2019; Shahzad et al., 2020). With the gradual awakening of environmental awareness, the question of whether and how enterprises assume environmental responsibilities to achieve green development and sustainable development has begun to become a topic of great interest for scholars and entrepreneurs (Abbas and Sagsan, 2019; Tian et al., 2022). There are multiple coexisting worldviews of corporate sustainability, but the most dominant worldview is focused on the business case for sustainability, a position anchored in the weak sustainability paradigm (Baumgartner, 2014; Baumgartner and Rauter, 2017) believe that in addition to being responsible to shareholders, companies should also be environmentally responsible, focusing on the sustainable enterprise development from both economic and environmental perspectives. Enterprises actively carrying out environmental management can directly promote their performance, and environmental management can help enterprises establish a sustainable and stable competitive advantage (Montiel and Delgado-Ceballos, 2014). Many businesses are increasingly using strategic partnerships to manage corporate environmental agendas. Alliance partnerships are of great significance to the sustainable development of enterprises (Sadovnikova and Pujari, 2017; Russo and Schena, 2021).

As the study of strategic alliances began to deepen, Nakamura (2005) found that the prevalence of strategic alliances is accompanied by high failure rates and instability. The main reason for the rupture of strategic alliances is the difficulty of

maintaining relationships between partners (van Beers and Zand, 2014; Dyer et al., 2018). The study of the relationship between partnerships and alliance performance has gradually attracted the attention of scholars. However, the results of such empirical research are inconsistent: some scholars believe that there is a positive relationship between partnerships and the development of strategic alliances (Hottenrott and Lopes-Bento, 2016; Jiao et al., 2019; Iwami, 2021). From the perspective of social networks, some scholars have discussed the influence of alliance network structure characteristics on alliance performance and found that interenterprise network connections can have an important impact on alliance performance (Kamal et al., 2021). Other scholars believe that there is an inverse relationship between these two factors (McEvily et al., 2003). The most critical reason for these conflicting results is that most of the existing research on the relationship between partnership and alliance performance focuses on only the direct impact of partnership on alliance performance, ignoring the intermediate effect between the two.

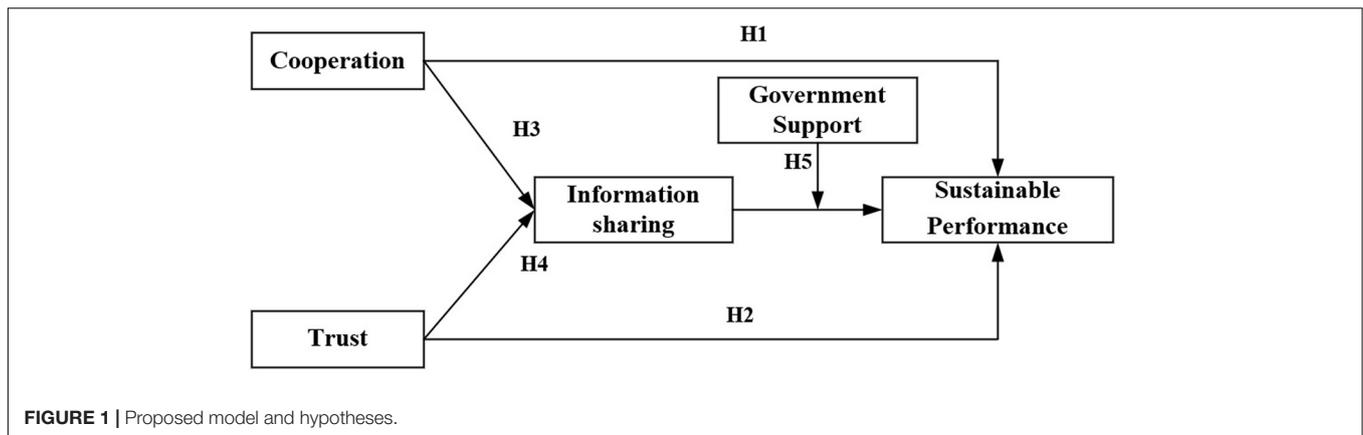
In contrast to general alliance situations, alliance partnerships, information sharing, and government support have important impacts on the sustainable development of alliances. This article argues that information sharing plays an intermediary role in the impact of alliance partnerships on alliances’ sustainable performance and further argues that this intermediated relationship is impacted by government support. Finally, by examining the adjusted mediation model, this article analyzes the process mechanism of the impact of alliance partnerships on the sustainable performance of alliances, providing a reference for alliance management practice.

The article is structured as follows. The second part presents the relevant research on partnerships, information sharing, government support, and sustainable alliance performance, makes research hypotheses, and constructs the theoretical model shown in **Figure 1**. The third part provides the method. The fourth part presents the data analysis and a discussion. The last part concludes the research.

THEORETICAL MODEL AND HYPOTHESES

Alliance Partnerships and Sustainable Performance

The literature in the field of strategic management suggests that relationship quality refers to the “degree of relationship bonding” and reflects the nature of strategic relationships. The relationship between enterprises affects the individual behavior of the members of the organization, which in turn affects the performance of the enterprise. Literature in the field of supply chain management shows that high-quality relationships between node companies and upstream and downstream partners can help improve the efficiency of the entire supply chain and promote long-term and stable transactions between the two parties. Huntley (2006) pointed out that



the measurement of relationship quality should take into account both relationship behavioral factors (such as trust, cooperation) and environmental factors. The main characteristics of interalliance partnerships are trust, cooperation and a high level of information sharing. Factors such as an inability to accurately define the degree of partnership, an uneven distribution of benefits and risks, a lack of sufficient trust in alliance partners, and the possibility of potential partner benefits being less considerable than their external risks can lead to the failure of partnerships (Martin et al., 2016). Alliance partners need to exhibit qualities such as mutual trust, concern for alliance development, an understanding of partner needs, and positive responses to alliance actions (Wu et al., 2014). Trust is essential to initiate, establish, and maintain social relationships (Balliet and Van Lange, 2013). Based on the perspective of current research, this article believes that the measurement indicators of enterprise alliance partnerships mainly include cooperation and trust.

Cooperation and Sustainable Performance

Many studies have contended that cooperation in strategic alliances can effectively improve the finance-based performance of participants, such as cost and revenue, and their non-finance-based performance, such as customer service and market commercialization (Luo, 2008; Zhang et al., 2010). Other studies have discussed interfirm collaborations with links to both financial and non-financial performance for partners. Financial performance includes cost efficiency and return on investment, and non-financial performance may range widely, including factors such as reduced uncertainty through vertical integration, access to complementary resources, and risk avoidance *via* coinvestment with partners (Angel, 2002; Aarstad et al., 2015; Tran et al., 2021).

Firms must have sufficient capabilities and knowledge to respond to and develop solutions for current dynamic environmental demands. Therefore, cooperation with partners has become crucial to enabling firms to acquire basic knowledge, conduct competitive research, respond to new demands, and gain access to networks while increasing their reputations and thus improving their positions in the market (Arroyave et al., 2020). Furthermore, cooperation with partners has

turned in an opportunity for firms to obtain funding for research projects conducted by administrative bodies; on the other hand, it has also turned into an opportunity to implement long-term technological strategies to make the most of opportunities offered to them by the public R&D system (Bayona-Saez et al., 2002). Choi and Choi (2021) found that vertical R&D cooperation positively affected overall industry performance, especially on service and marketing performance.

Hence, considering that cooperation with partners increases firm's information sharing and the development of their sustainable performance and that we expect a positive relationship between information sharing and firm performance, we propose direct and indirect effects of cooperation and performance. Cooperation increases a firm's knowledge base and its image and reputation. This reputation also improves if a firm is environmentally sound and developing sustainable performance (Moreno-Mondejar et al., 2020). Therefore, we propose the following:

H1: Cooperation has a significant positive impact on an alliance's sustainable performance.

Trust and Sustainable Alliance Performance

Management scholars have studied trust from multiple perspectives, including those of the social exchange literature (Colquitt et al., 2012, 2013; Su et al., 2020), economics, marketing and operations, and supply chain management (Poppo et al., 2016). Trust is regarded as a key variable in developing and maintaining relationships. The effect of trust on enhancing performance in interorganizational relationships has been widely recognized in existing literature. Trust is a necessary condition for resource sharing among enterprises, a representative social capital factor, and a topic that is generally a concern of social capital theory (Chen et al., 2014; Lu et al., 2016). Trust can be defined as a firm's expectation that its partners will perform a particular action to benefit their interests irrespective of their ability to monitor or control their partners (Wu et al., 2014). In many studies, trust is considered a type of capital within social capital. Specifically, trust can be divided into two types: good faith trust and ability trust. Good faith trust refers to a high

degree of integrity between partners, while ability trust is the belief that partners have sufficient resources and capabilities to meet cooperation requirements; moreover, these two types of trust can be independent of each other. If a company enjoys a high level of goodwill trust from its partners, its partners hold positive attitudes toward the corresponding alliance's activities or have sufficient ability to achieve the alliance's goals. That is, the more trust a business places in a partnership, the greater it will show some behavior worthy of the trust of its partner. In turn, the partner evaluates the activities of the enterprise and reacts in the same way (Hashim and Tan, 2015). Working partners in a high-trust relationship are not hesitant to share all information and trust the information they receive, which increases their willingness to partake in information sharing in return for each other's contributions to the relationship. Therefore, trust plays a critical role in determining information sharing (Wang et al., 2014). Therefore, we propose the following:

H2: Trust has a significant positive impact on the sustainable performance of alliances.

The Mediating Role of Information Sharing

Information sharing has been regarded as the most basic premise of enterprise collaboration in many studies, and even represents collaboration. Information sharing is a central process through which team members collectively utilize their available informational resources. Information sharing can be understood as the process of disseminating knowledge across individuals or organizations, thereby further integrating it into one's own knowledge and innovating on this basis to achieve value creation. Information sharing is the basis for effective collaboration in a supply chain. Although many researchers have reported that information sharing can increase corporation performance, firms need to implement collaborative initiatives to achieve increased performance. The study of Kelle and Akbulut (2005) on the benefits of information sharing for manufacturers shows that the best performing firms not only share information with their partners but also work closely with them to achieve superior performance derived from activities such as collaborative planning and collaborative product development.

Knowledge management theory shows that a wide range of mutual exchanges, learning, and sharing is the only way to optimally use and realize the value-added effect of knowledge; moreover, the benefits of knowledge owners can be maximized in this way (Wang and Wang, 2012; Wang and Hu, 2020). Information sharing has become an integral part of organizations' business strategies, and it aids organizations in growing, innovating in the market and gaining competitive advantages (Ganguly et al., 2019). Obtaining knowledge from other members of an alliance can enrich the knowledge reserves of members and help members carry out knowledge innovation to seize new market opportunities (Kim et al., 2011). Many studies have attempted to identify prerequisites for collaborative relationships in terms of the

need for information sharing. Barratt (2004) argued that information sharing is a critical determinant of collaborative culture, as collaborative culture can effectively facilitate allied decision making among organizations. Effective information sharing among partners can be an important driver of collaborative effort and improve performance (Prajogo and Olhager, 2012). More specifically, collaboration requires that individual participants adopt e-business networks or common IT architecture to share information (Horvath, 2001). Information sharing facilitates collaborative decision making across supply chains. Firms enter networks to obtain knowledge, information, and other resources. Research shows that the content and quality of information have direct impacts on organizational practices such as manufacturing efficiency and responsiveness (Li et al., 2014).

Therefore, the following assumptions are proposed:

H3: Alliance member information sharing mediates the effect of cooperation on the sustainable performance of alliances.

H4: Alliance member information sharing mediates the effect of trust on the sustainable performance of alliances.

The Moderating Role of Government Support

In recent years, the relationship between government support and corporate performance has attracted the attention of many scholars. To better understand whether and how government support in areas such as policies and services affects business success, scholars have conducted extensive research, and they have generally arrived at the conclusion that government support has a positive effect on businesses that is regulated by certain factors (Collewaert et al., 2010; Jugend et al., 2018; Yong et al., 2022). As a major participant of socioeconomic networks, governments' support and intervention in enterprises greatly affects the open innovation activities of enterprises. In particular, governments have a strong driving effect on the technological innovation of enterprises in the national strategic adjustment industry; moreover, the industrial manufacturing industry, which encompasses general equipment manufacturing and professional equipment manufacturing, is particularly sensitive to changes in capital policies (Bai et al., 2019). Governments can support companies (e.g., *via* tax breaks or granting innovation funds) by alleviating the financial pressure on them to develop and innovate, and they can act as a bridge between companies and universities or the press. Governments can also help enterprises acquire information on cutting-edge technology and scientific and technological knowledge and accelerate the integration of knowledge innovation, production, education and research (Yu et al., 2016). In addition, regarding formal institutions, governments can create an appropriate institutional environment for enterprise development. In terms of financing, production and the operating environment, in relation to helping enterprises integrate internal and external resources to achieve strategic goals, the essence of government behavior is to control the macro innovation environment, which can promote technological innovation, standard formation, transfer and diffusion and create

a stable, sustained, friendly and open cooperation space between enterprises (Huang et al., 2019). Government support can be seen by partners as a positive signal that can act as a “microphone” that helps enterprises obtain the external innovation resources they need and increase their input and output, thereby improving their sustainable performance (Malik and Kotabe, 2009; Han et al., 2018; Guo et al., 2020). Therefore, we propose the following:

H5: Government support moderates the impact of member information sharing on corporate sustainability performance.

The research model in this article is shown in **Figure 1**:

MATERIALS AND METHODS

This research mainly adopts the method of commissioned survey. Through the recommendation of the Sichuan Sports Association, electronic questionnaires were distributed among sports equipment manufacturers in 25 provinces, autonomous regions and municipalities affiliated to the China Sports Association. The issuance period is from December 2021 to February 2022. The questionnaire was aimed at various types of participants in a strategic alliance in the sports equipment manufacturing industry. A total of 400 electronic questionnaires were distributed, and 346 questionnaires were recovered for a recovery rate of 86.5%. The questionnaires were filtered according to the following criteria: questionnaires with many identical selected numbers and those that had numbers filled in with a certain level of regularity were considered invalid. According to the above criteria, a total of 35 invalid questionnaires were excluded, and 311 valid questionnaires were retained for an effective rate of 90%. To ensure the validity and reliability of the measurement tools, this study adopted scales previously used in the literature. And through the opinions of three professors and three industry experts, some adjustments are made according to the characteristics of the industry alliance. The reliability and validity tests of the measurement scale and the whole model were tested using SPSS 24.0 software and AMOS 24.0 software.

Table 1 gives additional information on the variable definitions.

As shown in **Table 2**, the correlation between the main variables in this study reached a significant level, which laid the foundation for further hypothesis testing. Moreover, the Cronbach's α reliability coefficient values of all the scales were greater than 0.7, meeting statistical requirements.

In an SEM, common method bias (CMB) is a phenomenon caused by an incorrect measurement method design (Fuller et al., 2016). CMB can lead to artificial variations in the relationships between variables (Malhotra et al., 2017), as the data collected do not accurately reflect the actual opinions of the sample individuals surveyed. To prevent this bias, the questionnaire was drafted following the suggestions of Podsakoff et al. (2012). Additionally, a collinearity test based on variance inflation factors (VIFs) was performed to detect the presence of CMB (Kock, 2015). A VIF above 3.3 would indicate the existence of

collinearity and thus that the model may be affected by CMB. The model did not include any VIFs greater than 2.4 and could thus be considered free of CMB (Valero-Amaro et al., 2021).

RESULTS AND DISCUSSION

In this article, multiple regression models were used to examine the main effects, mediating effects, and regulatory effects.

Main Effects Test

Using linear regression, the impacts of the two dimensions of alliance partnership, namely, cooperation and trust, on the sustainable performance of alliances were examined separately, and the linear regression test results are presented in **Table 3**. With controls for gender, age, and experience, the macro plug-in PROCESS3.3 of SPSS24.0 was used to test the research hypothesis.

As shown in **Table 3**, in both M2 and M3, cooperation and trust have significant positive impacts on sustainable performance ($\beta = 0.315, p < 0.01$; $\beta = 0.222, p < 0.01$). Therefore, the study hypotheses H1 and H2 were verified. When cooperation and trust were both included in the regression models, their impact on alliance sustainability performance remained significant (M4, $\beta = 0.272, p < 0.01$; $\beta = 0.139, p < 0.01$).

Mediation Effect Test

Using the multiple regression analysis method, we tested the mediating role of alliance information sharing in the impacts of the two dimensions of alliance membership, namely, cooperation and trust, on sustainable alliance performance. **Table 4** presents the linear regression test results. After incorporating the control variables, cooperation, trust, and information sharing were incorporated into the regression model.

As shown in **Table 4**, in M2, cooperation and trust were shown to have significant positive impacts on the information sharing of alliance members ($\beta = 0, p < 0.05$; $\beta = 0, p < 0.01$). In both M3 and M5, cooperation and trust have significant positive impacts on the sustainability performance of the alliance ($\beta = 0.315, p < 0.01$; $\beta = 0.222, p < 0.01$). With the inclusion of alliance member information sharing in the regression model, the impacts of cooperation and trust on sustainable performance remained significant but declined (M4, $\beta = 0.256, p < 0.01$; M10, $\beta = 0.165, p < 0.01$). Moreover, the sharing of information among alliance members was shown to have a significant impact on sustainable performance ($\beta = 0.188, p < 0.01$; $\beta = 0.225, p < 0.01$). This shows that the sharing of information among alliance members plays a mediating role in the impacts of cooperation and trust on sustainable performance. Therefore, hypotheses H3 and H4 were verified.

The deviation correction non-parametric percentile bootstrapping method was used to repeatedly sample 10,000 times to facilitate a mediation effect test, and the results are shown in **Table 5**.

As shown in **Table 5**, the value corresponding to the mediating effect of information sharing among alliance members on the relationship between cooperation and sustainable performance is

0.098, 95% BC CI = [0.004,0.231], 0 is not included in the interval, and the mediating effect is significant. The value corresponding to the mediating effect of alliance member information sharing on the relationship between trust and sustainable performance is 0.029, 95% BC CI = [-0.034,0.099], and the mediating effect is not significant.

Moderating Role of Government Support

Linear regression was used to test the moderating role of government support in the impact of the information sharing of

alliance members on sustainable performance. **Table 6** presents the linear regression test results.

Table 6 shows that the interaction items of information sharing and government support in M4 have a significant negative impact on sustainable performance ($\beta = -0.231, p < 0.05$); therefore, research hypothesis H5 is verified.

Next, according to the suggestion of Aiken et al. (1991), a schematic diagram of the moderating effect of government support on the relationship between information sharing and sustainable performance was made based on a simple slope

TABLE 1 | Variables and questions.

Variables	Questions	Factor loading	Literature source
Cooperation	Alliance members promote a culture of cooperation and exchange	0.848	van Beers and Zand, 2014; Arroyave et al., 2020
	Alliance members emphasize teamwork	0.880	
	Alliance members believe that cooperation between partners is more important than competition	0.850	
	Cooperation between alliance members enables them to resolve business problems more efficiently	0.540	
Trust	Alliance members care for each other, communicate openly and trust each other	0.721	Nyaga and Whipple, 2011; Poppo et al., 2016
	Alliance members dare to invest more money in joint research and development or learning	0.728	
	Alliance members face sudden crises together	0.637	
Information sharing (IS)	Alliance members form cross-organizational learning teams and hold regular thematic discussions to share new knowledge and new technologies they have learned	0.899	Shang et al., 2016; Weeks et al., 2017; Wang et al., 2020
	Alliance members share technical knowledge with knowledge alliance partners in a timely manner through knowledge alliances	0.869	
	Alliance members actively seek to participate in the training provided by the knowledge alliance	0.830	
Government support (GS)	Local governments have enacted laws and regulations to support the development of knowledge-based enterprises and organizations	0.766	Lu et al., 2014; Ohta et al., 2021
	The government helps link knowledge partners	0.836	
	The government funds the organization of enterprises, scientific research institutes and institutions of higher learning to cooperate in basic research	0.683	
Sustainable performance (SP)	Economic performance: Your business is able to maintain a high level of profit over a long period of time	0.853	Griffiths and Finlay, 2004; Helfat and Peteraf, 2009; Ahmad, 2015
	Social performance: Your business is able to provide customers with products that satisfy them, maintaining high customer satisfaction	0.812	
	Environmental performance: Your business has strong dynamic sustainability and environmental resources	0.751	

TABLE 2 | Mean, standard deviation, correlation analysis, and reliability test results for each variable.

	Mean	Standard deviation	1	2	3	4	5
1 Cooperation	4.00	0.79	(0.730)				
2 Trust	3.59	0.82	0.334**	(0.709)			
3 Information sharing	3.83	0.95	0.336**	0.270**	(0.705)		
4 Government support	4.05	0.84	0.124*	0.177**	0.112*	(0.745)	
5 Sustainable performance	4.26	0.76	0.291**	0.192**	0.257**	0.307**	(0.712)

** $p < 0.01$ and * $p < 0.05$; the Cronbach's α reliability coefficients for each scale are on the diagonal in parentheses.

TABLE 3 | Regression analysis of the impact of alliance partnerships on alliance sustainability performance.

Independent variable	Dependent variable: Alliance sustainability performance			
	M1	M2	M3	M4
Gender	-0.026	-0.015	-0.025	-0.016
Age	0.013	0.085	0.053	0.101
Experience	0.134*	0.134*	0.154**	0.147**
Cooperation		0.315**		0.272**
Trust			0.222**	0.139*
R ²	0.020	0.113	0.067	0.130
ΔR ²	0.020	0.094	0.047	0.110
ΔF	2.067	32.33**	15.34**	19.36**

N = 311; **p < 0.01 and *p < 0.05; two-tailed test.

TABLE 4 | Analysis of the mediating effect of information sharing.

Independent variable	Dependent variable: Information sharing		Dependent variable: Alliance sustainability performance			
	M1	M2	M3	M4	M5	M6
Gender	-0.033	-0.022	-0.015	-0.011	-0.025	-0.018
Age	-0.190**	-0.100	0.085	0.108	0.053	0.086
Experience	0.047	0.063	0.134*	0.125*	0.154**	0.139*
Cooperation		0.257**	0.315**	0.256**		
Trust		0.172**			0.222**	0.165**
Information sharing				0.188**		0.225**
R ²	0.036	0.153	0.113	0.144	0.067	0.112
ΔR ²	0.036	0.116	0.094	0.124	0.047	0.093
ΔF	3.87*	20.97**	32.33**	22.18**	15.34**	15.89**

N = 311; **p < 0.01 and *p < 0.05; two-tailed test.

TABLE 5 | Bootstrapping analysis of the mediating effect of information sharing.

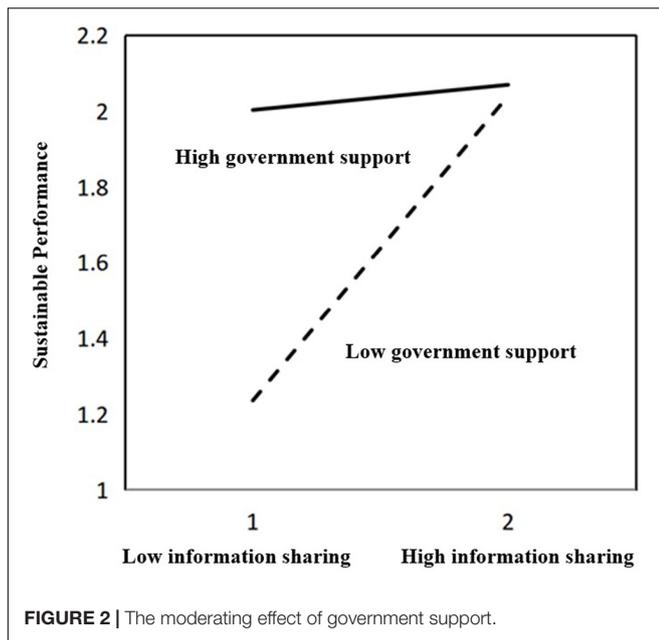
Model	Direct effects P _{YX}	95% BC CI	Indirect effects P _{YM} P _{MX}	95% BC CI	Total effect P _{YX} + P _{YM} P _{MX}	95% BC CI
Cooperation→IS→SP	0.341*	[0.031,0.626]	0.098*	[0.004,0.231]	0.439**	[0.151,0.691]
Trust→IS→SP	0.040	[-0.179,0.248]	0.029	[-0.034,0.099]	0.069	[-0.160,0.271]

** and * indicate significant correlations at the p < 0.001, 0.01, and 0.05 levels (double tailed), respectively. P_{YX} represents the effect of the anterior dependent variable on the result variable; P_{MX} represents the influence of the antecedent variable on the mediation variable; and P_{YM} stands for the effect of a mediation variable on a result variable.

TABLE 6 | Moderating effect of government support.

Independent variable	Dependent variable: Sustainability performance			
	M1	M2	M3	M4
Gender	-0.026	-0.018	-0.037	-0.028
Age	0.013	0.063	0.055	0.051
Experience	0.134*	0.121*	0.088	0.079
Information sharing		0.266**	0.234**	0.229**
Government support			0.271**	0.237**
IS × GS				-0.231**
R ²	0.020	0.088	0.159	0.211
ΔR ²	0.020	0.068	0.071	0.052
ΔF	2.07	22.83**	25.79**	20.07**

N = 311; **p < 0.01 and *p < 0.05; two-tailed test.



analysis point method. We constructed high- and low-level moderator variables representing government support for this regression analysis. **Figure 2** and the regression analysis show that when government support is high, the positive effect of member information sharing on sustainable performance is relatively weak ($\beta = 0.034$, n.s.). When government support is low, the positive effect of member information sharing on sustainable performance is significantly enhanced ($\beta = 0.423$, $p < 0.01$).

CONCLUSION

Research Conclusion

As important participants of emerging markets, manufacturing companies not only follow the inherent requirements of green economic development but also assume responsibility for actively responding to environmental challenges. In the context of the knowledge economy, to prevent the uncertainty caused by competition between related enterprises in industries, enterprises are giving increasing attention to obtaining new knowledge from outside their industries. Therefore, industrial alliances have become the main structural form and source that enterprises use realize sustainable development. Based on previous research, this study summarizes the influencing factors of partnership, information sharing, and government support, constructs a conceptual model of the mechanism of action between these variables and the sustainable performance of an industry, and proposes the basic assumptions of the research. To test these hypotheses, a questionnaire was designed that was used to obtain relevant data by means of a scale, and these data were statistically analyzed based on correlation analysis. The reliability and validity tests of the measurement scale and the whole model were tested using SPSS 24.0 software and AMOS 24.0 software. Through theoretical analysis and empirical research, the

following conclusions are obtained. (1) The positive impact of partnership and member information sharing on the sustainable performance of industry alliances is verified. (2) The mediating effect of member information sharing in partnership on the sustainable performance of industry alliance is verified. (3) It verifies the moderating effect of government support in the impact of information sharing on sustainable performance.

Theoretical Contribution

This research has practical guiding significance for improving the theory of alliances and for enterprises and organizations aiming to enhance their green development and sustainable development through alliances.

(1) Partnerships and member information sharing have significant positive impacts on the sustainable performance of industry alliances.

Partnerships are mainly characterized by cooperation and trust among members. The cooperation and trust of members are the basis for further collaboration. The theoretical assumptions that motivation induces behavior and that willingness guides action are also applicable from the study of individual behavior to organizational behavior. Information sharing is the foundation of and key link to promoting knowledge development. An industry alliance is not an enterprise organization based on equity but a loose alliance based on knowledge development.

(2) Information sharing plays a partial mediating role in the impact of partnerships on the sustainable performance of industry alliances.

Information sharing is used not only to transmit information to another party but also to digest and absorb shared knowledge, integrate it existing knowledge structures, and develop new knowledge capabilities. In the era of big data, enterprise project teams should strive to realize the complementarity of potential absorptive capacity and actual absorptive capacity, especially to strengthen the acquisition and learning of external information. Only in this way can the potential absorptive capacity of an enterprise be transformed into its innovation achievement and sustainable development be achieved.

(3) Government support plays a moderating role in the impact of information sharing on sustainable performance.

The government can not only formulate policies to support the green development of industries but also directly provide resources. In addition, the government can provide industry alliances with public infrastructure and resources, green and sustainable development subsidies, science and technology funds, etc., to support such alliances in increasing their green innovation activities and enhancing their competitiveness and sustainable development level.

Limitations and Future Research Directions

Due to a lack of research experience and resource constraints, this study is still insufficient. First, most of the questionnaires used in this study were developed based on foreign national conditions; thus, it is uncertain whether they are suitable for the Chinese cultural situation. Therefore, in future research, we can further

develop a questionnaire suitable for the local cultural situation of China. Second, in terms of data collection, the measurement of the core variables used in this study was based on employee self-assessment and carried out during a single period, so it is difficult to further clarify the causal relationship of the model. In future research, a time series design and other evaluation methods will be used to collect data to reduce CMB.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories

and accession number(s) can be found in the article/supplementary material.

AUTHOR CONTRIBUTIONS

LY designed the study and analyzed the data. QC discussed the results. MY drafted the manuscript. Finally, the authors have agreed to be accountable for all aspects of the manuscript in ensuring that questions related to the accuracy or integrity of any part of it are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

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Returnee Executives, Corporate Social Responsibility, and Stock Price Synchronicity

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Executive characteristics have a significant impact on corporate decision-making, corporate sustainable behavior, and stock market performance, which may influence the corporations' sustainable development in the long run. The role of returnee talents in the corporate sustainable development has received extensive academic attention. Using data of Chinese A-share listed companies over the period of 2008–2018, we find that there is a negative relationship between executives' foreign experience and stock price synchronicity. We also prove that corporate social responsibility (CSR) has a significant mediating effect on the relationship between returnee executives and stock price synchronicity. The returnee executives tend to pursue long-term sustainable activities and improve CSR engagement quality, thereby reducing stock price synchronicity. Our extended analysis reveals that the benefit of returnee executives is more pronounced for non-SOEs and for firms located in regions with a low degree of marketization. This study has some implications for the Chinese firms in relation to their CSR information disclosure behavior, and it gives suggestions to strengthen capital market efficiency for the sustainable development of corporations.

Keywords: corporate social responsibility, stock price synchronicity, corporate sustainable development, returnee executives, information asymmetry

OPEN ACCESS

Edited by:

Shiyang Hu,
Chongqing University, China

Reviewed by:

Jie Tian,
Chongqing Technology and Business
University, China

Dehui Li,
Sichuan University, China

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 22 May 2022

Accepted: 23 June 2022

Published: 13 July 2022

Citation:

Gao D, Zhao Y and Tian Q (2022)
Returnee Executives, Corporate
Social Responsibility, and Stock Price
Synchronicity.
Front. Psychol. 13:950436.
doi: 10.3389/fpsyg.2022.950436

INTRODUCTION

The executives, as the decision-maker and implementer of corporate strategy, play an essential role in corporate sustainable development. Prior researchers investigate the economic consequences of executives' personal experience and background from the perspective of academic experience (White et al., 2014), military experience (Benmelech and Frydman, 2015), pilot experience (Cain and McKeon, 2016), acquisition experience (Field and Mkrtychyan, 2017), and early-life experience (Bernile et al., 2017). Recently, executives' foreign experience has attracted more academic attention. For example, Giannetti et al. (2015) investigate the impact of directors with foreign experience on firm performance in China. Yuan and Wen (2018) attempt to explain the channels by which foreign experience could promote firm performance and they find that managers with foreign experience not only contribute to R&D investment, but also contribute to the increase of patents. With the development of global market integration and international talent communication, the number of returnee executives from

overseas increases rapidly. From 1978 to 2018, among the five million people who had studied in abroad and the total number of people who had completed their studies totaled more than 4 million, 84.46% of them chose to return to China. Generally, returnee executives are believed to be conducive to corporate sustainable development in China. By 2020, the number of overseas returnees sending resumes to domestic posts increased by 33.9% from 2019, and the growth rate is much higher than that of 2019 (5.3%) and 2018 (4.3%).

The overseas talents not only have impact on firm decision-making, but also can affect stock market information transmission. According to the prior literature, a returnee executive can help to improve the efficiency of corporate sustainable development through international expansion, innovation, corporate governance, and corporate social responsibility (CSR) strategies at the firm level (Giannetti et al., 2015; Iliiev and Roth, 2018; Yuan and Wen, 2018; Zhang et al., 2018; Conyon et al., 2019). In addition, Cao et al. (2018) conduct empirical research based on the data of Chinese listed firms and show the evidence that the uncertainty of directors' foreign experience is negatively related to crash risk. Returnee executives tend to be more likely to enhance the timeliness of financial reporting (Dobija and Puawska, 2021). Meanwhile, a growing body of the literature provides evidence that excessive stock price synchronicity can seriously damage the resource allocation function of the capital market, and even leading to financing difficulties, hindering enterprises' sustainable development (Wurgler, 2000; Gul et al., 2011; Morck et al., 2013). Stock price synchronicity, a measure of the degree to which individual stocks co-move with the market, indicates information transmission efficiency in capital market. In comparison with the developed markets, the cost of acquiring private information is much higher in emerging markets and the profitability of informed trading is lower, which leads to higher stock price synchronicity (Gul et al., 2010). As China's capital market is at the early stage of development and the regulations on corporate information disclosure are not fully-forced, listed firms have the incentives to selectively disclose private information to outside investors. The stock price synchronicity in China is always much higher than that in the developed markets (Morck et al., 2000; Jin and Myers, 2006). However, whether returnee executives can affect stock price synchronicity is still unclear. Thus, this paper reveals the role of returnee executives in explaining the synchronicity of stock price movements and investigates the significance of corporate sustainable behaviors.

Corporate social responsibility (CSR) is an important long-term investment for a firm; it is a firm's sustainable development behavior as well as an important issue of information transmission in stock markets. According to Gelb and Strawser (2001), firms with high CSR are more likely to provide informative disclosures. Executives' foreign experience may help to improve the informativeness of stock prices by improving corporate social responsibility strategy, thereby disseminating a firm's specific information to investors. On the one hand, firms with returnee talents are more likely to enhance their corporate governance, thus improving firms' foreign acquisition performance and executives' incentive mechanism (Giannetti et al., 2015; Conyon et al., 2019). On the other hand, agency

theory shows that self-interested managers may hide bad news and have short-decision-horizon problems, which influence firms' long-term success, and thereby, agency cost may arise (Antia et al., 2010; Kim et al., 2014). Since executives with foreign experience have a broader vision and reduced managerial myopia, they may influence firms' CSR-related decision-making. Therefore, executives with foreign experience are more likely to pursue long-term investment activities. They have the intention to improve CSR engagement quality (Zhang et al., 2018). According to the above statements, we posit that firms with returnee executives are likely to have reliable and high-quality information available to the public, and their stock prices should be less synchronous with the market, which results in the lower stock price synchronicity.

Using data from the China Stock Market & Accounting Research (CSMAR) over the period of 2008–2018, we examine whether executives' foreign experience is related to stock price synchronicity. We also explore the potential channels through which returnee executives affect the stock market by analyzing the mediating effect of CSR. The results show that returnee executives can significantly reduce stock price synchronicity. The main findings withstand checks for endogeneity, self-selection bias, and robustness tests. Additionally, the mediating analysis indicates that returnee executives reduce stock price synchronicity through CSR engagement. Further analyses indicate that executives' foreign working experience and foreign studying experience have important impacts on stock price synchronicity. For the non-state-owned enterprises (non-SOEs) and the firms located in the low-marketization regions, executives with foreign experience have a more significant impact on stock price synchronicity.

Our manuscript makes three major contributions to the literature. First, this study examines the role of returnee executives in reducing stock price synchronicity and enriches the existing literature on the influence of executives' background information. Previous literature has shown the influence of executives' experience on international exposure (Lee and Park, 2008; Iliiev and Roth, 2018), innovation (Yuan and Wen, 2018), firm performance (Giannetti et al., 2015), CSR strategy (Zhang et al., 2018), financial reporting (Dobija and Puawska, 2021), and stock crash risk (Cao et al., 2018), but less is known about the impact of returnee executives on stock price synchronicity. We provide evidence that executives' foreign experience has a negative impact on stock price synchronicity. Second, this manuscript explores the mechanism by analyzing the mediating effect of CSR, and we prove that executives' foreign experience can significantly affect CSR practices. Given the significant impact of executives' foreign experience on corporate success, our study highlights the importance of executives' foreign experience in corporate information transmission and corporate sustainable development in emerging markets.

The remainder of this manuscript is organized as follows. Section "literature background and hypotheses development" reviews the literature and develops the hypotheses. Section "Research Design" describes data, variables, and model design. Section "Empirical Results and Analysis" presents the empirical results, the robustness checks, and heterogeneity analysis. Section "Conclusion" concludes the manuscript.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Returnee Executives and Corporate Sustainable Behavior

Exploring the influencing factors of corporate sustainable behavior from the executives' characteristics is a hot topic in the recent years. According to the upper echelons theory (Hambrick and Mason, 1984), the personality characteristics and cognitive model of executives will affect the strategic decision-making choices. Thus, executives have a statistically significant effect on corporate behavior and to achieve sustainable competitive advantage (White et al., 2014; Benmelech and Frydman, 2015; Bernile et al., 2017; Field and Mkrtchyan, 2017). Internationalization exposes executives to multiplicity of countries with different institutional systems (Xue et al., 2021). Due to the importance of sustainable development for a firm's global competitiveness, a number of studies have explored executives' foreign experience that stimulates this corporate behavior. An increasing number of literature has started to empirically study the influence of executives' foreign experience on the stock market and firm performance (Lee and Park, 2008; Giannetti et al., 2015; Cao et al., 2018; Iliev and Roth, 2018; Yuan and Wen, 2018; Zhang et al., 2018; Conyon et al., 2019; Dobija and Puawska, 2021). For example, Yuan and Wen (2018) attempt to explain the channels by which foreign experience contributes to firm performance and they find that managers with foreign experience not only contribute to R&D investment, but also contribute to the increase of patents. Cao et al. (2018) conduct empirical research based on the data of Chinese listed firms and show the evidence that the uncertainty of directors' foreign experience is negatively related to crash risk, implying that the imprinting effect and eyeball effect are the underlying mechanisms. Specifically, Zhang et al. (2018) find that returnee directors may influence firms' CSR engagement by advising managers to adopt additional CSR activities. Corporate sustainable development clearly benefits from returnee executives. However, it is not yet clear how returnee executives affect firms' stock price synchronicity.

Returnee Executives and Stock Price Synchronicity

Stock price synchronicity, a measure of the degree to which individual stocks co-move with the market, reflects firm-specific information transmission efficiency in capital market. Once the unique information of firm is not well-reflected by its stock price, the synchronicity would increase (Morck et al., 2000; Durnev et al., 2003). Prior studies investigated the determinants of stock price synchronicity from the perspectives of the information efficiency view. For example, Jin and Myers (2006) extend prior research and find that stock price synchronicity is higher in countries with more opaque information environments, which enables that insiders control firm-specific information flows to the public and therefore reduce information transparency. Wan et al. (2021) state that investors are information-intensive and will adapt their investment strategies to new market patterns. The higher the information transparency, the more information about

the firm-specific information that investors could collect, thereby reducing the synchronicity of stock prices. Further studies investigate other determinants of stock price synchronicity, such as ownership concentration (Gul et al., 2010), large controlling shareholders (Boubaker et al., 2014), institutional investors (An and Zhang, 2013), analysts (Jiang et al., 2018), and managerial characteristics (Neifar and Ajili, 2019). In emerging markets, the stock price synchronicity is much higher than that of developed markets (Jin and Myers, 2006). We argue that returnee executives may affect stock market efficiency from the following aspects.

First, returnee executives are more likely to engage in corporate sustainable development, because more private information can be incorporated into the stock price through their activities, thereby improving the information efficiency and reducing stock price synchronicity. As Chinese economy is at the stage of transition, China's rapid development requires talents urgently, especially those with foreign experience (Yuan and Wen, 2018; Zhang et al., 2018). Foreign experience refers to the particular experience of the individuals; the returnee executives consider it as a crucial part of the accumulation of human and social capital, including international knowledge and valuable foreign networks (Conyon et al., 2019). The executives with foreign experience could affect the decision-making process of the enterprises, and they are expected to be good at tackling the international challenge faced by the firms (e.g., Piaskowska and Trojanowski, 2014; Iliev and Roth, 2018). It is therefore vital and urgent to discuss the influence of returnee executives on firm-level decisions and capital market allocation (Cao et al., 2018). Second, the returnees may benefit firms initiatively to promote corporate governance and improve the quality of information disclosure. Prior studies find that specialized foreign expertise and networks contribute to corporate innovation, corporate governance, firm performance, and executives' incentive mechanism (Giannetti et al., 2015; Yuan and Wen, 2018; Conyon et al., 2019). In addition, returnee executives tend to be more likely to enhance the timeliness of financial reporting (Dobija and Puawska, 2021). Stock price synchronicity is affected by information opacity (Jin and Myers, 2006), and better corporate governance should reduce stock price synchronicity by mitigating the risk caused by information asymmetry (Ashbaugh et al., 2006). Thus, in comparison with firms without returnee executive, firms with the returnee talents are more likely to enhance the corporate sustainable development, and as a result choose to disclose more firms' unique information and reduce stock price synchronicity.

In summary, we posit that firms with returnee executives are likely to have more reliable and high-quality information available to the public, which results in lower stock price synchronicity.

Hypothesis 1. There is negative association between total stock price synchronicity and returnee executives.

Returnee Executives, Corporate Social Responsibility, and Stock Price Synchronicity

As an important long-term investment and a sustainable development behavior for a firm, CSR significantly affects

influence stock price synchronicity. A large number of studies examine the determinants of CSR, as well as the economic consequences of CSR. Gelb and Strawser (2001) show evidence that socially responsible firms provide more financial disclosure. Kim et al. (2012) show that socially responsible firms exhibit less evidence of both accrual-based and real-activity earnings' management. A number of empirical studies find evidence suggesting that CSR is associated with transparent and reliable financial information, and it has positive impact on other dimensions of firm sustainable behavior and outcomes (Lee and Faff, 2009; Kim et al., 2012). In addition, Kim et al. (2014) argue that socially responsible firms commit to a high standard of information transparency and engage in less bad news hoarding, and they prove that firms' CSR performance is negatively associated with stock price crash risk. A study of Kent and Bu (2020) indicates that investors recognize their firm-specific information and adjust investment behavior when companies report the indirect method.

From the agency cost perspective, managers have an incentive to cover up their self-serving behaviors regardless of shareholders' interests, by withholding unfavorable information or selectively disclosing information or opportunistically timing the release of value relevant, private information to the market (Jensen and Meckling, 1976; Antia et al., 2010; Kim et al., 2014). Thus, self-interested managers deter the flow of firm-specific information to the market, which contributes to more opaque information environments. As the core figures of enterprise operation and the executors to achieve the objectives of the board of directors, executives with foreign experience are more likely to have a broader vision and reduced managerial myopia. Zhang et al. (2018) prove returnee directors improve firms' CSR engagement by advising managers to adopt additional CSR activities in China. They state that firms integrate not only the knowledge and skills of returnee directors but also their stakeholder-oriented business approach. In that case, better CSR engagement can encourage investors to collect and trade on proprietary information. Besides, executives with foreign experience are more likely to pursue long-term investment success and promote financial reporting quality (Dobija and Puawska, 2021).

This role of CSR is particularly important in Chinese stock market. Since CSR engagement plays an important role in reducing stock price synchronicity, we predict that firms with returnee executives can alleviate agency conflicts and enhance firms' CSR engagement efficiently, which is helpful to decrease stock price synchronicity. Our second hypothesis is formalized as follows:

Hypothesis 2: CSR plays a mediating role in transmitting the impact of returnee executives on stock price synchronicity.

RESEARCH DESIGN

Data

In this study, the sample of data is collected on Chinese A-share listed firms during the period 2008–2018. All financial data and data about CSR and executives' background information were

retrieved from the China Stock Market and Accounting Research (CSMAR) database. We choose 2008 as the beginning year of the sample period because the overseas background data of senior executives disclose normally from 2008. Samples were screened according to the following criteria: (1) we excluded financial firms and insurance firm from the sample, (2) we excluded listed firms subjected to special treatment (ST and ST*), (3) we excluded firms with annual trading weeks less than 30 weeks, and (4) the variables were winsorized at both the top and bottom of 1% quantiles to reduce the potential impact of outliers. Following these procedures, the final sample comprised of 23,805 firm-year observations.

Dependent Variable

The dependent variable is stock price synchronicity. The stock price synchronicity can be used as a proxy for information efficiency in the capital market (Morck et al., 2000). According to the Efficient Markets Hypothesis (EMH), when the information efficiency is relatively high, more information with company traits will be contained in the stock price, which makes it hard to fluctuate with market, thereby showing low stock price synchronicity. Following Morck et al. (2000), Jin and Myers (2006), and Boubaker et al. (2014), we estimate stock price synchronicity for each firm in a particular year using R^2 from the following market model:

$$RET_{i,w} = \alpha + \beta_1 MKTRET_{i,w} + \beta_2 MKTRET_{i,w-1} + \beta_3 INDRET_{i,w} + \beta_3 INDRET_{i,w-1} + \varepsilon_{i,w} \quad (1)$$

where $RET_{i,w}$ is firm i 's return on week w , $MKTRET_{i,w}$ is the value weighted market return for week w , and $INDRET_{i,w}$ is the industry value-weighted return excluding firm i 's weekly return. $\varepsilon_{i,w}$ represents unspecified random factors.

Synchronicity is often measured by the regression's R -squared value of individual stock returns on market and industry indexes. The larger R -squared an individual firm has, the more its stock prices are synchronous with market and/or industry returns. The R -squared value is obtained from the above regression. As the value of R^2 is bounded by zero and one, we need to apply a logistic transformation of the R^2 in the empirical analyses to make R^2 meet the normal distribution. Therefore, our synchronicity proxy is defined as follows:

$$SYNCH_i = \log \left(\frac{R_i^2}{1 - R_i^2} \right) \quad (2)$$

where R_i^2 is the R -squared value from Equation 1 for firm i in year t and $SYNCH_i$ is our empirical measure of annual synchronicity for firm i . We also follow Durnev et al. (2003) and Gul et al. (2010) to calculate the fitting coefficient R^2 and use other measures to proxy the stock price synchronicity in the robustness test.

Independent Variable

The independent variable is executives with foreign experience. Following prior studies (e.g., Yuan and Wen, 2018; Zhang et al., 2018; Conyon et al., 2019), we employ two measures. The first measure, *Foreign_N*, is the number of executives with foreign

experience in a company in a given year. The second, *Foreign_D*, counts for 1 if there is at least one executive with foreign experience, and 0 otherwise.

Mediating Variable

Corporate social responsibility (CSR) is the mediating variable. It is measured by the CSR score of the listed firm that mainly obtained from the Running's CSR report. Following Zhang et al. (2018), we collect CSR score for Chinese listed firms and use this quantitative indicator to measure the quality of CSR strategy.

Control Variables

The control variables are firm characteristics which are typically used as the determinants of stock price synchronicity (e.g., Gul et al., 2010; Boubaker et al., 2014). The control variables include firm size (*Size*, the natural logarithm of total assets), return on assets (*ROA*, net profit scaled by total assets), leverage (*Lev*, liabilities scaled by total assets), growth opportunity (*Growth*, annual growth rate of sales), proportion of fixed assets (*FIX*, fixed asset scaled by total asset), market value to book value ratio (*MB*, total market value of the company's stock divided by the book value of the net assets), and stock turnover rate (*TurnR*, the number of shares traded in the current year divided by the number of shares outstanding). **Appendix Table A1** provides the definitions of all variables used in our analysis.

Model Design

To investigate the effect of executives' foreign experience on synchronicity (H1), we estimate the following regression model:

$$SYN_{i,t} = \alpha + \beta_1 Foreign_{i,t} + \sum Control + Industry + Year + \varepsilon_{i,t} \quad (3)$$

where for firm *i* and year *t*, *Foreign* proxies executives with foreign experience, we employ the two measures *Foreign_N* and *Foreign_D*. *Control* refers to the set of control variables mentioned above. In addition, the industry and year are included in the model.

To test for the mediating effect of CSR on the relationship between executives' foreign experience and synchronicity (H2), we estimate the following regression:

$$CSR_{i,t} = \alpha + \beta_1 Foreign_{i,t} + \sum Control + Industry + Year + \varepsilon_{i,t} \quad (4)$$

$$SYN_{i,t} = \alpha + \beta_1 Foreign_{i,t} + \beta_2 CSR_{i,t} + \sum Control + Industry + Year + \varepsilon_{i,t} \quad (5)$$

where *CSR_{i,t}* represents the mediating variable. *Control* refers to the control variables, and the effect of industry and year is also controlled in the model.

EMPIRICAL RESULTS AND ANALYSIS

Descriptive Statistics

Table 1 shows the distribution of sample firms by year. The number of executives with foreign experience increases monotonically over the sample period, the proportion of companies with foreign executives has increased from 12% in 2008 to 27% in 2018, reflecting that more and more overseas talents have chosen to return to China and hold important positions in the company in the recent years. The total number of executives with working experience has always been higher than that of executives with learning experience. Although, there is a steady growth of returnee executives in Chinese stock market, the proportion is still relatively low.

Table 2 presents the descriptive statistics for the variables. The mean value of stock price synchronicity (*SYN*) calculated by Equation 1 is -0.322 , and the standard deviation is 0.931 , which demonstrate that there is a big difference in the stock price synchronicity among sample firms. The mean value of the number of foreign executives in a company (*Foreign_N*) is 0.33 , and the mean value of the other dummy variable for foreign executives (*Foreign_D*) is 0.217 , indicating that on average, only 21.7% of the companies in the sample have at least one executive with foreign experience. It means that many overseas talents have been attracted by China's rapid economic development and decided to work in the Chinese listed firms. The mean value of CSR is 38.658 , and it ranges from 13.330 to 89.003 , indicating that CSR engagement of Chinese listed firms is unbalanced. In the statistical analysis of the control variables, the average firm has a level of total assets (*Size*) of 22.061 , and *ROA* has an average (median) of 3.9% (3.7%), whereas leverage (*Lev*) has a mean (median) of 0.436 (0.433). In addition, the firms in our sample have an average fixed asset ratio (*FIX*) of 0.225 , an average market value to book value ratio (*MB*) of 0.616 , an average sales growth (*Grow*) of 0.441 , and an average stock turnover rate (*TurnR*) of 1.656 .

We use univariate test to show the impact of foreign executives on the stock price synchronicity. **Table 3** reports the results. The mean (median) of stock price synchronicity is -0.389 (-0.303)

TABLE 1 | Sample distribution.

Year	N	Foreign_N	Foreign_D = 1	Foreign_E = 1	Foreign_W = 1
2008	1,361	239	158	91	105
2009	1,395	256	176	103	114
2010	1,637	423	266	149	184
2011	1,938	536	343	212	231
2012	2,188	641	432	264	290
2013	2,248	677	469	286	315
2014	2,206	747	496	299	343
2015	2,283	856	558	335	390
2016	2,463	951	633	377	450
2017	2,838	1,193	760	446	559
2018	3,248	1,343	867	466	665
Total	23,805	7,862	5,158	3,028	3,646

for the firms with foreign experienced executives and -0.303 (-0.209) for the firms without these talents. The differences are statistically significant at the 1% level, which means that firms with foreign experienced executives have lower stock price synchronicity than firms without these talents.

Basic Regression Results

The Impact of Executives' Foreign Experience on Stock Price Synchronicity

First, we discuss the influence of executives with foreign experience on stock price synchronicity. The main results of Equation 3 are reported in **Table 4**. Columns (1) and (2) show that *Foreign_N* and *Foreign_D* are negatively related to *SYN* at the 1% significance level, indicating that executives with foreign experience decrease the stock price synchronicity significantly. Specifically, the coefficient on executives with foreign experience (*Foreign_N*) in Column (3) is -0.040 , and the coefficient on *Foreign_D* in Column (4) is -0.062 . After controlling year and industry effects, as shown in Columns (3) and (4) of **Table 4**, executives with foreign experience can significantly reduce stock price synchronicity, both statistically and economically. This verifies Hypothesis 1. For the control variables, the results in **Table 4** show that firm performance, leverage, and stock turnover rate are significantly and negatively related to stock price synchronicity, which indicates that firms with better financial performance, more leveraged firms, and firms with higher stock turnover rate could reduce stock price synchronicity. However,

firm size is positively and significantly related to stock price synchronicity, suggesting that larger firms have higher stock price synchronicity. The coefficients on fixed asset ratio are found to be insignificant. The coefficients on the control variables are generally consistent with prior studies (Gul et al., 2010; Boubaker et al., 2014; Shen et al., 2021).

Mechanism Analysis

The Mediating Effect of Corporate Social Responsibility

Corporate Social Responsibility (CSR), as an important sustainable development behavior for a firm, significantly encourages investors to collect and trade on proprietary information and improve informative disclosure efficiency (Gelb and Strawser, 2001). Therefore, the returnee executives might promote the incorporation of firm-specific information into stock prices, through CSR practices. Further, we examine the mediating role of CSR underlying the effect of executives with foreign experience on stock price synchronicity. As shown in **Table 5**, we find that the coefficient estimates of *Foreign_N* and *Foreign_D* are negative and significant at the 1% level. Meanwhile, the coefficients on *Foreign_N* and *Foreign_D* are 0.039 and 0.066, respectively; both are significant at the 1% level, which indicates that the quality of CSR activities managed by foreign executives is higher. The regression results of Equation 5 are shown in Column 3 of **Table 5**, and CSR is negatively related to *SYN* at the 1% level, suggesting that the higher the quality

TABLE 2 | Descriptive statistics.

Variable	N	Mean	Std Dev	Min	p25	p50	p75	Max
SYN	23,805	-0.322	0.931	-3.247	-0.864	-0.227	0.329	1.515
Foreign_N	23,805	0.330	0.740	0.000	0.000	0.000	0.000	4.000
Foreign_D	23,805	0.217	0.412	0.000	0.000	0.000	0.000	1.000
CSR	23,805	38.658	12.319	13.330	30.198	36.014	44.609	89.003
Size	23,805	22.061	1.288	19.617	21.121	21.884	22.805	26.022
ROA	23,805	0.039	0.054	-0.192	0.014	0.037	0.066	0.192
Lev	23,805	0.436	0.210	0.050	0.268	0.433	0.598	0.892
Grow	23,805	0.441	1.292	-0.689	-0.036	0.133	0.432	9.631
FIX	23,805	0.225	0.168	0.002	0.094	0.190	0.322	0.721
MB	23,805	0.616	0.240	0.118	0.430	0.619	0.803	1.112
TurnR	23,805	1.656	1.256	0.000	0.749	1.318	2.218	12.863

TABLE 3 | Univariate analysis.

Variable	Foreign_D = 1			Foreign_D = 0			Differences	
	N	Mean	Median	N	Mean	Median	Mean Diff.	Median Diff.
SYN	5,158	-0.389	-0.303	18,647	-0.303	-0.209	-0.086***	-25.947***
Size	5,158	22.204	21.959	18,647	22.021	21.864	0.182***	14.521***
ROA	5,158	0.043	0.041	18,647	0.038	0.036	0.004***	45.809***
Lev	5,158	0.412	0.409	18,647	0.443	0.439	-0.031***	-40.353***
Grow	5,158	0.403	0.145	18,647	0.451	0.130	-0.048**	8.038***
FIX	5,158	0.197	0.166	18,647	0.233	0.198	-0.035***	-109.709***
MB	5,158	0.603	0.599	18,647	0.619	0.624	-0.017***	-21.653***
TurnR	5,158	1.571	1.235	18,647	1.680	1.340	-0.109***	-26.847***

*, **, and *** refer to 10, 5, and 1% levels of significance, respectively.

of CSR engagement, the less stock price synchronicity. Thus, the results support our hypothesis (H2) that returnee executives reduce a company’s stock price synchronicity by improving the quality of CSR engagement. Because of the existence of principal-agent problems, managers have short-decision horizons (Antia et al., 2010). Thus, self-interested managers may make investment decisions at the expense of company prospects and hide bad news from the market for self-interested motivation (Kim et al., 2014). Returnee executives are more likely to reduce managerial myopia, pursue long-term investment activities, and improve governance quality, which leads to improving CSR engagement quality (Zhang et al., 2018).

Endogeneity Issues and Robustness Test

The relationship between returnee executives and stock price synchronicity investigated in this paper may be affected by other unobservable factors, which may result in endogeneity problems. To address the potential endogeneity issue, we perform difference-in-difference analysis, propensity score matching procedure, Heckman two-step sample selection model, and firm fixed effect model.

The Difference-in-Difference Analysis

To alleviate the concern that endogeneity related to omitted variables biases our main finding, we use the exogenous labor

supply shock events as a natural experiment to implement the difference-in-difference (DID) analysis. “Since the labor market for board directors is local, the policies to attract highly skilled returnee migrants led to arguably exogenous increases in the supply of potential directors with foreign experience in different provinces at different times,” as argued by Giannetti et al. (2015). The rationale is that, from the late 1990s, a series of provincial governments’ programs aimed at attracting skilled returnees has acted as a form of the so-called human capital supply shock. However, in the recent years, we find that the time of returnee talent introduction policies is different across different cities. By expanding the research depth of exogenous shock (Giannetti et al., 2015), we manually collect the microdata of municipal returnee talent introduction policies, using new city-level regulations for talent returnees as exogenous labor supply shocks, to test whether returnee executives behave differently from non-returnees. We then estimate the following DID regression model:

$$SYN_{i,t} = \alpha + \beta_1 Treat_{i,t} \times Post_{i,t} + \sum Control + Industry + Year + \epsilon_{i,t} \quad (6)$$

TABLE 4 | The effect of returnee executives on stock price synchronicity.

Variable	SYN			
	(1)	(2)	(3)	(4)
Foreign_N	-0.053*** (-6.57)		-0.040*** (-5.54)	
Foreign_D		-0.096*** (-6.63)		-0.062*** (-4.94)
Size	0.093*** (15.01)	0.092*** (14.93)	0.120*** (18.62)	0.119*** (18.48)
ROA	-0.123 (-0.98)	-0.126 (-1.00)	-0.677*** (-5.89)	-0.675*** (-5.87)
Lev	-0.291*** (-8.06)	-0.291*** (-8.06)	-0.469*** (-14.00)	-0.467*** (-13.94)
Grow	-0.015*** (-3.28)	-0.016*** (-3.31)	-0.024*** (-5.39)	-0.024*** (-5.41)
FIX	0.085** (2.34)	0.081** (2.24)	-0.006 (-0.15)	-0.006 (-0.17)
MB	0.560*** (17.47)	0.560*** (17.48)	0.486*** (14.89)	0.488*** (14.96)
TurnR	0.034*** (6.34)	0.034*** (6.34)	-0.089*** (-16.24)	-0.089*** (-16.24)
Constant	-2.634*** (-21.34)	-2.614*** (-21.22)	-1.721*** (-13.33)	-1.699*** (-13.18)
Year	No	No	Yes	Yes
Industry	No	No	Yes	Yes
N	23,805	23,805	23,805	23,805
R ²	0.044	0.044	0.324	0.323

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

TABLE 5 | Mechanism analysis.

Variable	SYN	CSR	SYN	SYN	CSR	SYN
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign_N	-0.040*** (-5.54)	0.039*** (7.75)	-0.031** (-2.13)			
Foreign_D				-0.062*** (-4.94)	0.066*** (7.27)	-0.056* (-1.95)
CSR			-0.186*** (-4.31)			-0.188*** (-4.35)
Size	0.120*** (18.62)	0.000 (0.74)	0.120*** (18.55)	0.119*** (18.48)	0.000 (0.59)	0.118*** (18.40)
ROA	-0.677*** (-5.89)	-0.054*** (-3.17)	-0.698*** (-6.07)	-0.675*** (-5.87)	-0.054*** (-3.16)	-0.459*** (-13.69)
Lev	-0.469*** (-14.00)	0.020*** (4.54)	-0.461*** (-13.75)	-0.467*** (-13.94)	0.020*** (4.60)	-0.696*** (-6.06)
Grow	-0.024*** (-5.39)	0.004*** (4.03)	-0.023*** (-5.07)	-0.024*** (-5.41)	0.004*** (4.03)	-0.023*** (-5.09)
FIX	-0.006 (-0.15)	-0.055*** (-14.59)	-0.019 (-0.52)	-0.006 (-0.17)	-0.054*** (-14.51)	-0.020 (-0.53)
MB	0.486*** (14.89)	-0.015*** (-3.92)	0.487*** (14.92)	0.488*** (14.96)	-0.014*** (-3.87)	0.490*** (14.99)
TurnR	-0.089*** (-16.24)	0.003*** (4.62)	-0.090*** (-16.31)	-0.089*** (-16.24)	0.003*** (4.64)	-0.090*** (-16.31)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.721*** (-13.33)	0.883*** (10.70)	-1.922*** (-6.84)	-1.699*** (-13.18)	0.858*** (10.38)	-1.904*** (-6.78)
N	23,805	23,805	23,805	23,805	23,805	23,805
R ²	0.324	0.268	0.085	0.323	0.265	0.085

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Treat is a dummy variable, taking the value of one if a firm that had returnee talents and zero otherwise. *Post* is a dummy variable equal to one in the year that the local government of the listed company promulgates the policy on the introduction of overseas returnees and zero otherwise. Using this specification, we can investigate whether the governments' programs of attracting skilled returnees are beneficial to reduce the synchronicity of firms with returnees.

Table 6 shows the results of difference-in-difference analysis. Columns (1) and (2) report the results of the full sample. The coefficients on *Treat* × *Post* are -0.134 and -0.052 , respectively, and are significant at 1% level, indicating that the stock price synchronicity of the companies with skilled returnees decreases significantly after the staggered implementation of these regional regulations for talent returnees. The results help us to identify how talent returnees react to exogenous changes in the information environment.

Propensity Score Matching Procedure

To eliminate this problem and control self-selection bias caused by non-random factors as shown in prior studies, we use propensity score matching procedure following the prior studies (Yuan and Wen, 2018; Conyon et al., 2019). The first step is to predict the selection decision of returnee executives, by estimating a probit model of the binary outcome that equals

one if the firm hires an executive with foreign experience, with observable firm characteristics as explanatory variables. Second, we compare firms with foreign-experienced executives (i.e., treatment firms) to a sample of control firms with no foreign-experienced executives (i.e., control firms) matched on the propensity for a firm to appoint executives with foreign experience and then re-estimate model (3) using the treatment and matched control sample.

Table 7 reports the PSM procedure results. The results in Panel A show that firms that hired a returnee executive differ systematically from those that did not, indicating that the selection of executive with foreign experience is strongly endogenous with firm-level characteristics. To ensure that the matching is satisfactory, we assess covariate balance by testing whether the means and medians of the covariates differ between the treatment firms and matched control firms. As Panel B shows, there are no significant differences in the means of any covariates, indicating that the propensity score-matched control sample resembles the treatment firms along virtually all dimensions. At last, we re-estimate model (3) using PSM and report the regression results of our baseline model using the PSM sample. The results remain robust as shown in Panel C.

Heckman Two-Step Estimation

It is possible that the self-selection bias problem remains. A firm's decision to appoint an executive with foreign experience may be non-random, and it is likely that executives with foreign experience are more likely to be selected by the companies with low stock price synchronicity, which may cause a self-selection bias. In this case, we attempt to alleviate these concerns using the two-stage Heckman (1979) test. In the first step, we estimate a probit model with a binary dummy *Foreign_D* as the dependent variable, which equals 1 if a firm has at least one executive with foreign experience, 0 otherwise. Following the previous literature (Yuan and Wen, 2018), we conduct *Foreign_M*, which is the mean of the proportion of returnee executives in other companies in the same industry in the same year. In addition, we add the following determinants of appointing executives with foreign experience: *Size*, *ROA*, *Lev*, *Grow*, *FIX*, *MB*, *TurnR*, and *Foreign_M*. The year and industry effects are controlled. In the second stage, the inverse Mills ratio (IMR) is generated from the first step and then included to control for the potential sample selection bias.

Table 8 reports the regression results of Heckman model. The results of the first-step regression show that *Size* and *Foreign_M* have significant and positive impacts on a firm's decision to appoint executives with foreign experience. The results of the second-step regressions indicate that after controlling the endogenous problems caused by self-selection bias, returnee executives still significantly reduce stock price synchronicity.

Firm Fixed Effect Model

To mitigate potential problems that may arise from omitting time-invariant firm-specific characteristics, we re-estimate the regressions of model (3) using the firm fixed effect model, when *SYN* is adopted as the dependent variable. The regression results of the fixed effect model are shown in **Table 9**. The results suggest that the estimated coefficients on the variable returnee

TABLE 6 | The difference-in difference approach.

Variables	SYN	
	(1)	(2)
<i>Treat</i> × <i>Post</i>	-0.134^{***} (-7.96)	-0.052^{***} (-3.58)
<i>Size</i>	0.093^{***} (14.63)	0.116^{***} (18.30)
<i>ROA</i>	-0.136 (-1.02)	-0.711^{***} (-6.12)
<i>Lev</i>	-0.297^{***} (-8.28)	-0.460^{***} (-13.94)
<i>Grow</i>	-0.014^{***} (-2.74)	-0.024^{***} (-5.21)
<i>FIX</i>	0.083^{**} (2.28)	0.003 (0.07)
<i>MB</i>	0.571^{***} (17.20)	0.487^{***} (15.08)
<i>TurnR</i>	0.043^{***} (7.37)	-0.093^{***} (-15.98)
<i>Cons</i>	-2.646^{***} (-21.10)	-1.642^{***} (-12.91)
<i>Year</i>	No	Yes
<i>Industry</i>	No	Yes
<i>N</i>	23,805	23,805
<i>R</i> ²	0.045	0.328

The *t*-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

TABLE 7 | PSM procedure.

Panel A: First stage of propensity score	
Variable	Foreign_D
Size	0.161*** (6.68)
ROA	-0.631*** (-2.07)
Lev	-0.499*** (-4.20)
Grow	-0.010 (-0.75)
FIX	-0.697*** (-4.69)
MB	-0.354*** (-3.35)
TurnR	-0.034** (-2.30)
Cons	-4.075*** (-8.11)
Year and Industry	Yes
N	23,805
Pseudo R ²	0.046

Panel B: Descriptive statistics for propensity-score matched subsamples

Variable	Foreign_D = 1	Foreign_D = 0	t-stat
Size	22.204	22.207	-0.12
ROA	0.043	0.041	1.26
Lev	0.412	0.412	0.03
Grow	0.403	0.392	0.51
FIX	0.197	0.199	-0.47
MB	0.603	0.611	-1.78
TurnR	1.571	1.553	0.75

Panel C: Sample matched by propensity score: second stage

Variables	SYN	
	(1)	(2)
Foreign_N	-0.037*** (-3.17)	
Foreign_D		-0.058*** (-2.77)
Size	0.118*** (7.55)	0.116*** (7.42)
ROA	-1.035*** (-4.77)	-1.033*** (-4.76)
Lev	-0.473*** (-6.65)	-0.467*** (-6.59)
Grow	-0.032*** (-3.07)	-0.032*** (-3.09)
FIX	-0.045 (-0.53)	-0.045 (-0.53)
MB	0.372*** (5.22)	0.376*** (5.26)
TurnR	-0.078*** (-7.11)	-0.078*** (-7.09)
Constant	-1.543*** (-4.89)	-1.496*** (-4.75)
Year	Yes	Yes
Industry	Yes	Yes
N	10,316	10,316
R ²	0.296	0.296

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

executives *Foreign_N* and *Foreign_D* are significantly negative at the 1% level. This implies that our results are not driven by time-invariant firm-specific characteristic, and the main findings are robust for endogeneity issues.

Other Robustness Checks Alternative Methods of Identifying Independent Variables

A total of three alternative approaches are considered to confirm the robustness of our results. First, we use alternative methods of identifying the independent variables of returnee executives. Following Zhang et al. (2018), we use the proportional variable (*Foreign_R*) as a new identifying method for returnee executives. Panel A of Table 10 shows the results. It is observed that the coefficient on *Foreign_R* is still significantly negative at the level of 1%, suggesting that after changing the independent variable identifying method, returnee executives can significantly reduce stock price synchronicity.

TABLE 8 | Heckman two-step estimation.

The first stage	The second stage		
	Foreign_D	SYN	
Variable	(1)	(2)	(3)
Foreign_N		-0.040*** (-5.63)	
Foreign_D			-0.064*** (-5.03)
IMR		-0.211** (-2.51)	-0.208** (-2.47)
Foreign_M	-10.258*** (-6.85)		
Size	0.162*** (14.41)	0.094*** (7.67)	0.093*** (7.60)
ROA	-0.621*** (-3.11)	-0.576*** (-4.74)	-0.576*** (-4.74)
Lev	-0.503*** (-8.37)	-0.388*** (-8.37)	-0.387*** (-8.35)
Grow	-0.010 (-1.24)	-0.022*** (-4.94)	-0.022*** (-4.96)
FIX	-0.689*** (-9.88)	0.109* (1.87)	0.107* (1.82)
MB	-0.369*** (-6.39)	0.542*** (13.69)	0.544*** (13.72)
TurnR	-0.035*** (-3.56)	-0.084*** (-14.03)	-0.084*** (-14.03)
Constant	-4.079*** (-17.35)	-0.888** (-2.49)	-0.878** (-2.46)
Year and Industry	Yes	Yes	Yes
N	23,805	23,805	23,805
Pseudo R ²	0.0485		
R ²		0.324	0.323

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

TABLE 9 | Firm fixed effect model.

Variable	SYN	
	(1)	(2)
Foreign_N	-0.030*** (-2.58)	
Foreign_D		-0.049** (-2.46)
Size	0.017 (1.20)	0.017 (1.19)
ROA	-0.560*** (-4.37)	-0.559*** (-4.36)
Lev	-0.096* (-1.80)	-0.095* (-1.78)
Grow	-0.022*** (-4.72)	-0.022*** (-4.72)
FIX	0.207*** (3.14)	0.209*** (3.19)
MB	0.685*** (15.89)	0.684*** (15.85)
TurnR	-0.145*** (-24.51)	-0.146*** (-24.53)
Constant	-0.170 (-0.60)	-0.166 (-0.59)
Firm	Yes	Yes
Year	Yes	Yes
N	23,805	23,805
R ²	0.332	0.332

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Alternative Methods of Identifying Dependent Variables

The regression results of changing the SYN calculation method of the dependent variable are shown in **Table 10**. Following the literature of Piotroski and Roulstone (2004) and Gul et al. (2010), we recalculated SYN2 and SYN3. The regression results prove that the above basic regression results are robust. Panel B of **Table 10** presents the results relating to alternative measures of stock price synchronicity. Similarly, the foreign experience variables are significantly and negatively associated with SYN2 and SYN3.

Adding Control Variables

Considering that the stock price synchronicity could be affected by the executives' foreign background as well as other characteristics, such as age, position, tenure, and so on, we add CEO duality, executives' age, and tenure, and we add more control variables (Krishnan and Parsons, 2008; Gul et al., 2010; Li et al., 2016). The results are tabulated in Panel C of **Table 10**. As the table shows, *Age* and *Tenure* is positively associated with stock price synchronicity, whereas *Dual* is negatively associated with stock price synchronicity. The relationship between executives' foreign experience and stock price synchronicity is significantly negative at the 1% level. Overall, the findings provide robust evidence that firms with returnee executives have lower stock price synchronicity.

TABLE 10 | Robustness tests.

Panel A: Alternative methods of identifying dependent variables				
Variable	SYN2			
Foreign_R	-0.172*** (-3.23)			
Control	Yes			
Year	Yes			
Industry	Yes			
Constant	-1.679*** (-13.06)			
N	23,805			
R ²	0.323			
Panel B: Alternative methods of identifying independent variables				
Variable	SYN2		SYN3	
	(1)	(2)	(3)	(4)
Foreign_N	-0.028*** (-4.63)		-0.048*** (-6.73)	
Foreign_D		-0.050*** (-4.56)		-0.091*** (-7.22)
Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Constant	-1.198*** (-10.63)	-1.186*** (-10.54)	-0.442*** (-3.46)	-0.425*** (-3.34)
N	23,805	23,805	23,805	23,805
R ²	0.339	0.339	0.436	0.437
Panel C: Robustness check: adding control variables				
Variable	SYN			
	(1)			(2)
Foreign_N	-0.034*** (-4.66)			
Foreign_D				-0.048*** (-3.78)
Size	0.106*** (16.36)			0.105*** (16.22)
ROA	-0.657*** (-5.73)			-0.655*** (-5.71)
Lev	-0.468*** (-14.00)			-0.466*** (-13.93)
Grow	-0.023*** (-5.14)			-0.023*** (-5.16)
FIX	-0.046 (-1.26)			-0.046 (-1.25)
MB	0.502*** (15.44)			0.505*** (15.51)
TurnR	-0.090*** (-16.30)			-0.090*** (-16.29)
Age	0.014*** (9.07)			0.013*** (8.99)
Dual	-0.056*** (-4.78)			-0.057*** (-4.87)
Tenure	0.001*** (3.71)			0.001*** (3.72)
Year	Yes			Yes
Industry	Yes			Yes
Constant	-2.076*** (-15.11)			-2.050*** (-14.95)
N	23,805			23,805
R ²	0.327			0.327

The t-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Further Analysis

Foreign Working Experience vs. Foreign Education Experience

Bernile et al. (2017) find that executives' different experiences or abilities have significant different impacts on executives' decision-making style and the signals they send to the capital market. In addition, prior researchers argue that the amount of international education in a management team contributes to corporate innovation and good performance (Yuan and Wen, 2018). Thus, we predict that executives with foreign study experience may have more significant impacts on stock price synchronicity than those with work experience. We construct two variables: *Foreign_E* is a dummy variable, which equals 1 if a firm has at least one executive with foreign education experience. *Foreign_W* is a dummy variable, which equals 1 if a firm has at least one executive with foreign working experience, and 0 otherwise.

We re-estimate model (3) and the regression results are shown in **Table 11**. From the regression results in Columns (1) and (2), we can see that the regression coefficient on executives with foreign working experience *Foreign_W* and those of foreign education experience *Foreign_E* are significantly at the 1% level, suggesting that both types of experience significantly reduce the stock price synchronicity.

SOEs vs. Non-SOEs

Considering the actual situation in China, state-owned enterprises are different from non-state-owned enterprises in terms of business operation, management structure, and external

environment. Previous studies have documented that SOEs are less efficient than private firms (Dewenter and Malatesta, 2001; Chen et al., 2017). In comparison with non-SOEs, SOEs may not effectively release the content of firm-specific information, and the lack of efficiency may hinder the process, which may lead to higher stock price synchronicity. Consequently, we argue that returnee executives in SOEs are less likely to reduce stock price synchronicity than those in non-SOEs.

We divide the sample into two groups, SOEs and non-SOEs, and employ the regression model (3) to verify whether the impact of returnee executives on the stock price synchronicity will be relatively different in terms of different property rights. The regression results are shown in Columns (3) and (4) of **Table 11**. This regression results indicate that returnee executives in non-SOEs can play their own role much better in reducing stock price synchronicity and have more incentives to release the content of stock price information than those in SOEs.

High Marketization vs. Low Marketization

Property right protection and financial development influence the information efficiency of the capital market by affecting the information collection cost and power of investors. Morck et al. (2000) believe that stock price synchronicity is affected by the strength of the legal system on the protection of property rights. When the property rights of investors cannot be fully guaranteed by law, the information reflecting the value of the company will become invalid. In areas with better legal environment, the

TABLE 11 | Further analysis.

Variable	<i>Foreign_W</i>	<i>Foreign_E</i>	SOEs	Non-SOEs	<i>MKT_high</i>	<i>MKT_low</i>
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Foreign_D</i>	-0.052*** (-2.78)	-0.083*** (-3.93)	-0.019 (-1.44)	-0.032** (-2.10)	-0.021 (-0.96)	-0.113*** (-4.06)
<i>Size</i>	0.120*** (17.20)	0.114*** (16.13)	0.095*** (10.35)	0.092*** (9.46)	0.027** (2.27)	0.075*** (5.94)
<i>ROA</i>	-0.751*** (-6.10)	-0.599*** (-4.79)	-0.156 (-0.90)	-0.849*** (-5.61)	-0.095 (-0.44)	-0.223 (-1.12)
<i>Lev</i>	-0.491*** (-13.81)	-0.472*** (-13.18)	-0.590*** (-11.95)	-0.427*** (-9.18)	-0.448*** (-6.94)	-0.614*** (-9.73)
<i>Grow</i>	-0.022*** (-4.68)	-0.023*** (-4.93)	-0.026*** (-4.37)	-0.022*** (-3.39)	-0.023*** (-2.51)	-0.043*** (-6.40)
<i>FIX</i>	0.014 (0.37)	-0.040 (-1.03)	-0.230*** (-4.68)	0.121** (2.17)	0.005 (0.07)	-0.154** (-2.48)
<i>MB</i>	0.500*** (14.35)	0.504*** (14.24)	0.591*** (12.20)	0.492*** (11.01)	0.917*** (14.33)	0.704*** (11.63)
<i>TurnR</i>	-0.092*** (-15.79)	-0.091*** (-15.27)	-0.081*** (-10.02)	-0.100*** (-13.62)	-0.081*** (-8.19)	-0.086*** (-9.31)
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Constant</i>	-1.729*** (-12.47)	-1.600*** (-11.38)	-1.101*** (-5.96)	-1.236*** (-6.37)	-0.488* (-1.89)	-0.617** (-2.47)
<i>N</i>	20,777	20,159	9,867	13,938	7,299	6,603
<i>R²</i>	0.325	0.323	0.336	0.305	0.332	0.344

The *t*-statistics reported in parentheses are based on standard errors clustered at the firm level. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

implementation of the law inhibits the information occupation of insiders and increases the information content of stock prices, which leads to lower stock price synchronicity (Fernandes and Ferreira, 2009). In that case, returnee executives play a limited role in improving information efficiency, and we predict that the effect of foreign experiences on reducing stock price synchronicity is more significant in regions with a low-degree marketization.

Following Bu et al. (2022), we use a marketization index *MKT* to represent the province-specified marketization degree and divide the sample into two groups. *MKT = high* is a dummy variable, which equals 1 if firm located in regions that the marketization level is higher than median value in a given year, and 0 otherwise. The results of further analysis are presented in Columns (5) and (6) of **Table 11**. It can be seen that the information transmission requires environment with better financial development and good property rights protection. The coefficient on *Foreign_D* in low degree of marketization subsets is negative and significant at the 5% level. However, the coefficient on *Foreign_D* is insignificant in sample with a high degree of marketization.

CONCLUSION

This manuscript examines whether and how executives' foreign experience and corporate social responsibility affect stock price synchronicity. Using the data of Chinese listed firms from 2008 to 2018, it provides evidence that returnee executives have a significantly negative effect on stock price synchronicity. Through mediating analysis, we find that the negative impact of returnee executives on stock price synchronicity is caused by CSR engagement, which is consistent with the benefits of foreign experience. We also find that the benefit of returnee executives is more pronounced for the non-SOEs or for firms located in regions with a low degree of marketization. Both foreign working experience and foreign education experience of the returnee executives can significantly reduce the stock price synchronicity. Robustness tests support the above results.

Our study emphasizes the importance of returnee executives and CSR practices for corporate sustainability, suggesting that the returnee executives hired by the Chinese listed firms can contribute to corporate information transmission, and they can help Chinese enterprises achieve long-term sustainable development. Based on our findings, we propose the following

recommendations. First, firms with knowledgeable and skilled returnee executives can enjoy several advantages; executives' foreign experience has a positive effect on firms' CSR strategy and international business integration. The government and enterprises should pay more attention to the executive incentive including executive compensation and policies on talents' introduction. Reasonable incentive and management mechanism should be established. Second, as the stock price synchronicity in emerging markets is much higher than that in the developed markets, identifying the elements that affect firms' information transparency has important practical implications. Therefore, to reduce the stock price synchronicity, listed firms should reduce information asymmetry by strengthening corporate governance, CSR practices, and increasing information disclosure quality. At the same time, the relevant regulators are supposed to strengthen the supervision of listed companies, curb the self-interest behavior of managers, and create a good condition for the sustainable development of enterprises. Finally, the sustainable development of enterprises is closely related to the stock price in the capital market. Firms should enhance their CSR engagement and reduce the risk of information asymmetry in their sustainable development, so as to win the trust of their investors in the capital market.

DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

DG and YZ contributed to the conception and design of the study. QT organized the database. DG and QT performed the statistical analysis. DG wrote the draft of the manuscript. YZ contributed to writing, reviewing, and editing. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This work was supported by the Modern Financial Theory Research Platform with Chinese Characteristics.

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Conflict of Interest: QT is employed by Shenzhen Branch of China Telecom Corporation Limited.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX

Appendix Table A1 | Variable definitions.

Variable	Definition
<i>SYN</i>	Logarithmic transformation of R^2 for the market model in Eq. 1, defined as $\log [R^2/(1 - R^2)]$, Following Morck et al. (2000), Jin and Myers (2006), and Boubaker et al. (2014) model.
<i>SYN2, SYN3</i>	Logarithmic transformation of R^2 , defined as $\log [R^2/(1 - R^2)]$, following Durnev et al. (2003) and Gul et al. (2010) model
<i>Foreign_N</i>	The number of executives with foreign experience
<i>Foreign_D</i>	A dummy variable defined as 1 if there is at least one returnee executive and 0 otherwise
<i>Foreign_W</i>	A dummy variable defined as 1 if there is at least one executive who has overseas working experience and 0 otherwise (only for further analyses)
<i>Foreign_E</i>	A dummy variable defined as 1 if there is at least one executive who has overseas education experience and 0 otherwise (only for further analyses)
<i>Foreign_R</i>	A proportional variable defined as the proportion of returnee executives of the total number of executives in the company.
<i>CSR</i>	The CSR score of the listed firm obtained from the Running's CSR report
<i>Size</i>	The natural logarithm of total assets
<i>ROA</i>	The company's net profit divided by the total assets
<i>Lev</i>	The value of liabilities divided by total assets
<i>Grow</i>	The annual growth rate of sales
<i>FIX</i>	The sum of fixed assets scaled by total assets
<i>MB</i>	The total market value divided by the book value of assets
<i>TurnR</i>	The total number of shares traded in a year, divided by the total number of shares outstanding at the end of the fiscal year
<i>Dual</i>	A dummy variable defined as 1 if the CEO is also the chairman of the board, and 0 otherwise.
<i>Age</i>	The log value of executives' age.
<i>Tenure</i>	The log value of number of years since an executive took office at that company.



To Share or Not to Share? The Role of Retailer's Information Sharing in a Closed-Loop Supply Chain

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OPEN ACCESS

Edited by:

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Specialty section:

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

Received: 12 May 2022

Accepted: 13 June 2022

Published: 18 July 2022

Citation:

Zhang H, Hong X and Cao X
(2022) To Share or Not to Share? The
Role of Retailer's Information Sharing
in a Closed-Loop Supply Chain.
Front. Psychol. 13:941952.
doi: 10.3389/fpsyg.2022.941952

Retailers are faced with a dilemma of whether to share demand information with other supply chain members, and if so, how to share it. Our research interest is motivated by the grounds that the value of downstream retailers' sales information to upstream manufacturers is to improve the accuracy of manufacturers' order forecasting. This problem is particularly important in the remanufacturing of closed-loop supply chains (CLSCs). In this study, we consider a retailer (she) as the demand information holder, who sells new and remanufactured products in wholesale to a manufacturer (he) and, simultaneously, she and the manufacturer competitively collect used products from the customers. We explicitly characterize the role of information sharing in a CLSC. We contributed to the information-sharing literature by integrating the existing information-sharing model with dual recycling channels and channel power structure. Previous literature suggests that retailers prefer to share demand information with other firms when the market demand is high. However, surprisingly, we find that when the manufacturer does not play a leading role, the retailer shares her forecast demand information with the manufacturer if the market demand is low. We also show that information sharing reduces the overall profit of the supply chain when the manufacturer dominates the market. In addition, our results also illustrate that information sharing affects the performance of the supply chain mainly by affecting the wholesale price.

Keywords: supply chain management, information sharing, remanufacturing, dual recycling channels, power structure

INTRODUCTION

Information sharing among members can enhance the coordination of the supply chain with the advances in information technology (Hosoda et al., 2015; Zhou et al., 2017; Li et al., 2021; Jain, 2022). Our research interest is motivated by the grounds that the value of downstream retailers' sales information to upstream manufacturers is to improve the accuracy of manufacturers' order forecasting, according to some empirical and theoretical researches on the value of information sharing. Better prediction accuracy may lead to lower safety inventory and better service for manufacturers (Cachon and Fisher, 2000; Chen et al., 2000; Chen and Lee, 2009). Cui et al. (2015) show that the improvement in the mean square forecast error for all studied products ranged from 7.1 to 81.1% if the company included the retailer's sales data into the demand forecast based on the

data collected from a consumer packaging company. In recent years, remanufacturing of closed-loop supply chains (CLSCs) has made a dent in industry and academia due to the scarcity of material resources (Govindana et al., 2015; Liu B. Y. et al., 2019; Aminipour et al., 2021; Qiao and Su, 2021; Soleimani et al., 2021; Zhang and Zhang, 2022). Although many studies have shown that remanufacturing can reduce production costs by 40–65%, Akçalı and Çetinkaya (2011) argue that compared to the traditional supply chain, the coordination problem is more sophisticated due to the uncertainty of the recycle rate and market demand in the CLSC.

Although many studies look at the retailer's decision about sharing demand information in the traditional supply chain (Li and Zhang, 2008), academic researches still ignore some gaps regarding information-sharing demand. Previous studies ignore the influence of dual recycling channels on the retailer's decision with regard to demand information sharing under different channel power structures. As far as we know, the retailer's decision on whether to share forecast demand information is very important for profits. When the retailer is the leader, she has more control over her information-sharing decision. In addition, compared with a single recycling channel, dual recycling channels have higher efficiency (Hong et al., 2013; Huang et al., 2013).

To bridge these gaps, we further expand the influence of dual recycling channels on the retailer's information-sharing decision in the CLSC under three power structures. We construct a CLSC model that considers three elements of information sharing, channel power structure, and dual recycling channels.

To answer the research question, we present a two-echelon game model to compare and analyze the supply chain members' optimal decisions to promote supply chain coordination under three-channel power structures (Jin et al., 2021). We assume that the two-echelon model has only two participants, the manufacturer and the retailer. The manufacturer sells new products and remanufactured products through the retailer. The manufacturer and retailer synchronously recycle used products from consumers and compete with each other. The retailer can forecast customer's demand information and has the right to determine whether to share forecast demand information. This study analyzes the optimal retailer's decision about demand information sharing when the manufacturer dominates the market, the retailer dominates the market, and the retailer and the manufacturer are equally matched in the market (i.e., there is no leader in the market).

This study provides several theoretical contributions and practical implications. First, we make a contribution to the information-sharing literature by integrating the existing information-sharing model with dual recycling channels and channel power structure. Second, we find some interesting results. When the manufacturer and the retailer compete to recycle used products, the retailer conceals her forecast demand information if the manufacturer dominates the market; the retailer shares her demand information with the manufacturer if the market demand is low, and the retailer plays a dominant role in the market. In the Nash game between the manufacturer and the retailer, the situation is similar to when the retailer is the leader in the market. Finally, this study provides

some valuable insights into the retailer's information-sharing decision. Information always is an important influencing factor for enterprises to make decisions. However, in reality, it is difficult for enterprises to obtain complete market information because when enterprises have private information, they can bring additional benefits; enterprises generally conceal their proprietary information from other participants. Motivating participants to share demand information is an important means to enhance supply chain performance.

The rest of this study is organized as follows. We review the related literature about information sharing, dual recycling channels, and channel power structure in section "Literature Review." We present our assumptions and model in sections "Descriptions" and "Model Framework." We analyze how dual recycling channels affect the retailer's information-sharing decision under the three power structures in sections "Comparison and Analysis of Results" and "The Value of Information Sharing." Finally, we give the conclusion in section "Numerical Examples." We put all the proofs in the **Supplementary Appendix**.

LITERATURE REVIEW

Our study relates to the literature on three dimensions: the literature on information sharing, the literature on dual recycling channels, and the literature on the channel power structure, each of which we review below.

The first stream is about information sharing. Many studies have explored the role of information sharing in the positive channel (Gal-Or et al., 2008; Li and Zhang, 2008; Chen and Lee, 2009; Shamir and Shin, 2015; Shang et al., 2016; Huang et al., 2018). They argue that retailers can induce manufacturers to cut wholesale prices by disclosing low demand and withholding high demand. Li (2002) considers that information sharing brings both "direct effects" and "indirect effects" to the manufacturer. The above researches focus on what is the retailer's condition for sharing her private information with other participants (Zhang Q. et al., 2019). A few studies have shown that manufacturers as participants in the supply chain can also share information in some cases where the manufacturer possesses better demand information than the downstream retailer (Jiang et al., 2016; Zhou et al., 2017; He et al., 2018). In addition, information sharing may occur between retailers and consumers (Liu Y. et al., 2019). Absolutely, some studies look at information sharing within an enterprise where the sales department is responsible for forecasting demand and the operations department is responsible for ordering (Scheele et al., 2018). An increasing number of studies are paying attention to information sharing in dual channels (Ha and Tong, 2008; Guo et al., 2014; Ha et al., 2017). Information sharing is beneficial to the supply chain, and the dominant strategy is to reduce the investment cost of information sharing in the supply chain with information sharing. A supply chain without information sharing has lower product sales by comparing the performance of the two types of supply chains (i.e., supply chains with and without information sharing). Existing researches focus on how information sharing

enhances the product sales in the traditional supply chain (Zhang and Zhang, 2020). Unlike existing studies, we consider how dual recycling channels affect the retailer's information-sharing decision in the CLSC.

The second stream is about dual recycling channels. Although the dual-channel problem has been mentioned frequently, most of the relevant studies focus on sales in dual forward channels; the following part discusses the application of dual channels in a CLSC (Li and Zhang, 2008; Bandyopadhyay and Paul, 2010; Ma et al., 2013; Feng et al., 2017; He et al., 2019). The manufacturer always faces the challenge of strategically designing the reverse recycling channel because the price competition is between two channels (Feng et al., 2017; Zhang S. G. et al., 2019; Shekarian et al., 2021). Most studies about dual recycling channels concern recycling by supply chain participants, such as manufacturers or retailers (Hong et al., 2013; Huang et al., 2013; Liu et al., 2017). Bulmus et al. (2014) study the recycling competition between an OEM and a third-party remanufacturer in a two-period closed-loop supply chain model. Some studies divide recycling channels into formal and informal recycling channels (Liu et al., 2016). As for dual-channel researches, most researches focus on how manufacturers design and choose the power channel to sell their products in the positive channel. However, only a few studies investigate the influence of dual recycling channels on the retailers' information-sharing decision on CLSCs (Lei et al., 2014). Few studies consider the interaction between information-sharing decision and dual recycling channels. Existing studies on remanufacturing primarily consider distribution channels and marketing competition (Shi et al., 2020; Nie et al., 2021). Apart from existing studies, we consider recycling competition in a double-recycling channel CLSC. We look at how the manufacturer can achieve efficient recycle of used products and how the retailer's information-sharing decision affects the recycle of used products different from the existing literature.

The third stream is about the channel power structure. The "power of the supply chain member" receives plentiful attention from academia in the CLSC, enterprises as well as in the mass media. Kadiyali et al. (2000) explains power in his research: The power is based on the proportion of channel profits obtained by each channel member. Power structure has attracted a lot of attention because the firm that has higher channel power gains more profit (Majumder and Srinivasan, 2008; Pan et al., 2010; Shi et al., 2013; Chen and Wang, 2015). Most of the existing literatures consider the market structure where the manufacturer dominates the market but ignore the market power of retailers and third-party recyclers (Savaskan et al., 2004; Raju and Zhang, 2005; Savaskan and Wassenhove, 2006; Chen et al., 2012). However, many examples of enterprises prove that there are strong retailers as the leader or the retailer and manufacturer are evenly matched in the market (Edirisinghe et al., 2011; Xiao et al., 2014; Luo et al., 2017). The influence of information sharing on dual channels is different under different power structures (Ha et al., 2011). There have been many researches on information sharing, dual recycling channels, and channel power structure in the CLSC, but only a few studies on the coordination among the three elements (Yue and Liu, 2006; Huang and Wang, 2017). Unlike

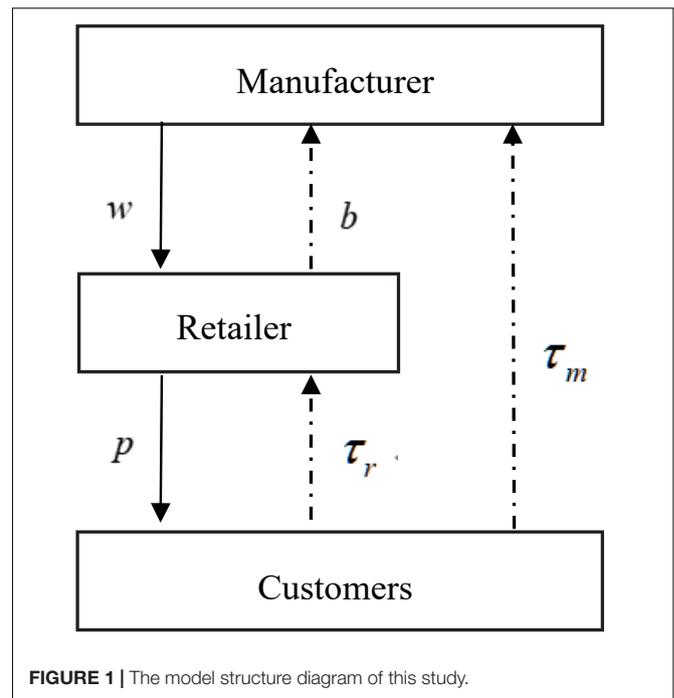


FIGURE 1 | The model structure diagram of this study.

previous studies that considered manufacturers usually playing a leading role in the market (Vedantam and Iyer, 2021), our research focuses on different channel power structures. Given the lack of the influence of different channel power structures on the information-sharing decision, we study how to make an optimal information-sharing decision under different power structures when the manufacturer and retailer synchronously recycle used products.

Based on the above considerations, this study structures a CLSC model that considers three elements of information sharing, channel power structure, and dual recycling channels, and studies the problems such as formulating pricing strategies, designing coordination contracts, and optimizing system efficiency in the CLSC.

DESCRIPTIONS

We structure a CLSC system that only has a monopoly manufacturer and a monopoly retailer in the market (Jin et al., 2021). As shown in **Figure 1**, the retailer purchases new and remanufactured products from the manufacturer at wholesale price w , and then sells products to customers at retailer price p in the forward channel. We assume that the retailer can predict the demand and has the right to decide whether to share this demand information. In the reverse channel, consumers can choose to recycle used products through the manufacturer or the retailer. In addition, the manufacturer recycles used products from the retailer by paying the transfer fee b and undertakes the remanufacturing operation.

We show the parameters involved in this study and their meanings in **Table 1**. π_i^j represents the profit of

member i in the supply chain in model j . The superscript $j \in \{M - S, M - N, R - S, R - N, M - R - S, M - R - N\}$ represent, respectively, the Stackelberg model that the manufacturer dominates the market with and without information sharing, the Stackelberg game model that the retailer dominates the market with and without information sharing, and the Nash model between the manufacturer and the retailer with and without information sharing. The subscript $i \in \{m, r, s\}$ represent, respectively, the manufacturer, the retailer and the supply chain system. V_i^l represents in model l the information value that information-sharing behavior of retail brings to supply chain participants i . The superscript $l \in \{M, R, M - R\}$ represent, respectively, the Stackelberg model that the manufacturer dominates the market, the Stackelberg model that the retailer dominates the market, and the Nash model between the manufacturer and the retailer.

We assume that the manufacturer produces new and remanufactured products (Nie et al., 2021). The manufacturer undertakes not only the business of directly using raw materials to produce new products, but also the business of remanufacturing used products. The unit production cost of a product made from old recycled products is lower than the unit production cost of a new product (i.e., $c_m > c_r$) (Jin et al., 2022). We make $\Delta = c_m - c_r$ and $\Delta > 0$, which means the unit production cost saved by the manufacturer in producing remanufactured products from the recycled used products. According to the research of Savaskan et al. (2004), we consider remanufactured products are indistinguishable from new products in terms of quality and function. They are invested in the market at the same retail price through the same channels. Consumers are equally willing to pay for new and remanufactured products (Huang et al., 2013). We assume that the market demand is $D = \alpha - \beta p$, where α is the potential market demand, β is the price elasticity coefficient, $\alpha > 0$, $\beta > 0$, $\alpha > \beta c_m$ (Kushwaha et al., 2022). Note that this linear demand function is widely used in remanufacturing CLSC literature (Rahmani et al., 2020; Zhou et al., 2021).

We consider that the manufacturer and retailer synchronously recycle used products. In this study, a represents the recycling competition intensity between the manufacturer and the retailer. The larger the a is, the more competitive the recycle is, and

$0 \leq a \leq 1$. Huang et al. (2013) have the same hypothesis that competition affects each other symmetrically. Consistent with Hong et al. (2017), we use the cost structure in Eq. (1) to describe the manufacturer and retailer recycling rates:

$$\tau_m = \sqrt{\frac{I_m - aI_r}{C_L}}, \tau_r = \sqrt{\frac{I_r - aI_m}{C_L}}, 0 \leq \tau_m + \tau_r \leq 1, 0 \leq a \leq 1 \tag{1}$$

Where, I_m and I_r represent, respectively, the fixed investment of the manufacture and the retailer in recycling used products. C_L is a scale parameter and assumed enough to ensure $\tau_T < 1$, where τ_T represents the total recycling rate.

The potential market demand α is a random variable, i.e., $\alpha = \alpha_0 + e$, where, α_0 is the part of the market where potential demand is determined. e is the uncertain part of market demand caused by indefinite elements. The expectation of random variable e is 0 and the variance is k (Ha et al., 2014).

Because the retailer is closer to customers than the manufacturer in the supply chain structure, she can use her structural advantages to predict the uncertain part of the market demand. The prediction of market information by the retailer can help supply chain participants make decisions. A large number of studies have made similar assumptions, such as Huang and Wang (2017). We set the market demand predicted by the retailer is f , and $f = \alpha + \varepsilon$, where ε is the error term whose expectation is 0 and variance is θ . Random variables e and ε are independent of each other. According to the research of Li (2002), we have the information structure assumption of Eq. (2):

$$E(\alpha|f) = \frac{\theta}{k + \theta} \alpha_0 + \frac{k}{k + \theta} f \equiv A, E((f - \alpha_0)^2) = k + \theta \tag{2}$$

We assume that t represents the accuracy of the retailer's prediction of market demand and $t \in (0, 1)$. There are two extremes: when $t = 0$, the predicted value of the market demand by the retailer is completely different from actual market demand. At this time, the accuracy of the prediction of the market demand by the retailer is the lowest. When $t = 1$, the predicted market demand by the retailer is exactly the same as the actual market demand. At this time, the accuracy of predicted market demand by retailer is the highest.

In our study, the manufacturer pays the retailer a transfer fee b when collecting used products from the retailer, where $0 \leq b \leq \Delta$. In order to simplify the derivation of the model, we assume that the fee for paying to consumers is zero, which has no change on the conclusion of our study. Savaskan and Wassenhove (2006) adopt the same assumption. Finally, we assume that products are produced according to orders, so the manufacturer and the retailer have no inventory cost when selling products (Li, 2002).

MODEL FRAMEWORK

This study considers that retailer has two options for the private demand information: (1) share demand information with the manufacturer and (2) withholding demand information from the manufacturer. Next, we consider three power structures

TABLE 1 | The description of the symbols.

Symbol	Descriptions
α	Potential market size
β	Coefficient of price elasticity
w	Wholesale price
ρ	Retailer price
c_m	Unit production cost of new product
c_r	Unit production cost of remanufactured product
b	The transfer price paid by the manufacturer to the retailer
τ_r	Retailer's recycling rate
τ_m	The manufacturer's recycling rate
a	Recycle competition intensity
π_i^j	The profit of member i of the supply chain in model j

with/without information sharing about customers' demand, namely the manufacture as a leader (Model M), the retailer as a leader (Model R), and the Nash game (Model M-R) under this assumption.

If the retailer hides her forecast demand information from the manufacturer, the manufacturer makes decisions only based on the determined part of market information, while the retailer makes decisions based on her own forecast of market demand. We describe the optimal expected profits of manufacturer and retailer as follows [Eqs. (3, 4)]:

$$\begin{aligned} \underset{p, \tau_r}{\text{Max}} E(\pi_r | f) &= ((p - w)(\alpha - \beta p) + b\tau_r(\alpha - \beta p) - \\ &\frac{C_L(\tau_r^2 + a\tau_m^2)}{1 - a^2} | f) \end{aligned} \quad (3)$$

$$\begin{aligned} \underset{w, \tau_m, b}{\text{Max}} E(\pi_m) &= [(w - c_m + \Delta(\tau_m + \tau_r))(\alpha - \beta p) - \\ &\frac{C_L(\tau_m^2 + a\tau_r^2)}{1 - a^2} - b\tau_r(\alpha - \beta p)] \end{aligned} \quad (4)$$

The manufacturer and retailer both make optimal decisions according to demand information by predicting if the retailer shares demand information. The target function of the retailer is calculated as per Eq. (3), and the manufacturer's expected profit decision model is as follows [Eq. (5)]:

$$\begin{aligned} \underset{w, \tau_m, b}{\text{Max}} E(\pi_m^{M-S} | f) &= [(w - c_m + \Delta(\tau_m + \tau_r))(\alpha - \beta p) - \\ &\frac{C_L(\tau_m^2 + a\tau_r^2)}{1 - a^2} - b\tau_r(\alpha - \beta p) | f] \end{aligned} \quad (5)$$

Model M

Manufacturers usually play a leading role in the market based on real business examples (Vedantam and Iyer, 2021). In this case, the manufacturer occupies the dominant position in the market and can make decisions in the game process in priority and according to the reaction of the retailer. As a follower of the market, the retailer makes decisions according to the decisions of the manufacturer. When selling products, the retailer can only determine the retail price of products according to the wholesale price determined by the manufacturer. The manufacturer and retailer synchronously recycle used products. The manufacturer reproduces the used products and puts them and new products in the market for sale.

At this point, we set the game sequence of the model as follows:

- (1) The manufacturer first determines the wholesale price w of new and remanufactured products, the manufacturer's recycling rate τ_m for used products, and the transfer price b to the retailer.
- (2) The retailer sets the retail price p of new and remanufactured products and the retailer's recycling rate τ_r for used products.

Propositions 1: When the manufacturer is the market leader without information sharing, the optimal decisions of the

manufacturer and retailer are as follows:

$$\begin{aligned} w^{M-N^*} &= \\ &\frac{[4C_L - \beta\Delta^2(1 - a^2)(2 - a)]\alpha_0 + [4C_L - \beta\Delta^2(1 - a^2)]\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(3 - a)]}, \\ p^{M-N^*} &= \frac{[6C_L - \beta\Delta^2(1 - a^2)(3 - a)]\alpha_0 + 2C_L\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(3 - a)]} + \\ &\frac{[6C_L - \beta\Delta^2(1 - a^2)(3 - a)]t(f - \alpha_0)}{\beta[8C_L - \beta\Delta^2(1 - a^2)(3 - a)]}, \\ \tau_m^{M-N^*} &= \frac{\Delta(1 - a^2)(\alpha_0 - \beta c_m)}{8C_L - \beta\Delta^2(1 - a^2)(3 - a)} \text{ and } \tau_r^{M-N^*} = \frac{\Delta(1 - a^2)(\alpha_0 - \beta c_m)}{8C_L - \beta\Delta^2(1 - a^2)(3 - a)} + \\ &\frac{\Delta(1 - a^2)t(f - \alpha_0)}{8C_L - \beta\Delta^2(1 - a^2)(3 - a)} \end{aligned}$$

Propositions 2: When the manufacturer is the market leader with information sharing, the optimal decisions of the manufacturer and retailer are as follows:

$$\begin{aligned} w^{M-S^*} &= \\ &\frac{[4C_L - \beta\Delta^2(1 - a^2)(2 - a)]}{[\alpha_0 + t(f - \alpha_0)]} + \frac{[4C_L - \beta\Delta^2(1 - a^2)]\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(3 - a)]}, \\ p^{M-S^*} &= \frac{[6C_L - \beta\Delta^2(1 - a^2)(3 - a)]}{[\alpha_0 + t(f - \alpha_0)]\alpha_0} + \frac{2C_L\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(3 - a)]}, \\ \tau_m^{M-S^*} &= \frac{\Delta(1 - a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{8C_L - \beta\Delta^2(1 - a^2)(3 - a)} \text{ and} \\ \tau_r^{M-S^*} &= \frac{\Delta(1 - a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{8C_L - \beta\Delta^2(1 - a^2)(3 - a)} \end{aligned}$$

Model R

Nowadays, there are more and more large retailers, such as the famous retailers (i.e., Wal-Mart, Carrefour, Su-Ning, and JD.com), gradually becoming the dominant force in the market. The following study structures a Stackelberg CLSC model with the retailer as the leader. Retailers are the closest members to consumers in CLSC. They always play an increasingly significant role in improving supply chain performance. Under this model, the retailer dominates the market and decides first in the game process. The manufacturer is the follower and makes decisions according to the decisions of the retailer. The retailer and manufacturer are still competing in the reverse channel for recycling used products. Then the manufacturer takes on the remanufacturing business.

At this point, we set the game sequence of the model as follows:

- (1) The retailer first determines the retail price p of new and remanufactured products and the retailer's recycling rate τ_r for used products.
- (2) Then, the manufacturer determines the wholesale price w of new and remanufactured products, the manufacturer's recycling rate τ_m for used products and the transfer fee b to the retailer.

Propositions 3: When the retailer is the market leader without information sharing, the optimal decisions of the manufacturer and retailer are as follows:

$$w^{R-N^*} = \frac{[2C_L - \beta\Delta^2(1 - a^2)]\alpha_0 + [6C_L - \beta\Delta^2(1 - a^2)(1 - a)]\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(2 - a)]},$$

$$p^{R-N^*} = \frac{[6C_L - \beta\Delta^2(1 - a^2)(2 - a)][\alpha_0 + t(f - \alpha_0)] + 2C_L\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(2 - a)]},$$

$$\tau_m^{R-N^*} = \frac{\Delta(1-a^2)(\alpha_0 - \beta c_m)}{8C_L - \beta\Delta^2(1-a^2)(2-a)} \text{ and } \tau_r^{R-N^*} = \frac{\Delta(1-a^2)(\alpha_0 - \beta c_m)}{8C_L - \beta\Delta^2(1-a^2)(2-a)} + \frac{\Delta(1-a^2)t(f - \alpha_0)}{8C_L - \beta\Delta^2(1-a^2)(2-a)}$$

Propositions 4: When the retailer is the market leader with information sharing, the optimal decisions of the manufacturer and retailer are as follows:

$$w^{R-S^*} = \frac{[2C_L - \beta\Delta^2(1 - a^2)]}{[\alpha_0 + t(f - \alpha_0)]} + \frac{[6C_L - \beta\Delta^2(1 - a^2)(1 - a)]\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(2 - a)]},$$

$$p^{R-S^*} = \frac{[6C_L - \beta\Delta^2(1 - a^2)(2 - a)]}{[\alpha_0 + t(f - \alpha_0)]} + \frac{2C_L\beta c_m}{\beta[8C_L - \beta\Delta^2(1 - a^2)(2 - a)]},$$

$$\tau_m^{R-S^*} = \frac{\Delta(1-a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{8C_L - \beta\Delta^2(1-a^2)(2-a)} \text{ and } \tau_r^{R-S^*} = \frac{\Delta(1-a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{8C_L - \beta\Delta^2(1-a^2)(2-a)}$$

Model M-R

In reality, although market forces gradually shift to retailers, retailers are not always strong enough to dominate the market. There are also situations where manufacturers and retailers are evenly matched in the market, where they make decisions at the same time. In this mode, the manufacturer and the retailer still conduct competitive recycling of used products in the market. The manufacturer undertakes the business of recycling used products for reproduction. Apple, for example, and its retailers recycle used phones and computers at the same time.

At this point, we set the game sequence of the model as follows:

The manufacturer determines the wholesale price w , the recycling rate τ_m and the transfer price b to the retailer. The retailer simultaneously determines the retail price p and the recycling rate τ_r .

Propositions 5: The optimal decisions of the manufacturer and retailer are as follows in the Nash game between the manufacturer and the retailer without information sharing:

$$w^{M-R-N^*} = \frac{[2C_L - \beta\Delta^2(1 - a^2)]\alpha_0 + [4C_L - \beta\Delta^2(1 - a^2)]\beta c_m}{\beta[6C_L - 2\beta\Delta^2(1 - a^2)]},$$

$$p^{M-R-N^*} = \frac{[4C_L - 2\beta\Delta^2(1 - a^2)][\alpha_0 + t(f - \alpha_0)] + 2C_L\beta c_m}{\beta[6C_L - 2\beta\Delta^2(1 - a^2)]},$$

$$\tau_m^{M-R-N^*} = \frac{\Delta(1-a^2)(\alpha_0 - \beta c_m)}{6C_L - 2\beta\Delta^2(1-a^2)} \text{ and } \tau_r^{M-R-N^*} = \frac{\Delta(1-a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{6C_L - 2\beta\Delta^2(1-a^2)}$$

Propositions 6: The optimal decisions of the manufacturer and retailer are as follows in the Nash game between the manufacturer and the retailer with information sharing:

$$w^{M-R-S^*} = \frac{[2C_L - \beta\Delta^2(1 - a^2)]}{[\alpha_0 + t(f - \alpha_0)]} + \frac{[4C_L - \beta\Delta^2(1 - a^2)]\beta c_m}{\beta[6C_L - 2\beta\Delta^2(1 - a^2)]},$$

$$p^{M-R-S^*} = \frac{[4C_L - 2\beta\Delta^2(1 - a^2)][\alpha_0 + t(f - \alpha_0)] + 2C_L\beta c_m}{\beta[6C_L - 2\beta\Delta^2(1 - a^2)]},$$

$$\tau_m^{M-R-S^*} = \frac{\Delta(1-a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{6C_L - 2\beta\Delta^2(1-a^2)} \text{ and } \tau_r^{M-R-S^*} = \frac{\Delta(1-a^2)[\alpha_0 + t(f - \alpha_0) - \beta c_m]}{6C_L - 2\beta\Delta^2(1-a^2)}$$

In this section, we obtain optimal decisions of the manufacturer and retailer using the backward induction method. We present these optimal decisions of the manufacturer and retailer and their profits in **Supplementary Appendix Tables 1, 2**. We then compare these results and present some interesting findings.

COMPARISON AND ANALYSIS OF RESULTS

In this section, we compare the results in Model M, Model R, and Model M-R. Moreover, we analyzed these results under the three power structures with or without information sharing and got the following propositions.

Proposition 7: The relationship of the optimal wholesale price is $w^M > w^{M-N} > w^R$. When $f > \alpha_0$, $w^S > w^N$, on the contrary $w^S \leq w^N$ when $f \leq \alpha_0$.

The manufacturer's profit is determined by the difference between the production cost and the wholesale price. When production cost is fixed, a higher wholesale price meets the manufacturer's expectation. Accordingly, when the manufacturer plays a leading role, the wholesale price is the highest. In the market, where the retailer dominates the market, the retailer takes priority in decision-making. Because the retailer is closer to the consumer, she can use its structural advantages and market forces to lower the wholesale price to improve her profit. On the contrary, when the manufacturer is the market leader, he can use his market power to set higher wholesale prices for higher profits.

Moreover, market demand affects the wholesale price from the manufacturer's point of view. In the game between the manufacturer and consumers, when the market demand is low, the manufacturer reduces the wholesale price to reduce the

possibility of unmarketable products. Instead, when demand is high, the manufacturer raises wholesale prices because he does not need to worry about sales. If the manufacturer finds that the demand that the retailer shares with him is higher than he knows, the manufacturer raises wholesale prices. At this point, the manufacturer knows that raising wholesale prices has only a small effect on profits because demand is enough. In contrast, if the manufacturer finds that the market demand is lower than he knows, he cuts the wholesale price for the sake of stimulating retailer to wholesale more products to not generate an inventory.

Proposition 8: The relationship of the optimal retail price is $p^R > p^M > p^{M-N}$, and $p^S = p^N$.

The retail price improves with the accuracy of retailers' forecasts of market demand. When the retailer is the market leader, she sets higher retail price to increase her profits. At this point, the difference in retail prices is not significant whether the manufacturer dominates the market or the retailer dominates the market. However, the retailer gets a higher profit when selling the same unit of products since the retailer can use her market power to force the manufacturer to set a lower wholesale price. The retailer sets the best retail price according to demand information she predicts when setting the wholesale price. Therefore, information-sharing decisions do not affect retail price, but it affects manufacturers' decisions about the wholesale price.

The retailer's information-sharing decision depends on the demand information she predicts. The retailer chooses not to share her forecast market information because it increases the wholesale price when the predicted market demand is large. When market demand observed by the retailer is small, the manufacturer reduces the wholesale price to simulate the retailer to sell products for the sake of avoiding loss caused by the small market demand. At this time, the retailer gains a higher unit profit, so the retailer decides to share her forecast market demand. The retailer formulates strategies to reduce the wholesale price for the sake of obtaining higher profits at a given wholesale price. We can get Corollary 1.

Corollary 1: Under a particular power structure, the retailer shares her forecast demand information if the market demand is low.

The retailer has the power to make an information-sharing decision. She makes decisions that tend to maximize her profits. The retailer chooses not to share her forecast demand information when her forecast market demand is large. However, she decides to share her forecast demand information when her forecast market demand is low. This is because that the wholesale price is directly proportional to the perceived market demand. The wholesale price is higher when the perceived market demand is higher. Higher wholesale price cuts into retailer's profits. Therefore, the retailer conceals her forecast demand information from the manufacturer for the sake of preventing the manufacturer from raising the wholesale price when the demand predicted by the retailer is higher than the demand known by the manufacturer.

Proposition 9: Under three power structures, the relationship between the manufacturer's and retailer's recycling rates

is, respectively, $\tau_m^R < \tau_m^M < \tau_m^{M-R}$ and $\tau_r^R < \tau_r^M < \tau_r^{M-R}$. The retailer's information-sharing decision influences the manufacturer's recovery rate, which is $\tau_m^N < \tau_m^S$ if $f > \alpha_0$, otherwise, $\tau_m^N \geq \tau_m^S$ if $f \leq \alpha_0$. The retailer's information-sharing decision does not influence retailer's recycling rate, i.e., $\tau_r^N = \tau_r^S$.

From proposition 9, we know that the manufacturer and retailer have the highest recycling rate in the Nash game model. From the supply chain perspective, the Nash game has an optimal recycling rate. The manufacturer and retailer have the lowest recycling rate for used products when the retailer dominates the market. From the perspective of information sharing, information sharing has no influence on the retailer's recycling rate for used products. While information sharing affects the manufacturer's rate.

Comprehensive information sharing affects the manufacturer's decisions. Information sharing itself is a part of the retailer's decision, and the retailer must have taken information sharing into consideration when making other decisions. Therefore, from the result, it is concluded that information sharing has no impact on the retailer's decision. Nevertheless, information sharing still affects the profits of the manufacturer and retailer because information sharing affects the manufacturer's decisions.

Proposition 10: When the retailer shares her forecast demand information, $\tau_r^S = \tau_m^S$. When the retailer chooses not to share her forecast demand information, if $f > \alpha_0$, $\tau_r^S > \tau_m^S$; Otherwise, $\tau_r^S \leq \tau_m^S$.

The recycling rates of the manufacturer and retailer are the same and increased with the accuracy of the forecast when the retailer shares her forecast demand information. When the retailer chooses not to share her forecast demand information, if the retailer observes a large market demand, the retailer's recycling rate is higher than that of the manufacturer. Conversely, the manufacturer's recycling rate is higher than the retailer's if the retailer observes a smaller market demand, which is consistent with Corollary 1.

The accuracy of forecasting market demand affects supply chain participants expected profit level. The manufacturer and retailer gain higher profit margins as forecasting accuracy improves. Therefore, the way to enhance the performance of the supply chain is to improve the accuracy of retailers' prediction of uncertain market demand.

Proposition 11: The relationship of the manufacturer's profit is $\pi_m^M > \pi_m^{M-R} > \pi_m^R$; The relationship of the retailer's profit is $\pi_r^R > \pi_r^{M-R} > \pi_r^M$.

Market demand determines the retail price, while the manufacturer's aware demand determines wholesale price according to Propositions 7 and 8. In terms of the channel power structure, the manufacturer's profit is the largest when the manufacturer dominates the market; analogously, the retailer's profit is the largest when the retailer dominates the market. Because members with dominant market forces can use their power to make decisions that are most favorable to them. For example, when the retailer is the leader in the market, she can use her power to compel the manufacturer to reduce wholesale price while raising retail price. It can be seen that the market power

structure has a great impact on the profit level of participants in CLSC. In general, leaders in the market can make more profits than those in other power structures.

Proposition 12: The relationship of market demand is $D^{M-R} > D^M > D^R$.

According to economic theory, market demand is inversely proportional to the retail price. According to Proposition 8, the retail price of products is the lowest and the consumer surplus is the largest in the Nash game model. Therefore, demand is greatest in Model M-R. From the perspective of market demand, the maximum market demand is definitely the best choice for the supply chain.

The wholesale price and retail price of products, the recycling rate of used products, and the profit level of participants all increase with the improvement of the accuracy of retailers' prediction of uncertain market demand. Therefore, the coordination of the supply chain always tends to balance the market power of the manufacturer and retailer.

We discuss how the retailer's information-sharing decision affects other decisions and profits of the manufacturer and retailer in this section. According to the above analysis, we know that information-sharing decisions are not always inclined to happen in CLSC. We discuss when the retailer shares her forecast demand information in the next section.

THE VALUE OF INFORMATION SHARING

We discuss when the retailer shares her forecast demand information in this section. According to the last section, the retailer's information-sharing decision is related to her profits. She has an incentive to share information if it makes her more profitable, or at least not less profitable. Next, we present the effect of information sharing on profit of supply chain under three power structures.

The information value to the manufacturer when the retailer shares forecast demand information in Model M, Model R, and Model M-R:

$$V_m^M = \pi_m^{M-S} - \pi_m^{M-N} = \frac{C_L kt [8C_L - \beta \Delta^2 (1 - a^2) (3 - 2a)]}{\beta [8C_L - \beta \Delta^2 (1 - a^2) (3 - a)]^2},$$

$$V_m^R = \pi_m^{R-S} - \pi_m^{R-N} = \frac{C_L kt [4C_L - \beta \Delta^2 (1 - a^2)]}{\beta [8C_L - \beta \Delta^2 (1 - a^2) (2 - a)]^2},$$

$$V_m^{M-R} = \pi_m^{M-R-S} - \pi_m^{M-R-N} = \frac{C_L kt [4C_L - \beta \Delta^2 (1 - a^2)]}{\beta [6C_L - 2\beta \Delta^2 (1 - a^2)]^2}$$

Proposition 13: Information sharing enhances the manufacturer's profits under three channel power structures.

Under the certain channel power structure, the retailer shares forecast market demand information, which increases manufacturer's profit. The increase in manufacturer's profits is in direct proportion to the accuracy of retailer's forecasts of market demand.

The information value to the retailer when the retailer shares forecast market demand information in Model M, Model R, and Model M-R:

$$V_r^M = \pi_r^{M-S} - \pi_r^{M-N} = \frac{-C_L kt [8C_L - \beta \Delta^2 (1 - a^2) (3 - 3a)]}{\beta [8C_L - \beta \Delta^2 (1 - a^2) (3 - a)]^2},$$

$$V_r^R = \pi_r^{R-S} - \pi_r^{R-N} = \frac{-C_L kt [4C_L - \beta \Delta^2 (1 - a^2) (2 - a)]}{\beta [8C_L - \beta \Delta^2 (1 - a^2) (2 - a)]^2},$$

$$V_r^{M-R} = \pi_r^{M-R-S} - \pi_r^{M-R-N} = \frac{-C_L kt [4C_L - \beta \Delta^2 (1 - a^2) (2 - a)]}{\beta [6C_L - 2\beta \Delta^2 (1 - a^2)]^2}$$

Proposition 14: Information sharing reduces the retailer's profits under three channel power structure.

The retailer's choice to share forecast demand information with manufacturers reduces the retailer's profit. But when the retailer is the leader in the market, the reduction in retailer's profits is the least.

Since the retailer shares the forecast market demand information, the retailer's profit gets lower. Therefore, without any compensation, retailer chooses not to share forecast market demand information. The manufacturer must pay the retailer some compensation to offset the retailer's profit loss for the sake of encouraging retailer to share her forecasts demand information. However, the compensation that the manufacturer pays to retailer should not be higher than the value of the information added by the forecast information shared by the retailer. Therefore, retailer is likely to share forecast market demand if information sharing increases the profit of the supply chain system.

The value to the supply chain system when the retailer shares forecast market demand information in Model M, Model R, and Model M-R:

$$V_s^M = V_m^M + V_r^M = \frac{-C_L kta \Delta^2 (1 - a^2)}{[8C_L - \beta \Delta^2 (1 - a^2) (3 - a)]^2} < 0,$$

$$V_s^R = V_m^R + V_r^R = \frac{C_L kt \Delta^2 (1 - a^2) (1 - a)}{[8C_L - \beta \Delta^2 (1 - a^2) (2 - a)]^2} > 0,$$

$$V_s^{M-R} = V_m^{M-R} + V_r^{M-R} = \frac{C_L kt \Delta^2 (1 - a^2) (1 - a)}{[6C_L - 2\beta \Delta^2 (1 - a^2)]^2} > 0$$

Proposition 15: Information sharing enhances the profit of supply chain when the manufacturer does not play leading role.

Information sharing reduces the overall profit of the supply chain when the manufacturer dominates the market. Therefore, in this condition, the retailer chooses not to share forecast demand information is the optimal decision for CLSC. Since manufacturer's dominant position in the market reduces the profit of the retailer, the profit level is lower if retailer shares

forecast demand information. Information sharing is beneficial to the manufacturer, but is bad for retailer. From the manufacturer's point of view, if the manufacturer pays a certain amount of compensation to the retailer to offset the retailer's profit loss, the manufacturer's profit is less than if he does not accept the information sharing, so the manufacturer chooses not to accept

information sharing. From the perspective of the retailer, if the manufacturer pays the retailer compensation without reducing his profit, then the maximum compensation that the retailer can obtain is not enough to make up for the decrease of the profit. Therefore, the retailer refuses to share proprietary information about their forecasts. From the perspective of supply chain performance, when the manufacturer dominates the market, the retailer shares the forecast market demand, which reduces the profit of the supply chain.

When the manufacturer does not play a leading role, information sharing improves the supply chain's profit. At this point, retailer has an incentive to share the forecast market demand information because the manufacturer has the ability to offset the loss of the retailer caused by information sharing.

Corollary 2: If the manufacturer does not play a leading role, the retailer shares her forecast market demand information when the manufacturer gives her a certain subsidy.

Through Propositions 13, 14, and 15, we can find that the retailer shares forecast market demand information if the retailer dominates the market or the manufacturer and retailer are evenly matched in the market. The retailer and manufacturer

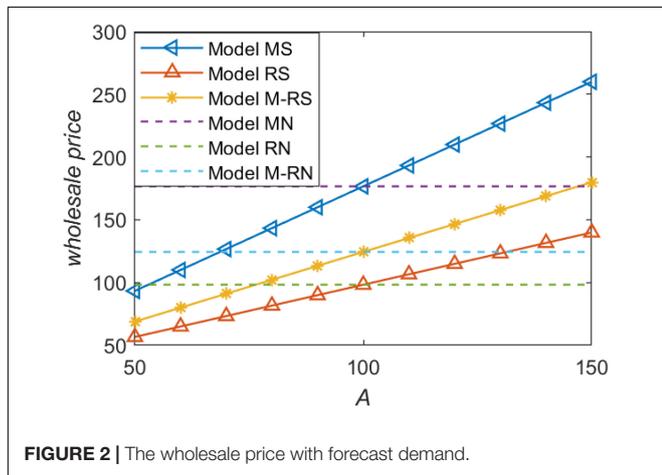


FIGURE 2 | The wholesale price with forecast demand.

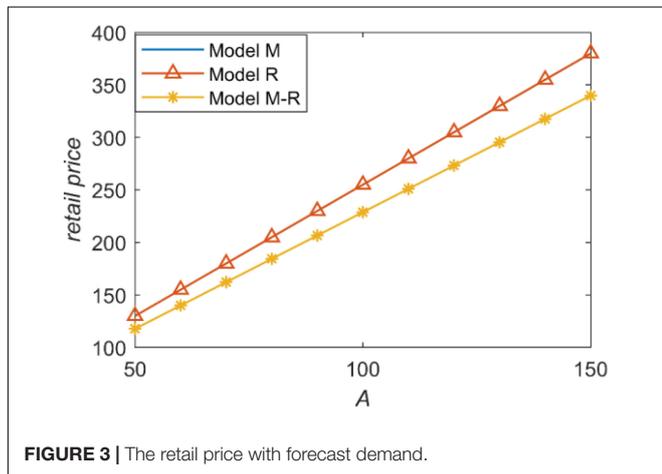


FIGURE 3 | The retail price with forecast demand.

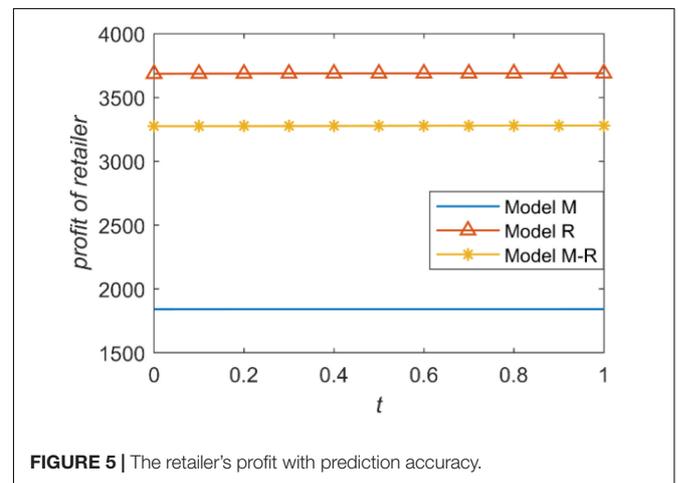


FIGURE 5 | The retailer's profit with prediction accuracy.

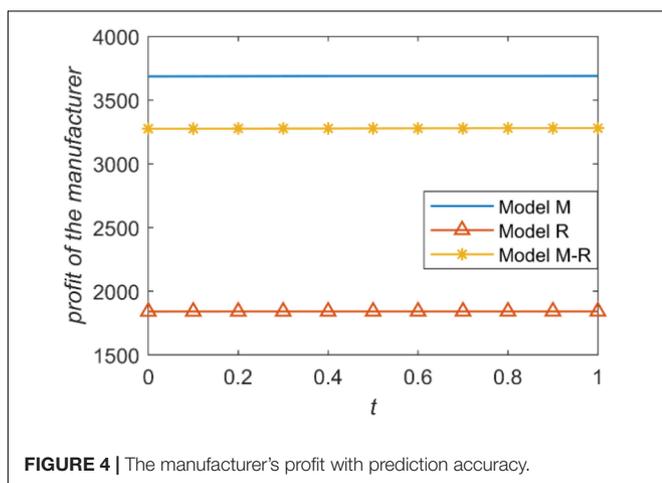


FIGURE 4 | The manufacturer's profit with prediction accuracy.

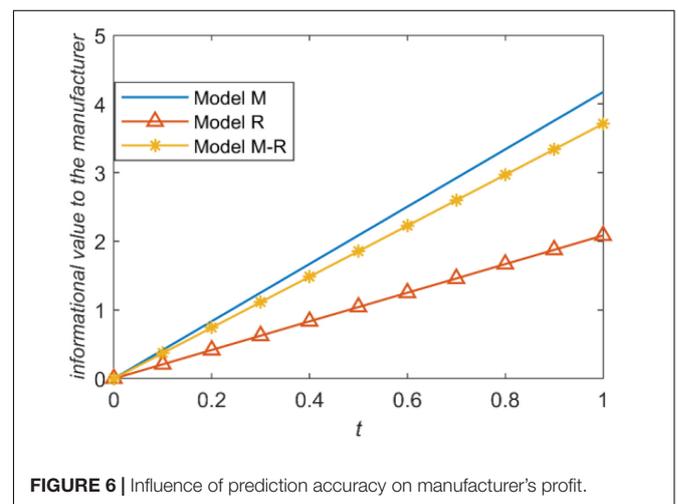


FIGURE 6 | Influence of prediction accuracy on manufacturer's profit.

conduct competitive recycling of used products at the same time in CLSC with dual recycling channels, retailer decides not to share forecast market demand information when the manufacturer dominates the market. When the retailer is a leader or the manufacturer and retailer are evenly matched in the market, because information sharing improves supply chain's profit, retailer shares forecast demand information when the manufacturer gives her a certain subsidy.

The retailer's first goal must be to protect her own interests. Based on the above analysis, we can draw the most important conclusion of this study. The retailer only shares forecast demand information when the manufacturer is not the leader and the market demand is relatively low.

NUMERICAL EXAMPLES

We present numerical examples to compare three channel power structures model with/without information sharing. Then we calculated $C_L = 1000$, $\beta = 0.3$, $c_m = 20$, $c_r = 15$, $b = \Delta = 5$, $a = 0.7$, $f = 150$, $\alpha_0 = 100$, $k = 10$, based on Huang et al. (2013) assignment, which is used for all of the parameters in this study. We intuitively show the relationship among variables (information sharing, wholesale price, retail price, and profit and information value).

We show the relationship between the wholesale price and forecast demand in **Figure 2**. If we set the situation without information sharing as the benchmark model, we can know from **Figure 1** that the wholesale price is higher than the benchmark model no matter under which channel power structure when the market demand predicted by the retailer is higher (i.e., $f > \alpha_0$). Consistent with Proposition 1, what is important to our conclusion is that, regardless of the channel power structure, wholesale price is lower than the benchmark model when the market demand predicted by the retailer is lower (i.e., $f < \alpha_0$). We must make it clear that lower wholesale price is definitely a better option for the retailer when the retailer only consider price. Therefore, the retailer chooses to hide the demand information to avoid the manufacturer raising the wholesale price when the market demand is high. The wholesale price is the highest when the manufacturer is the market leader.

Figure 3 shows that the retailer price is higher with the increase of forecast market demand. This conclusion is consistent with the classical cognition in economics. Regardless of channel power structures, the information-sharing decision does not affect the retail price, because the retailer decides the information-sharing decision and the retail price at the same time. Therefore, the retailer hopes that the wholesale price is low.

We present the relationship between the accuracy of forecast demand information and the profit of the manufacturer and retailer in **Figures 4, 5**. The profit of a supply chain member is proportional to the power he has. For example, when the manufacturer is the leader, he has the highest power and gets the highest profit. When the retailer is the leader, the manufacturer also gets the lowest profit because he has the least power. The retailer's profit is the opposite. **Figures 4, 5** intuitively reflect that

channel power structure has a greater impact on the profits of the supply chain rather than the accuracy of information prediction.

We present the influence of prediction accuracy of demand information on the manufacturer's profit under three power structures, as shown in **Figure 6**. According to **Figure 5**, information sharing brings the most value to the manufacturer when the manufacturer is the leader; information sharing brings the least value to the manufacturer when the retailer is the leader. Consistent with Proposition 7, information sharing always enhance the manufacturer's profit. The main reason that information sharing brings different information values to the manufacturer under different channel power structures is the influence of information sharing on wholesale price.

CONCLUSION

We structure a game model to compare and analyze the optimal decision under three channel power structures. We build a CLSC model that only has a manufacturer and a retailer. The retailer can predict market demand information and decide whether to share forecast demand information. This study analyses the impact of dual recycling channels on optimal information-sharing decisions in CLSC under three power structures.

We explicitly characterize the role of information sharing in a CLSC. Surprisingly, we find that when the manufacturer does not play a leading role, the retailer shares her forecast demand information with the manufacturer if the market demand is low. We also show that information sharing reduces the overall profit of the supply chain when the manufacturer dominates the market. In addition, our results also illustrate that information sharing affects supply chain profits by affecting the wholesale price. We make a contribution to the information-sharing literature by integrating the existing information-sharing model with dual recycling channels and channel power structure. Finally, this study provides some valuable insights into the retailer's information-sharing decision.

Information always is an important influencing factor for enterprises to make decisions. However, in reality, it is difficult for enterprises to obtain complete market information because when enterprises have private information, they can bring additional benefits, enterprises generally conceal their proprietary information from other participants. Motivating participants to share demand information is an important means to enhance supply chain performance. The conclusions are all based on the assumptions of this study, and some of the assumptions are only put forward to simplify the operation, which may not be consistent with the actual situation in the market. Future research can refine the model by relaxing the assumptions mentioned in this study. For example, Apple adopts a differential pricing strategy depending on the consumers' willingness to pay for new and remanufactured products. Future research can study how the information-sharing decisions of retailers in differential pricing affect the optimal decisions in CLSC with dual-recycling channels. We only consider the retailer's forecast for uncertain part of market demand. Future research can consider how the information-sharing decisions of

manufacturers and retailers affect the supply chain coordination when they simultaneously forecast the uncertain part of market demand. In general, used products are heterogeneous. However, our research regards used products as homogeneity, and future research can consider heterogeneous used products.

DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

HZ was responsible for conceptualization and methodology of the manuscript. XH was responsible for supervision, project administration, and validation of the manuscript. XC writing

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the original draft of the manuscript, and revised the manuscript according to the comments of reviewers. All authors contributed to the manuscript and approved the submitted.

FUNDING

This research was supported in part by the Natural Science Foundation of Guangdong Province (Grant No. 2021A1515011569) and “13th Five-Year Plan” Foundation of Philosophy and Social Sciences of Guangdong Province (Grant No. GD20CGL55).

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.941952/full#supplementary-material>

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 09 March 2022

ACCEPTED 01 July 2022

PUBLISHED 04 August 2022

CITATION

Cao Q, Zhou Y, Du H, Ren M and
Zhen W (2022) Carbon information
disclosure quality, greenwashing behavior,
and enterprise value.
Front. Psychol. 13:892415.
doi: 10.3389/fpsyg.2022.892415

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Carbon information disclosure quality, greenwashing behavior, and enterprise value

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As global warming becomes increasingly prominent, countries worldwide advocate for a low-carbon economy to cope with the pressure to reduce greenhouse gas emissions. The Chinese government has proposed a “dual carbon” goal of peaking carbon emissions by 2030 and becoming carbon neutral by 2060. The disclosure of carbon information by Chinese enterprises has attracted widespread attention from society. This study selects the constituents of the Social Responsibility Index of China Shanghai Stock Exchange from 2016 to 2020 as samples to empirically analyze the relationship between the level of carbon information disclosure and corporate value, and the moderating effect of greenwashing behavior. Results indicated that the quality of carbon disclosure is positively correlated with the enterprise value. Greenwashing behavior promotes the positive impact of carbon disclosure quality on enterprise value in the short run, but this promoting effect fades in the long run. We further found that the carbon information disclosure of non-heavy-pollution enterprises has a more obvious positive impact on enterprise value than that of heavily polluting enterprises. Additionally, the positive impact of carbon information disclosure on enterprise value is more visible among enterprises in a good legal environment than those in a poor legal environment. This study enriches the relevant literature on carbon information disclosure and enterprise “greenwashing” behavior and has practical significance for promoting China’s low-carbon development in the context of ecological civilization and improving the enthusiasm for the quality of enterprise carbon information disclosure.

KEYWORDS

carbon information disclosure, greenwashing behavior, enterprise value, dual carbon goal, corporate social responsibility

Introduction

Natural disasters and public health events caused by global warming have occurred frequently worldwide (Marino et al., 2016). Extreme weather, such as typhoons and tsunamis, has occurred continuously worldwide, posing a serious threat to the survival and development of humanity (Todea et al., 2013). In deteriorating living environments, there is a global consensus to curb greenhouse gas emissions and achieve the sustainable

development of human beings. Most countries believe that a low-carbon economy is an effective solution to the problem of climate change and has become the development trend of the current global economy (Ionescu, 2021; He et al., 2022).

As one of the largest carbon emitters in the world, China is also a participant in constructing a global ecological civilization and actively demonstrates its responsibility as a major country in the global carbon reduction course (He et al., 2022). In 2015, at the Paris Climate Conference, China committed to reduce carbon emissions per unit of GDP by 60%–65% from 2005 to 2030 (Tollefson, 2016). China launched a national carbon trading market covering major industries in 2017. In 2021, the State Council of China formulated the 14th Five-Year Plan for Energy Conservation and Emission Reduction to promote the all-around green transformation of economic and social development and help achieve the “dual carbon” goal. China’s economic development goals have shifted from high-speed growth to high-quality development. A series of policies successively issued by the Chinese government reflect the high importance of carbon emission reduction.

Being cells of the national economy, enterprises are the main sources of carbon emissions (He et al., 2022). As an important way for enterprises to show their carbon emission data and low-carbon behavior to stakeholders, carbon information disclosure has attracted increasing attention from academia and the public. Enterprises disclose social responsibility reports or sustainable development reports to the public to show that they actively undertake social responsibilities, such as environmental protection. Conversely, enterprises can use disclosed carbon information to analyze their environmental risks, avoid risks, seize opportunities, and improve enterprise value (Yan and Chen, 2017). Disclosed carbon information can be an important indicator for stakeholders in evaluating the effectiveness of corporate carbon emission reduction and serve as a window to convey signals of corporate low-carbon behavior. In this context, it is of great significance to study the impact of carbon information disclosure on enterprise value.

However, China’s current carbon enterprises still belong to the category of voluntary disclosure of information. The content and methods of carbon disclosure are not standardized, and information disclosure becomes formal. Under the natural opportunism tendency of enterprises and asymmetric information in the green market, enterprises may encounter adverse selection and moral hazards to meet external demand and obtain higher returns. They may adopt greenwashing strategies regarding disclosure content and depth to whitewash their environmental performance (Huang et al., 2019). The greenwashing phenomenon is a new type of unethical business behavior in response to environmental regulations and green management practices (Laufer, 2003). It is a response mode of social responsibility that adapts to form without making fundamental changes. Greenwashing is a means for enterprises to meet the needs of legitimacy and interact positively with stakeholders to establish a good corporate image (Huang, 2020). Greenwashing behavior also

has negative effects on enterprises. After exposure to this behavior, the cumulative excess return rate of an enterprise is significantly negative (Du, 2015), which also influences its green brand effect and corporate reputation, causing significant losses (Akturan, 2018). Existing studies have investigated the impact of greenwashing behavior on green buying (Akturan, 2018; Zhang et al., 2018) and corporate financial performance (Testa et al., 2018). However, few studies have discussed the relationship between greenwashing and enterprise value, and the moderating effect of greenwashing on the relationship between carbon information disclosure and enterprise value.

We used the Shanghai Stock Exchange Social Responsibility Index in selecting our sample enterprises. This index is a sample stock comprising the top 100 enterprises with social contribution value per share of corporate governance on the Shanghai Stock Exchange. It is composed of companies that have performed well in fulfilling their social responsibilities as sample stocks, and plays a leading role in disclosing the social responsibility information of listed companies. Research on carbon information disclosure and greenwashing behavior can encourage and promote other listed companies to actively fulfill their social responsibilities, deepen their environmental awareness, and enrich the sample selection for future research (Wang and Jin, 2013).

This study analyzed the impact of carbon disclosure and greenwashing behavior on enterprise value. It discusses the moderating effect of greenwashing behavior on the relationship between carbon disclosure and enterprise value. It further discusses the impact of industry and legal environment heterogeneities on the relationship between carbon disclosures and enterprise value. Existing literature has discussed the impact of carbon information disclosure on an enterprise value. However, few studies have focused on the greenwashing behavior of enterprises and applied it to empirical research. This study extends the research on the factors influencing enterprise value and enriches the theoretical research on carbon information disclosure and greenwashing. It innovates by using the specific characteristics and factors of the data and principal component analysis. It also builds the carbon disclosure quality of the evaluation system and introduces a floating green behavior recognition model applied to empirical research, which provides a new idea for future studies of carbon disclosure quality and floating green behavior indicators. In addition, the moderating effect of greenwashing is discussed from both short-term and long-term perspectives. A heterogeneity test of the industry and legal environment was also conducted in this study. The difference in the impact of carbon information disclosure on enterprise value for heavily polluting versus non-heavily polluting enterprises and for enterprises in good legal environments versus those in poor legal environments is investigated. Furthermore, this study has practical significance; it provides empirical evidence for enterprises to actively respond to the call for “double carbon” and operate low-carbon businesses to improve their corporate value. It provides a reference for government regulatory authorities and other stakeholders in evaluating the quality of

carbon information disclosure and supervising enterprises' greenwashing behaviors. It also regulates management's carbon information disclosure behavior from an organizational psychology perspective to enhance corporate value.

The remainder of this paper is organized as follows: Section "Literature Review and Hypothesis" presents the literature review and hypotheses; Section "Materials and Methods" presents the materials and methods and the empirical research design; Section "Results" presents the results and analyzes the empirical results; and Section "Conclusion, Revelations, and Limitations" provides the conclusion, revelations, and limitations of the study.

Literature review and hypothesis

Carbon information disclosure quality and enterprise value

The level of carbon information disclosure affects enterprise value, and domestic and foreign scholars have drawn different conclusions from different research perspectives. Enterprises with more carbon inputs or significant carbon performance tend to disclose more carbon information. Therefore, compared to enterprises with a lower level of carbon information disclosure, enterprises with a higher level of carbon information disclosure tend to take the initiative in carbon management and invest more capital, technology, and other resources. This affects the resource input of enterprises in business activities and other aspects, thereby reducing short-term performance to a certain extent (Liu et al., 2021). Additionally, suppose that illegal pollution is included in carbon information disclosed by enterprises. In this case, intangible pressure will also be brought to enterprises, making them passively invest more costs and resources for carbon control. This will also be detrimental to short-term performance and not conducive to enhancing the short-term value of the enterprise.

However, academics have arrived at the opposite conclusion in the long term. According to social responsibility theory, enterprises must undertake specific social responsibilities while creating value for themselves. The excellence of corporate governance lies in its ability to take on corporate social responsibility and thus promote growth (Akram et al., 2020). Environmental protection and reduction of carbon emissions are critical components of social responsibility. Global warming is becoming an increasingly serious issue. People increasingly focus on enterprise information disclosure of carbon. Carbon information disclosure includes strategy, governance, and measures to help stakeholders effectively make decisions. Meanwhile, when investors consciously and actively take responsibility for a good corporate image, it increases an enterprise's reputation (Horiuchi et al., 2009). As an essential intangible asset, corporate reputation can bring capital premiums to an enterprise. This can enhance the confidence of many investors, attract more investments, and improve enterprise value in the long run (Le et al., 2020).

According to organizational legitimacy theory, if an organization wants to survive for a long time, its behavior must conform to the values and norms recognized by the public. The carbon information disclosure of enterprises must conform to the corresponding legal standards and codes of conduct. This is conducive to enhancing the organization's legitimacy, alleviating the adverse impact of negative news on enterprises, gaining public recognition and support, and improving enterprises' long-term value (Liu et al., 2021).

Additionally, from the perspective of signal transmission theory, enterprises' disclosure of internal information alleviates the information asymmetry between enterprises and investors. It enhances the recognition and trust of investors in enterprises, thus increasing investment and improving enterprise value (Li et al., 2016). Enterprises that disclose higher-quality carbon information can convey a more competitive advantage signal to investors and other information users, establish a good corporate image, and thus stimulate investors' willingness to buy their stocks. This increases stock liquidity and promotes value creation. Thus, hypothesis one is proposed as follows:

H1: The quality of carbon information disclosure is positively correlated with enterprise value.

Carbon information disclosure quality, greenwashing behavior, and enterprise value

Short-term effects of greenwashing

Greenwashing enterprises can conduct impression management when they voluntarily disclose environmental information. Scholars at home and abroad have found through their research on corporate annual reports that enterprises influence information recipients' understanding of the company through self-serving attribution, manipulation of readability and comprehensibility, charts, and color rendering (Brennan et al., 2009). Greenwashing enterprises often use word games to make superficial appearances and use vague, ambiguous, and symbolic language to "whitewash" their environmental performance (Walker and Wan, 2012). From an organizational psychology perspective, senior executives' psychology also affects enterprises' carbon information disclosure. Senior executives, as corporate managers, are motivated to selectively disclose information that is beneficial to their interests (Lu et al., 2017). Enterprises often implement incentive measures for their management. This increases the possibility that senior executives choose to disclose information beneficial to their operations and management for their interests while deliberately concealing the information affecting the enterprise. From the viewpoint of new institutional economics, information asymmetry and human limited rationality provide favorable opportunities for enterprises' greenwashing behavior, which urges them to try to establish a responsible social image through lying and deception

(Xiao et al., 2013). Stakeholders are the inferior side of information, and their cognition of products mainly comes from advertising and their own experience (Leonidou et al., 2013), which also gives enterprises the opportunity to adopt greenwashing behavior to seek benefits for themselves. Carbon information is important non-financial information for a company, while disclosure information under greenwashing behavior shows more positive performance of carbon emission reduction responsibility and better environmental performance (Delmas and Burbano, 2011). Greenwashing behavior can improve a company's social recognition and stakeholders' expectations of the company's future behavior and performance, promote investor optimism (Gatti et al., 2021), and reduce expected risks, thus reducing the cost of equity capital for the enterprise. This improves the expected cash flow of the enterprise and promotes an improvement in enterprise value. In the short run, the greenwashing behavior of enterprises has not been perceived by the public. Through low-cost greenwashing, enterprises can avoid punishment and even improve their profits (Wang et al., 2015). Therefore, in the short run, this sends out a seemingly more transparent corporate signal, reflecting the enterprise's investment in maximizing stakeholders' interests. Greenwashing behavior can improve an enterprise's social recognition, promote investor optimism, and reduce expected risks, thus reducing the cost of equity capital of the enterprise. This improves the expected cash flow of the enterprise and promotes an improvement in enterprise value. Based on this, hypothesis two is proposed as follows:

H2: In the short run, greenwashing behavior promotes the positive effect of carbon information disclosure quality on enterprise value.

Long-term effects of greenwashing

Many researchers have studied the negative effects of greenwashing. Walker and Wan's (2012) study of two heterogeneous environmental responsibility response strategies, true green and greenwashing, found that although the true green strategy does not correlate with corporate financial performance, the "hypocritical" greenwashing strategy negatively impacts financial performance. Matejek and Goessling (2014) conducted a case study on BP suspected of greenwashing after an oil spill in the Gulf of Mexico. They found that BP's stock price dropped by approximately one-third after exposure to greenwashing and its market value evaporated by approximately 70 billion dollars. Wu et al. (2020) regard the Corporate Social Report (CSR) as a marketing gimmick. They developed a game-theoretic model of CSR investment to examine how information transparency affects a firm's strategies and social welfare and further identified the positive and negative aspects of greenwashing. Yu et al. (2020) pointed out that because the information on environmental social governance (ESG) disclosed by enterprises is not audited, the greenwashing behavior of enterprises may become an obstacle to incorporating ESG factors into investment decisions.

Greenwashing is a pseudo-social responsibility behavior. Some scholars have suggested that pseudo-social responsibility behaviors may cause a loss of overall social welfare or fail to promote social welfare (Fassin and Buelens, 2011). Even in the current institutional environment, the risk of corporate pseudo-social responsibility behavior being discovered is low; however, in the long run, it will eventually be exposed, and the false responsible image created by enterprises through pseudo-social responsibility behavior will eventually collapse (Xiao et al., 2013). Once the greenwashing behavior of enterprises is exposed, it will be regarded as "socially irresponsible" behavior, which will have negative effects on enterprises from multiple aspects, including punishment of enterprises by the capital market, resulting in a decline in shareholder wealth (Frooman, 1997). Janney and Gove (2011) believe that when the fake social responsibility of enterprises is perceived by consumers, they will not only feel betrayed, but also want to stay away from such enterprises. In the long run, brand loyalty will be lost, and customers will inform others of the pseudo-social responsibility behavior of enterprises, which will damage the reputation of enterprises. Furthermore, it can lead to a loss of confidence among consumers, investors, and non-governmental organizations (Painter-Morland, 2006; Jahdi and Acikdilli, 2009; Lyon and Montgomery, 2015). Greenwashing may create a short-term gain for deceptive companies; however, in the long run, the entire green market will experience a fall (Polonsky et al., 2010). If the environmental, social, and governance information disclosed by enterprises is unreliable, the greenwashing behavior of enterprises may become an obstacle to incorporating environmental, social, and governance factors into investment decisions (Yu et al., 2020). Over time, greenwashing damages investor confidence and provokes negative market feedback (Yang et al., 2020). At the same time, it inhibits investors' optimism, and the positive promotion effect of carbon information disclosure on enterprise value fades with it. Based on this, hypothesis three is proposed as follows:

H3: In the long run, the positive effect of greenwashing behavior on promoting the quality of carbon information disclosure on enterprise value fades.

Materials and methods

Sample and data sources

Unlike the semi-mandatory disclosure policy of social responsibility information disclosure, carbon information disclosure is voluntary. Hence, this study attempted to select samples with fewer missing values. According to Wang and Jin (2013), Shanghai Stock Exchange Social Responsibility Index is a sample stock comprising the top 100 enterprises with social contribution value per share of corporate governance on the Shanghai Stock Exchange. It is generally believed that information disclosure by constituent companies is relatively comprehensive.

By contrast, carbon information disclosure, which is part of environmental disclosure in social responsibility disclosure, has a lower missing value. However, considering that 2016–2020 was the implementation stage of China's 13th Five-Year Plan, a study on implementing energy conservation and emission reduction during this period will provide valuable experience and lessons for the performance of green development goals during the 14th Five-Year Plan.

Therefore, data from 100 enterprises in the Social Responsibility Index of the Shanghai Stock Exchange from 2016 to 2020 were selected as our research samples. Since the financial industry's participation in the carbon trading mechanism is different from the carbon emission reduction method and other industries, such as the traditional manufacturing industry and agriculture, its financial information cannot meet research needs. A total of 350 data samples were collected, after excluding financial enterprises and enterprises with missing data. Carbon and greenwashing information are mainly from corporate social responsibility and sustainability reports, while other data are from the China Stock Market and Accounting Research (CSMAR) database.

Dependent variable

The dependent variable was enterprise value (V). Li et al. (2017a, 2017b) consider Tobin's Q value considering the circumstances of the present and future of the enterprise as the company's market value and the ratio of the current replacement cost. It comprehensively embodies the present and future value of an enterprise's potential profitability and is more apt to measure enterprise value. Therefore, this study chooses Tobin's Q value to calculate the enterprise value.

Independent variables

Carbon information disclosure quality

The independent variable is the quality of carbon information disclosure (CID). This study followed the practices of Li et al. (2017a,b, 2019). Based on the four dimensions of carbon information disclosure in corporate reports (as shown in Table 1), a preliminary score is given to corporate social responsibility or sustainable development reports. Based on the scoring results, a quality evaluation model for carbon information disclosure was innovatively constructed. By using this model, we can obtain a more scientific quality index. This is convenient for studying the relationship between the carbon information disclosure quality of the sample enterprises under the influence of greenwashing and enterprise value.

Data introduction

As shown in Table 1, we have four first-level variables and 14s-level variables. They are "report disclosure time," "report

collection process," "review and verification," "graphic description," "professional terms," "carbon accounting quantification standard," "emission reduction strategy," "emission reduction target," "emission reduction management," "emission reduction risk," "emission reduction input," "emission reduction subsidy," "emission reduction accounting," and "emission reduction performance." All the variables above are categorical variables, and 13 of them have only three categories: 0, 1, and 2. The graphic description had four categories: 0, 1, 2, and 3. Because there is no given variable of carbon information disclosure in this data (it is not easy to obtain accurate values because it has excellent subjectivity and instability), we use unsupervised learning to analyze the data structure and then establish a formula for the carbon information disclosure model.

Correlation analysis

First, we tested the correlation analysis of the 14s-level variables. Two groups of variables with high correlation should have high collinearity. The approach used to analyze the correlation coefficient matrix is as follows: When the correlation coefficient of the two variables was higher than 0.7, a high correlation was observed. Meanwhile, the variables should be deleted or the sample size should be increased. The two groups of data with a correlation coefficient lower than 0.7 are not considered to be strongly correlated. K1–K14 represent 14 secondary variables, and their correlation coefficient matrices are listed in Table 2.

According to the correlation coefficient matrix results, all the correlation coefficients were less than or equal to 0.7. Therefore, this dataset has no correlation or collinearity.

Statistical description of variables

Table 3 provides a partial description of the statistics for the 14 variables, which facilitates a more intuitive understanding of the data.

According to the outcome in Table 3, the median of half of the variables is zero, which means that half of the variables have more than half the values of zero. The rest of the median does not reach 2, indicating that the data matrix is very sparse and corporate carbon information disclosure is fuzzy. Similarly, the mean values of none of the 14 variables' were higher than half of the range, except for the ninth variable, which barely exceeded 1 (the maximum of the fourth variable was 3; therefore, half of the content should be 1.5). The statistical description of the 14 variables shows that it is necessary to find appropriate methods to study carbon information disclosure and to promote its development.

Principal component analysis model

Because the original data did not provide artificial measurement data for carbon information disclosure, we could not make predictions through supervised learning models, such as a linear model, when constructing the formula. Instead, we can only build recipes by using the data themselves through

TABLE 1 Carbon information disclosure evaluation index system.

First-level variables	Second-level variables	Index scoring standard	Explanation
Timeliness	Disclosure time of the report	After annual report disclosure = 0; annual report disclosure or subsequent = 1	We need to check whether the carbon information disclosure (social responsibility report) is released in a reasonable time. Assign a value of 0 if the disclosure time is after the annual report disclosure; assign a value of 1, if it is before the annual report disclosure.
Reliability	Report collection process system	No system description = 0; relevant greenhouse gas description or calculation method = 1; detailed and complete process system description = 2	We need to check the description in the carbon information collection process system. Assign a value of 0 if there is no system introduction; assign a value of 1 if there is related greenhouse gas device description or calculation method introduction; assign a value of 2 if there is detailed and complete process system introduction.
	Examination and verification of evidence	No inspection = 0; social responsibility report authentication = 1; specialized carbon information disclosure authentication = 2	We need to check whether the disclosed carbon information is independently verified by a third party. If there is no verification or authentication of the carbon information disclosure, assign a value of 0; if there is verification of social responsibility report (carbon information is involved in the report, otherwise, it will be deemed as no verification), assign a value of 1; if there is special verification of the carbon information disclosure, assign a value of 2.
Comprehensibility	Picture and text description	None of the three = 0; only one of the three = 1; text + data = 2; synthesis of the three = 3	We need to check the balance of the use of text, data, and chart in the carbon disclosure information. If none, assign a value of 0; if there are only one of three, assign a value of 1; if there is text and data, assign a value of 2; if all three are combined, assign a value of 3.
	Professional term	No technical terms = 0; there are technical terms and no explanation = 1; there are technical terms with explanatory notes = 2	We need to check whether there are technical terms and their explanations in the carbon information disclosed (such as carbon dioxide equivalent, carbon sequestration). If there is no technical term, assign a value of 0; if there is a technical term but no explanation, assign a value of 1; if there is a technical term with an explanation, assign a value of 2.
Comparability	Quantitative standard of carbon accounting	No calculation methods and data = 0; there are popular standardized specific data = 1; there are calculation methods and specific data = 2	We need to check whether the carbon information accounting quantitative standards are unified. If no calculation method and data are available, assign a value of 0; if there is specific data of standardization, assign a value of 1; if there is calculation method and specific data, assign a value of 2.
Completeness	Emission reduction strategy	No explanation = 0; simple description = 1; detailed description = 2	We need to judge whether there is a description of a carbon emission reduction in the strategic plan. If no indication is given, assign a value of 0; if stated simply, assign a value of 1; if specified, assign a value of 2.
	Emission reduction target	Non-emission reduction target note = 0; qualitative description plan only = 1; qualitative + quantitative description plan = 2	We need to judge whether a carbon emission reduction target is disclosed in the report. If there is no description of the emission reduction target, assign a value of 0; if there is only a qualitative description of the plan, assign a value of 1; if there is a qualitative and quantitative description of the plan, assign a value of 2.
	Emission reduction management	Unreduced emission management note = 0; brief description = 1; detailed description = 2	We need to look at the establishment of functional emission reduction organizations, emission reduction management systems and other measures related to carbon emission reduction. If there is no emission reduction management description, assign a value of 0; if there is a simple description, assign a value of 1; if there is a detailed description, assign a value of 2.
	Emission reduction risk	No emission reduction risk note = 0; brief description = 1; detailed description = 2	We need to check whether the report contains descriptions of emission reduction risks such as non-emission reduction risks caused by government regulations, business risks caused by climate change, or possible loss of economic benefits caused by emission reduction. If there is no risk description for emission reduction, assign a value of 0; if there is a simple description, assign a value of 1; if there is a detailed description, assign a value of 2.
	Emission reduction input	No emission reduction input description = 0; qualitative description only = 1; qualitative + quantitative description = 2	We need to check whether the report shows the technical improvement and project investment for carbon emission reductions and the emission discharge fees and fines paid. If there is no description of emission reduction input, assign a value of 0, if there is only a qualitative description, assign a value of 1; if there is a qualitative and quantitative description, assign a value of 2.
Emission reduction accounting	Emission reduction subsidy	No explanation = 0; simple description = 1; detailed description = 2	We need to check whether the enterprise received any emission reduction subsidies or incentives from the government and other carbon information disclosure. If no indication is given, assign a value of 0; if stated simply, assign a value of 1; if specified, assign a value of 2.
	Emission reduction accounting	No accounting note = 0; qualitative description only = 1; qualitative + quantitative description = 2	We need to check whether the enterprise has disclosed carbon information such as accounting method, tons of energy saving and tons of emission reduction. If there is no description of the emission reduction target, assign a value of 0; if there is only a qualitative description of the plan, assign a value of 1; if there is a qualitative and quantitative description of the plan, assign a value of 2.
	Emission reduction performance	No explanation = 0; only qualitative description = 1; qualitative + quantitative description = 2	We need to check whether there is any economic benefit, environmental benefit, social benefit, honor, or other carbon information disclosure generated by emission reduction. If there is no description of the emission reduction target, assign a value of 0; if there is only a qualitative description of the plan, assign a value of 1; if there is a qualitative and quantitative description of the plan, assign a value of 2.

TABLE 2 Correlation matrix of second-level variables.

	k1	k2	k3	k4	k5	k6	k7	k8	k9	k10	k11	k12	k13	k14
k1	1													
k2	-0.15	1												
k3	-0.08	0.37	1											
k4	-0.11	0.44	0.49	1										
k5	-0.10	0.43	0.16	0.27	1									
k6	-0.06	0.59	0.36	0.59	0.56	1								
k7	-0.14	0.3	0.31	0.36	0.32	0.44	1							
k8	-0.07	0.33	0.19	0.19	0.34	0.41	0.56	1						
k9	-0.08	0.46	0.31	0.46	0.29	0.45	0.41	0.51	1					
k10	-0.04	0.17	0.12	0.23	0.31	0.37	0.26	0.27	0.2	1				
k11	-0.13	0.35	0.33	0.51	0.31	0.44	0.42	0.43	0.66	0.23	1			
k12	-0.46	0.16	0.11	0.2	0.07	0.08	0.16	0.14	0.16	0.17	0.15	1		
k13	-0.09	0.4	0.41	0.59	0.41	0.7	0.54	0.41	0.55	0.25	0.55	0.16	1	
k14	-0.16	0.38	0.35	0.54	0.27	0.42	0.33	0.44	0.58	0.22	0.66	0.19	0.53	1

unsupervised learning. It is worth noting that the more pronounced the 14 variables disclosed, the more obvious the carbon information should be disclosed. As the classification variables score each index, the higher the value, the higher the degree of carbon information disclosure. Therefore, the easiest method is to add all the data. However, the contribution of “variables” to carbon information disclosure will differ. Therefore, we need to introduce the concept of variable weight “W.” Principal component analysis (PCA) model describes the weight of each vector (variable) in the matrix through the eigenvalue of the matrix. The more influential the variable, the more significant the proportion of its weight. Therefore, according to the PCA model, we included the weights of 14 indicators in W1–W14. We can then construct a formula for carbon information disclosure:

$$Y = \sum_{i=1}^{14} W_i * k_i \tag{3.1}$$

Before calculating the weight k, we need to determine why PCA is appropriate for our research. First, the structure of the dataset satisfies the PCA method. Second, we used KMO and Bartlett’s tests to test whether PCA is good for this dataset. PCA is a good choice if KMO > 0.8, and Bartlett’s test is significant (<0.05). Based on Table 4, we conclude that PCA is a suitable research method.

We now need to determine the number of PCs (principal components) we need in our analysis. From Table 5, we should choose a PC whose eigenvalues are greater than 1. Therefore, we should choose the first four PCs and their variance percentages to calculate weight k and the final formulas.

Because we have determined that the number of PCs is four, we use the factor loading table or component matrix to calculate the weight k. The outcomes of the factor loading and component matrix in the first four PCs are listed in Table 6.

Then, we divide the values of each PC in Table 6 by the root of the eigenvalues of these PCs and product their ratios by considering only the first four PCs and percentages. Finally, we take the sum of all these new values of PCs to obtain the final values of weight k.

Therefore, we obtain the final formula of carbon information disclosure:

$$Y = \sum_{i=1}^{14} 0.0342 \times k_1 + 0.2104 \times k_2 + 0.1251 \times k_3 + 0.1759 \times k_4 + 0.2511 \times k_5 + 0.2861 \times k_6 + 0.1674 \times k_7 + 0.1526 \times k_8 + 0.1407 \times k_9 + 0.1761 \times k_{10} + 0.1309 \times k_{11} - 0.0187 \times k_{12} + 0.2189 \times k_{13} + 0.1185 \times k_{14} \tag{3.2}$$

Greenwashing

The other independent variable is greenwashing (GW). The degree of GW has not yet formed a unified measurement standard in academic circles. Referring to the practices of

TABLE 3 A partial description of statistics for 14 variables.

Variable	K1	K2	K3	K4	K5	K6	K7
Category	0,1	0,1,2	0,1,2	0,1,2,3	0,1,2	0,1,2	0,1,2
Minimum	0	0	0	0	0	0	0
Maximum	1	2	2	3	2	2	2
Mean	0.9743	0.3629	0.3686	1.269	0.3971	0.52	0.7629
Medium	1	0	0	1	0	0	1
Variable	K8	K9	K10	K11	K12	K13	K14
Category	0,1,2	0,1,2	0,1,2	0,1,2	0,1,2	0,1,2	0,1,2
Minimum	0	0	0	0	0	0	0
Maximum	2	2	2	2	2	2	2
Mean	0.95943	1.06	0.1314	0.9657	0.0657	0.9086	0.9286
Medium	0	1	0	1	0	1	1

TABLE 4 KMO and Bartlett's test.

KMO Test		0.850
Bartlett's test of sphericity	Approx. Chi-square	2078.883
	df	91
	Sig.	0.000

TABLE 5 Variance explained.

Component	Eigenvalues	Variance percentage	Cumulative variance percentage
1	5.563	39.73	39.73
2	1.402	10.02	49.75
3	1.163	8.31	58.06
4	1.069	7.63	65.69
5	0.833	5.95	71.64
6	0.781	5.58	77.22
7	0.632	4.52	81.74
8	0.552	3.94	85.68
9	0.468	3.34	89.02
10	0.411	2.93	91.95
11	0.368	2.63	94.58
12	0.298	2.13	96.71
13	0.278	1.98	98.70
14	0.183	1.30	100.00

Huang (2020) and Roulet and Touboul (2015), we define GW as selective disclosure and declarative manipulation. The former refers to the selective reporting of environmental issues and the latter refers to the beautification of the corporate image through strategic expression. The final GW degree index was obtained by calculating the geometric mean of the corresponding indices using the two methods. The specific methods are as follows:

Based on Huang et al. (2019), and according to the requirements of relevant laws and regulations, we summarize the issues that enterprises should disclose in social responsibility reports under ideal conditions. We constructed an indicator system of GW degree based on four aspects: governance and

TABLE 6 Component matrix.

	1	2	3	4
K1	-0.211	0.820	-0.071	-0.080
K2	0.651	0.012	0.020	0.352
K3	0.537	0.012	-0.412	0.304
K4	0.720	-0.009	-0.347	0.295
K5	0.564	0.144	0.480	0.281
K6	0.785	0.211	0.171	0.334
K7	0.653	0.005	0.225	-0.241
K8	0.625	0.068	0.322	-0.482
K9	0.745	0.054	-0.174	-0.328
K10	0.409	0.013	0.530	0.066
K11	0.749	0.010	-0.227	-0.319
K12	0.279	-0.802	0.091	0.021
K13	0.804	0.104	-0.061	0.058
K14	0.727	-0.056	-0.280	-0.248

structure, process and control, input and output, and compliance, as shown in Table 7. These four aspects contain 20 secondary indicators, which are the content analysis method scores. We manually searched and collected the corresponding content of each secondary indicator in the CSR or sustainable development report. Following this, we (1) determine whether the report discloses the relevant content of indicators and (2) judge whether the disclosure of the enterprise is substantive disclosure or symbolic disclosure. Substantive disclosure is assigned a value of one, symbolic disclosure is assigned a value of zero, and failure to disclose is not recorded. Based on the relevant literature (Clarkson et al., 2008; Walker and Wan, 2012), if enterprises disclose verifiable and inimitable information, such as fact statements, case descriptions, and quantitative descriptions, then their environmental information disclosure is more reliable and belongs to substantive disclosure. By contrast, if the environmental report is mainly a programmatic statement, qualitative disclosure, or a simple copy of the previous year's statement, which is difficult to verify and easy to imitate, the reliability of the environmental information disclosure is low and belongs to symbolic disclosure.

TABLE 7 Greenwashing measurement index system.

No.	Projects	Symbolic disclosure	Substantive disclosure
1	Governance and		
2	institutions	Environmental protection policy and environmental strategy	
3		Objectives and realization of environmental protection	
4		Environmental protection rules, regulations and implementation	
5	Process and control	Environmental management, organization and operation	
6		Environmental certification system and its implementation	
7		Honor and recognition of environmental protection	
8		Investment in environmental protection and comprehensive renovation scheme	
9		Environmental education and training and public welfare activities	
10	Input and output	Research and development of environmental protection technology and process innovation	
11		Energy consumption and reduction measures	
12		Water resources consumption and reduction measures	
13		Greenhouse gas emissions and reduction measures	
14		Emissions and reduction measures	
15		Waste water production and reduction measures	
16		Production and treatment measures of solid waste	
17	Compliance	Other emission reduction measures, such as greening, noise and logistics	
18		Statement of compliance with environmental laws and regulations	
19		Risk assessment brought about by environmental policy	
20		Statement on the impact of industry characteristics on the environment	
		A statement as to whether a major environmental pollution accident has occurred	

We calculated the total substantive, symbolic, and disclosed information of the sample enterprises to construct selective disclosure indicators (GWS) and expressive manipulation indicators (GWE).

In disclosing the report, the enterprise may have a commitment or performance in some respects, while there is no commitment or performance in others. Therefore, we measure the degree of selective disclosure by comparing the undisclosed items with the total disclosed items. The calculation formula is as follows:

$$\text{Selective disclosure (GWS)} = 100 \times \left(1 - \frac{\text{Number of disclosed projects}}{\text{Number of items to be announced}} \right) \quad (3.3)$$

We use the ratio of symbolic disclosure items to corporate disclosed items to measure the degree of expressive manipulation. The specific calculation formula is as follows:

$$\text{Expressive manipulation (GWE)} = 100 \times \frac{\text{Number of symbolic disclosures}}{\text{Number of disclosed items}} \quad (3.4)$$

According to Huang (2020), GW can be calculated using arithmetic or geometric means. The arithmetic mean is suitable for numerical data. The geometric mean can be applied to quality

data. When the total outcome equals the product of all stages (links), the geometric mean can be used to reflect the population's general level. Since selective disclosure (GWS) is equivalent to quantitative assessment, expressive manipulation (GWE) is equivalent to quality assessment, and the overall situation of enterprise greenwashing is equivalent to the product of quantitative assessment and quality assessment. It is more appropriate to use the geometric mean to theoretically and logically calculate the degree of greenwashing (GW). According to the mean value theorem, the geometric means of several numbers do not exceed the arithmetic mean. When these numbers are equal, the arithmetic mean is equal to the geometric mean: The use of geometric means in this study does not exaggerate the degree of enterprise greenwashing. If significant results can still be observed in this case, the results observed in other calculation methods may be stronger, which helps ensure the robustness of the empirical test results. Therefore, we used the geometric mean to calculate the degree of GW for each enterprise. A large GW value of listed companies represents a higher degree of greenwashing. The formula used is as follows:

$$GW = \sqrt{GWS \times GWE} \quad (3.5)$$

Control variables

Based on previous studies, we selected control variables, including company size (SIZE), listing age (AGE), debt-paying

TABLE 8 Variable definition.

Variables	Symbols	Descriptions
Enterprise value	V	Tobin Q value
Quality of carbon information disclosure	CID	Carbon information disclosure index
Greenwashing	GW	Greenwashing index
Company size	SIZE	Natural logarithm of total assets at the end of the period
Listing age	AGE	Number of years an enterprise has been listed
Debt paying ability	DEBT	Current ratio
Development ability	GROWTH	Sustainable growth rate
Operation ability	OPERATION	Total asset turnover
Industry	IND	Heavy pollution enterprises are recorded as 1, while other enterprises are recorded as 0
Year	YEAR	Year virtual variable

TABLE 9 Descriptive statistics.

Variables	N	Mean	SD	Minimum	Maximum
V	350	1.690	1.401	0.698	16.423
CID	350	1.452	1.112	0.0342	4.216
GW	350	45.68	26.50	0	97.47
SIZE	350	24.82	1.484	21.64	27.90
AGE	350	16.99	5.221	1	27
DEBT	350	1.577	1.143	0.175	10.57
GROWTH	350	0.0841	0.0701	-0.181	0.763
OPERATION	350	0.695	0.449	0.0890	3.096
IND	350	0.243	0.429	0	1

ability (DEBT), growth ability (GROWTH), operation ability (OPERATION), and industry (IND; Li et al., 2016; Liu et al., 2021). Industry (IND) is a dummy variable. For heavy-pollution enterprises, the value is 1; otherwise, the value is 0. The heavy-pollution industries in this study mainly include coal, mining, textiles, leather, paper, petrochemical, pharmaceutical, chemical, metallurgy, thermal power, and 16 other industries. The definitions of these variables are listed in Table 8.

Model design

According to the above correlation analysis, the following three models were designed to test H1, H2, and H3, and the following three models were designed, respectively:

$$V = \beta_0 + \beta_1CID + \beta_2SIZE + \beta_3AGE + \beta_4DEBT + \beta_5GROWTH + \beta_6OPERATION + \beta_7IND + \beta_8YEAR + \varepsilon$$

Model (1)

$$V = \beta_0 + \beta_1CID + \beta_2GW + \beta_3CID \times GW + \beta_4SIZE + \beta_5AGE + \beta_6DEBT + \beta_7GROWTH + \beta_8OPERATION + \beta_9IND + \beta_{10}YEAR + \varepsilon$$

Model (2)

$$V_{it+2} = \beta_0 + \beta_1CID_{it} + \beta_2GW_{it} + \beta_3CID_{it} \times GW_{it} + \beta_4SIZE_{it} + \beta_5AGE_{it} + \beta_6DEBT_{it} + \beta_7GROWTH_{it} + \beta_8OPERATION_{it} + \beta_9IND_{it} + \beta_{10}YEAR_t + \varepsilon_{it}$$

Model (3)

Model (1) was used to test H1 and the direct impact of carbon information disclosure quality on enterprise value. Model (2) was used to test H2, namely, the moderating effect of greenwashing behavior on carbon disclosure on enterprise value in the short run. Model (3) was used to test the moderating effect of greenwashing behavior on carbon disclosure on enterprise value in the long run (H3). This study verified H2 and H3 by introducing the cross-multiplication term of CID × GW. We also centralize the sub-variables used by the cross-product term before applying Models (2) and (3) to avoid multicollinearity caused by the cross-product term affecting the accuracy of the statistical test results and then multiply them to obtain the cross-product term, followed by regression.

Results

Descriptive statistics

Table 9 presents descriptive statistics for each variable. The mean enterprise value (V) for the 350 samples was 1.690, and the standard deviation was 1.401. Among the sample enterprises, the carbon

TABLE 10 Correlation analysis.

Variable	V	CID	GW	SIZE	AGE	DEBT	GROWTH	OPERATION	IND
V	1.0000								
CID	-0.0650	1.0000							
GW	0.091*	-0.517***	1.0000						
SIZE	-0.465***	0.324***	-0.109**	1.0000					
AGE	-0.0160	0.0420	0.0300	-0.229***	1.0000				
DEBT	0.435***	-0.199***	0.0860	-0.458***	0.0530	1.0000			
GROWTH	0.261***	-0.0720	0.0540	-0.127**	0.0020	0.284***	1.0000		
OPERATION	0.0150	0.0310	0.0770	-0.127**	0.0290	0.0330	0.100*	1.0000	
IND	0.261***	0.177***	-0.0850	-0.164***	0.193***	0.211***	0.0810	-0.0310	1.0000

*** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level.

information disclosure of the quality evaluation index (CID) was 4.216 at the highest and 0.0342 at the lowest, while the mean value was 1.452. This indicates that the carbon information disclosure level of the sample companies is generally low, and the quality difference in carbon information disclosure is significant. The greenwashing (GW) degree was 97.47, 0, 45.68, and 26.50, indicating that the difference in the degree of greenwashing of the sample companies is substantial and the fluctuation is strong. The difference in the top and minimum values in listing age (AGE) was 26, indicating a specific difference between the sample corporate listing years. The minimum value of debt-paying ability (DEBT) was 0.175, the maximum value was 10.57, and the standard deviation was 1.143.

The minimum value of growth ability (GROWTH) was 0.181, the maximum value was 0.763, and the standard deviation was 0.0701. The gap in the debt-paying ability of the sample companies is noticeable, but the opening of growth ability is small. Some enterprises have strong solvency and developmental abilities. The average value of industry (IND) was 0.243, indicating many non-heavy polluting companies in the sample companies. Overall, most data were relatively stable.

Correlation analysis

Table 10 shows the Pearson correlations for all the dependent, independent, and control variables. The table shows that CID is negatively correlated with V, which is insignificant and different from the expected result. The relationship between the two needs to be further tested using regression analysis. As expected, there is a positive correlation between greenwashing (GW) and enterprise value, and this is particularly significant. Company size (SIZE) is negatively correlated with enterprise value. This indicates that enterprises with more total assets in the sample companies have a smaller relative value. Debt-paying and growth abilities are significantly and positively correlated with enterprise value. This indicates that the better the solvency of the enterprise, the higher the sustainable development capacity, and the higher the value of the enterprise. In addition, there was a strong correlation between several control variables, and no correlation coefficient exceeded 0.6. Table 11 shows that the variance

TABLE 11 Variance inflation factor test for variables.

Variable	VIF	1/VIF
CID	1.24	0.806230
SIZE	1.51	0.660300
AGE	1.20	0.834137
DEBT	1.41	0.711037
GROWTH	1.11	0.900680
OPERATION	1.04	0.961556
IND	1.17	0.857184
Mean VIF	1.40	

inflation factor (VIF) value is less than 2 and the 1/VIF value is more significant than 0.6, indicating no multicollinearity problem.

Regression results

The regression results are presented in Table 12. The first column shows the test of a model (1). The main regression results show that CID is positively correlated with an enterprise value at a 5% significance level. This indicates that the higher the CID level, the higher the enterprise value. Carbon information disclosure improves enterprise value. This result confirms H1 and is consistent with the results of previous studies. It is good for carbon disclosure investors to consciously and actively take responsibility for a good corporate image, increase enterprise reputation, and thus bring about enterprise capital premiums. This will attract more investment and carbon disclosure to alleviate enterprises' and investors' information asymmetry. It will improve investors' recognition and trust in the enterprise, stimulate stock purchase intention, and further promote the value creation of enterprises. In addition, SIZE is significantly negatively correlated with enterprise value. The greater the total assets of a company, the lower its relative value. The coefficients of DEBT and GROWTH are significantly positive. This indicates that the higher the enterprise's debt-paying and sustainable development abilities, the higher the enterprise value.

TABLE 12 Multiple regression results.

Variables	(1)	(2)	(3)
	V	V	V _{t+2}
CID	0.105** (2.34)	0.255*** (3.36)	0.178 (1.40)
GW		0.010*** (3.14)	0.008 (1.44)
CID×GW		0.005** (2.18)	0.005 (1.09)
SIZE	-0.383*** (-9.26)	-0.402*** (-8.02)	-0.388*** (-4.93)
AGE	-0.048*** (-4.24)	-0.051*** (-4.07)	-0.054*** (-2.66)
DEBT	0.250** (2.51)	0.237*** (3.78)	0.218** (2.39)
GROWTH	3.216*** (3.19)	3.047*** (3.37)	2.922** (2.22)
OPERATION	-0.148** (-2.14)	-0.215 (-1.56)	-0.228 (-1.10)
IND	0.512*** (3.06)	0.524*** (3.46)	0.556** (2.32)
YEAR		controlled	
Constant	11.039*** (9.83)	11.899*** (8.64)	11.424*** (5.32)
Observations	350	350	210
R-squared	0.363	0.382	0.291

T-values are in parentheses. *** denotes significance at the 1% level, ** denotes significance at the 5% level.

Column 2 of Table 12 presents the results for H2. In the test of Column 2, the coefficient of CID × GW between the quality of carbon disclosure and greenwashing is 0.005, which is significantly positive at the 5% level, indicating a positive regulatory effect in the short run. Hence H2 is verified. Compared with the study by Li et al. (2017a, 2017b), we supplement the role of GW in the relationship between CID and enterprise value. In the short run, greenwashing might not be detected and enterprise value might be improved because of “green manipulation.” In particular, for impression management in the voluntary disclosure of environmental information of a floating green enterprise, carbon disclosure responsibility fulfillment will be more active, carbon performance will be better, and transparent information can attract more investors, further enhancing the positive effect of carbon disclosure on enterprise value. In the short run, GW plays a positive moderating role in the relationship between carbon information disclosure and enterprise value. The coefficients of the other variables are consistent with the main regression.

Column 3 of Table 12 shows the test for H3. The coefficient of CID × GW is 0.005, which is not significant, indicating that greenwashing has no significant positive regulatory effect on the relationship between CID and V after 2 years. The positive effect

of greenwashing fades in the long run. Consumers may perceive enterprises’ pseudo-social responsibility behavior in the long run, and brand loyalty and corporate reputation may be adversely affected. This damages consumers’ confidence affects investor sentiment, and causes the promotion effect of carbon information disclosure on enterprise value to fade. The results of the other control variables are consistent with the previous results.

Endogeneity tests

High-quality carbon information disclosure will improve corporate value and vice versa; high corporate value may also have an impact on the quality of carbon information disclosure. To avoid estimation bias caused by bidirectional causality, instrumental variables are constructed, and two-stage regression estimation (2SLS) is used to control the endogeneity problem. Referring to Larcker and Rusticus (2010) and Yan et al. (2020), the instrumental variable is represented by the average carbon information disclosure quality (IVCID) of the province where the sample is located, which is related to CID but is less likely to directly affect the value of a single enterprise. In the first regression stage,

control variables and tools (IVCID) were taken as independent variables, and carbon disclosure quality (CID) was taken as the dependent variable. The fitting value or predictive variable (PCID) was then obtained. In the second-stage regression, predictive variables (PCID) and control variables were used as independent variables to conduct a regression of enterprise value (V). Shear's partial R^2 value was used to test the strength of the tool variable. The results show that Shear's partial R^2 is 0.1896, the F -statistic is 102.67, and the p -value is 0.0000. Therefore, the selected tool variable was a strong tool variable. Table 13 shows that the regression coefficient of the enterprise value (V) and the prediction variable (PCID) is 0.193, which is significant at the 5% level. From this, we can see that the two variables have a significant positive correlation, which is consistent with the above results.

TABLE 13 Endogeneity tests.

Variables	First stage	Second stage
	CID	V
IVCID	0.876*** (8.89)	
PCID		0.193** (2.27)
SIZE	0.154*** (3.84)	-0.405*** (-9.23)
AGE	-0.0103 (-0.99)	-0.0490*** (-4.37)
DEBT	-0.0574 (-1.13)	0.258*** (2.61)
GROWTH	-1.001 (-1.36)	3.247*** (3.28)
OPERATION	0.230** (2.08)	-0.168** (-2.38)
IND	0.585*** (4.91)	0.456*** (2.66)
YEAR	controlled	
Constant	-3.615*** (-3.37)	11.50*** (9.98)
Observations	350	350
R-squared	0.347	0.359

*** denotes significance at the 1% level, ** denotes significance at the 5% level.

TABLE 14 Robustness tests.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	V	VB	VB	VB _{t+2}	V	V	V _{t+2}
CID	0.116*** (4.12)	0.091** (2.11)	0.236*** (3.18)	0.155 (1.24)	0.143** (1.99)	0.395*** (3.50)	0.220 (1.09)
GW			0.009*** (3.10)	0.008 (1.45)		0.012*** (2.97)	0.007 (0.92)
CID×GW			0.005** (2.29)	0.004 (1.05)		0.009*** (2.75)	0.006 (0.90)
SIZE	-0.274*** (-11.35)	-0.343*** (-8.51)	-0.361*** (-7.36)	-0.368*** (-4.74)	-0.486*** (-7.78)	-0.507*** (-7.79)	-0.519*** (-5.04)
AGE	-0.024*** (-4.08)	-0.043*** (-4.19)	-0.046*** (-3.71)	-0.058*** (-2.88)	-0.088*** (-4.89)	-0.089*** (-4.78)	-0.102*** (-3.42)
DEBT	0.084* (1.71)	0.280*** (2.83)	0.267*** (4.36)	0.245*** (2.73)	0.420*** (2.78)	0.399*** (4.81)	0.365*** (2.99)
GROWTH	2.299*** (5.14)	3.042*** (3.24)	2.872*** (3.25)	2.303* (1.78)	2.320** (2.37)	2.287** (2.05)	2.564 (1.55)
OPERATION	-0.093** (-2.08)	-0.174** (-2.55)	-0.238* (-1.76)	-0.226 (-1.10)	-0.449*** (-3.33)	-0.443** (-2.15)	-0.544* (-1.66)
IND	0.128 (1.53)	0.510*** (3.15)	0.524*** (3.54)	0.557** (2.36)	0.668*** (3.81)	0.585*** (2.98)	0.721** (2.33)
YEAR	controlled						
Constant	8.284*** (12.30)	9.869*** (9.14)	10.690*** (7.94)	10.932*** (5.17)	13.968*** (8.53)	14.947*** (8.35)	15.236*** (5.41)
Observations	350	350	350	210	245	245	147
R-squared	0.368	0.359	0.378	0.290	0.421	0.447	0.369

*** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level.

Robustness tests

We conducted a number of analyses to ascertain the robustness of the results. First, considering the possible heteroscedasticity of the samples, this study adopts the weighted least squares method to perform regression on the basis of the previous regression, as shown in Column 1 of Table 14. The regression results verify Hypothesis 1. Second, we use another Tobin's Q formula [market value A / (total assets – net intangible assets – net goodwill)] to replace the previous formula [market value B / (total assets – net intangible assets – net goodwill); Yan et al., 2020]. Then, we obtain another Tobin's Q value (VB) and carry out the regression test again to avoid the instability of empirical results due to the different calculation methods of market value. As shown in Columns 2, 3, and 4 of Table 14, the research results are consistent with the previous results. Third, following Tian et al. (2021), to further test the robustness of the results, we randomly selected 70% of the total sample and re-estimated the main regression. As shown in columns 5, 6, and 7 of Table 14, the results are consistent with the baseline results. Therefore, our baseline findings were robust and reliable.

Further analysis

Industry heterogeneity test

Heavy-pollution enterprises are resource-intensive with long production processes that require a large amount of energy and resources and discharge more pollution. Therefore, heavy-pollution enterprises should focus on a “double carbon” target. In this study, sample enterprises were divided into heavy-pollution enterprises and non-heavy-pollution enterprises, and regression was conducted to investigate the influence of industry heterogeneity on the relationship between CID and enterprise

TABLE 15 Further analysis.

Variables	Industry heterogeneity test		Legal environment heterogeneity test	
	Heavy polluting enterprise	Non-heavy polluting enterprise	Good legal environment	Poor legal environment
	V	V	V	V
CID	0.033 (0.13)	0.111*** (3.49)	0.137** (2.05)	0.104 (1.66)
SIZE	-0.577** (-2.28)	-0.362*** (-8.63)	-0.429*** (-5.46)	-0.385*** (-7.96)
AGE	-0.184 (-1.61)	-0.036*** (-4.22)	-0.044*** (-2.61)	-0.062*** (-3.63)
DEBT	0.362*** (2.69)	-0.078 (-1.17)	0.302** (2.09)	0.176 (1.62)
GROWTH	2.635 (1.44)	2.519*** (3.99)	2.955*** (2.77)	2.913* (1.91)
OPERATION	-0.580*** (-2.75)	-0.028 (-0.39)	-0.311** (-2.22)	0.044 (0.50)
IND			0.511** (2.44)	0.415* (1.68)
YEAR			controlled	
Constant	18.498** (2.50)	10.841*** (8.92)	12.136*** (5.71)	11.309*** (8.99)
Observations	85	265	220	130
R-squared	0.426	0.332	0.366	0.434

*** denotes significance at the 1% level, ** denotes significance at the 5% level, and * denotes significance at the 10% level.

value. Table 15 presents the results. Columns 1 and 2 show the influence of CID on heavy-pollution enterprises and non-heavy-pollution enterprises on enterprise value. The results show that the coefficient of CID is 0.033 for heavy-pollution enterprises, which is not significant. The CID coefficient is 0.111 for non-heavy-pollution enterprises, positively correlating with an enterprise value at the 1% level. The positive impact of the CID level on the enterprise value of non-heavy-pollution enterprises is more obvious than that of heavy-pollution enterprises. This is the same as Yan and Chen's (2017) conclusion. Listed companies consider costs and benefits when managing carbon emissions. Heavy-pollution enterprises need to consume a large amount of energy in production, and they also need to confirm future environmental liabilities. Additionally, non-heavy-pollution enterprises face relatively little environmental pressure during normal production activities. As a result, they are more sensitive to the government's ecological regulation policies and pay more attention to CID than heavy-pollution enterprises. This results in a more significant improvement in the value. The regression results for the other control variables are similar to those of the full-sample regression results.

Legal environment heterogeneity test

In China's economic environment, in addition to internal enterprise factors, the institutional environment also plays a profound role in influencing enterprises' behavior (Williamson, 2000). Wang et al. (2018) compiled the NERI Index of Marketization of China's Provinces' 2018 Report to measure the degree of marketization. The sub-indexes of the Chinese provinces included in this report can be used as substitute variables to study institutional differences among provinces in the Chinese market (Gupta et al., 2022). According to Liu and Zhang (2017); Xie (2017), and Gupta et al. (2022), the legal system environment index in the NERI index was selected to

conduct heterogeneity research. The higher the index, the better the legal environment of the region. According to the index, enterprises in regions larger than the mean are divided into the good legal environment group, and those in regions smaller than the mean are divided into the poor legal environment group. The regression results are presented in Table 15 and Columns 3 and 4. It can be seen that the direct impact of CID on the enterprise value is more significant in the good legal environment group than in the poor legal environment group. In other words, CID plays a more significant role in enhancing enterprise value in a good legal environment. The legal environment in which an enterprise is located may affect the profit and loss of some specific behaviors of the enterprise, thus affecting the motivation and decision preferences of the enterprise. Companies in a better legal environment may have stronger incentives to disclose higher-quality carbon information. Moreover, a sound legal regulatory environment can improve enterprise performance and effectively promote economic growth (La Porta et al., 2000). Therefore, in a good legal environment, enterprises can actively disclose carbon information and increase their ability to create value.

Conclusion, revelations, and limitations

Conclusion

This study explores the impact of carbon disclosure on enterprise value and the moderating effect of greenwashing behavior on these two factors. Based on the data of the constituents of the Social Responsibility Index of the China Shanghai Stock Exchange from 2016 to 2020, the innovative

CID index measurement formula was obtained through the data analysis of the specific characteristics and factors of the carbon information in the corporate social responsibility report or sustainable development report and PCA. The following conclusions were drawn from the regression analysis of carbon information disclosure, greenwashing behavior, and enterprise value. (1) A good CID can improve enterprise value. (2) GW can promote the improvement of corporate value through CID to a certain extent in the short run. In the long run, this promotion effect fades. (3) The positive impact of the CID level on the enterprise value of non-heavy polluters is more obvious than that of heavy polluters. (4) The positive impact of the CID level on enterprise value is more obvious for enterprises in a good legal environment than for enterprises in a poor legal environment.

Revelations

This study has several implications for managers and policymakers. First, China has not yet issued relevant laws and regulations on how and which carbon information the enterprises should disclose. Hence, enterprises' carbon information is not standardized, scattered, and even produces greenwashing behavior. Information users must spend considerable energy, time, and cost to extract effective carbon information. Greenwashing can bring some benefits to enterprises in the short term. However, in the long term, greenwashing does not add value to enterprises. Greenwashing is a type of information whitewashing with an unacceptable negative activity. Greenwashing seriously damages the interests of investors, and once exposed, has serious adverse effects on enterprises. The government should therefore establish relevant standards for mandatory CID based on China's reality, and regulate enterprises' information disclosure behaviors. In addition, relevant departments should strengthen the supervision of enterprises across different industries and improve the quality of the legal environment in various regions. They should improve the effectiveness of the capital market and narrow the value gap between CID and enterprise value across different industries and legal environments.

The enterprise should establish a special carbon reduction risk monitoring mechanism and set up low-carbon management to strengthen the management of low carbon. This can effectively improve the production efficiency and operations of enterprises; reduce costs; set up a good corporate image and corporate reputation; strengthen investors', creditors', and consumers' trust; and boost the sustainable development of the enterprise. Management psychology believes that changing unreasonable and incorrect behaviors can transform negative factors into positive ones. Therefore, enterprises should also strengthen the supervision of CID to prevent management from disclosing false carbon information for their selfish interests that result in the

greenwashing behavior of enterprises. Enterprise managers need to correctly understand the negative effects of greenwashing behavior and the significance of CID in the long-term development of enterprises. The disclosure of environmental information should be timely, accurate, and comprehensive.

Limitations

There are some limitations to this study. When constructing the CID formula in this study, the choice of variables was subjective, and there were more potential variables affecting CID. There are also interactions between the variables, which warrant further study. Additionally, our sample is limited to Social Responsibility Index on the Shanghai Stock Exchange. Future research can be based on further perfecting the carbon disclosure formula, selecting a more extensive social responsibility report or sustainable development report, and expanding the research scope, not restricting it to a particular area, region, or country. Additionally, as relevant government departments pay more attention to GW, more methods can be selected to conduct in-depth research on the influence of policy regulations on GW and the adverse consequences of GW in enterprises in the future.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

QC conceptualized and designed the empirical research and wrote this manuscript. YZ designed the empirical research, collected the data, and wrote this manuscript. HD designed the empirical research and performed the data analysis. MR and WZ performed the data analysis and revised the manuscript. All authors contributed to the article and approved the submitted version.

Funding

The work described in this manuscript was supported by the Sichuan Soft Science Research Project (2019JDR0345) and the Social Science Planning Project of Sichuan Province (SC19TJ026).

Acknowledgments

We appreciate the helpful comments from the reviewers.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.892415/full#supplementary-material>

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 18 June 2022

ACCEPTED 01 August 2022

PUBLISHED 12 September 2022

CITATION

Zhang Q, Xiong L, Yan Y, Song Z and
Wen Z (2022) Succession intention and
environmental investment: The moderating
role of social status.
Front. Psychol. 13:972565.
doi: 10.3389/fpsyg.2022.972565

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Succession intention and environmental investment: The moderating role of social status

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Drawing on expectancy theory, this study explains how founders' succession intentions might influence family firms' environmental environments. Using a nationally representative sample of Chinese private firms, we find that family firms make more environmental investments when founders have succession intentions. We also find that the relationship between founders' succession intentions and family firms' environmental investments is negatively moderated by the founders' subjective social status. Moreover, the results show that, compared with ownership succession intentions, the positive role of founders' management succession intentions on family firms' environmental investments is more prominent. This study helps us to better understand the impact of succession intentions on family business decision-making from a psychological perspective. It enriches the research on succession intentions and provides practical implications for family firms' sustainable development.

KEYWORDS

environmental investment, family firms, management succession intention, ownership succession intention, social status

Introduction

Family firms are not only the most prevalent business type around the world but also a norm in Asian countries (Claessens et al., 2000). The Chinese mainland has experienced dramatic growth since the reform and opening up in 1978. After 40 years of development, in 2018, Chinese family firms accounted for 85% of the private enterprises in China¹ and have played an essential role in job creation, technological innovation, and tax contributions. However, as the first-generation founders age, many family firms in China are now faced with the challenge of generational succession. In the United States, only about 40% of family-owned businesses have transitioned to the second generation (see footnote 1). Intergenerational succession is a top priority for family businesses to maintain family

1 Relevant data come from the Global Family Business Research Centre; for details, please refer to <http://eng.pbcsf.tsinghua.edu.cn/portal/list/index/id/123.html>.

control and is a critical choice for a firm's long-term development and continuance (Cao et al., 2015). In this study, we take private family firms as our unit of analysis to examine the effects of founders' succession intentions on firms' environmental protection behaviors.

Both developed and developing countries are facing the problem of environmental degradation. Green development has become an important component of global environmental governance (Maggioni and Santangelo, 2017). As the major contributor to environmental pollution (Huang and Lei, 2020; Bendell, 2021), firms' efforts in pollution control are important to the transition towards a "green economy" (Liu et al., 2022; Tian et al., 2022b). Most environmental research focuses on listed firms and is concerned with the influence of environmental regulations and governance on a firm's environmental investment. For example, Zeng et al. (2020) demonstrated the influence of implementing environmental responsibility audits on firms' environmental protection investments. Tian et al. (2021) empirically tested the positive impact of cross-shareholding on corporate environmental investments. Xu and Yan (2019) illustrated the significant positive links between political connections and corporate environmental investments. However, few studies have analyzed environmental investments by private family firms from the perspective of intergenerational succession.

Intergenerational succession is a key distinctive feature of family firms. During the intergenerational inheritance stage, these companies tend to focus more on non-financial goals and pursue the long-term survival of the family (Sharma et al., 2003). As an important manifestation of environmental responsibility, environmental investment improves the social image of family firms and the legitimacy of successors (Yang et al., 2022). In this study, we use a nationally representative sample of Chinese family firms to empirically test the relationship between founders' succession intentions and family firms' environmental investments. We also consider how a founder's perceived social status affects the relationship between their succession intention and the tendency to invest in pollution control. Aside from institutional pressures, environmental investments can also be driven by "preconscious acceptance of institutionalized values or practices" (DiMaggio, 1988: 17) or social expectations and norms that outline good behavior patterns (Berrone et al., 2010). Due to "being in the spotlight," high-social-status entrepreneurs face high stakeholder expectations and are subject to intense scrutiny of their corporate social responsibility (CSR) activities (Liu et al., 2021). Some research investigates the relationship between the social status of entrepreneurs and CSR activities focused on firms' donation engagement (Li et al., 2015; Liu et al., 2021; Niu et al., 2021). We explore the moderating role of social status in the relationship between succession intentions and environmental investments.

This study makes several contributions to the literature. First, drawing on expectancy theory, which is one of the most commonly used theories of motivation in the field of organizational psychology, this study helps us to better understand

the impact of succession intentions on family business decision-making from the perspective of social responsibility in environmental investment. It supports expectancy theory with empirical evidence and enriches the literature on the economic consequences of succession intentions. Second, our findings add to the environmental literature because most environmental studies that explore the factors influencing a firm's environmental strategies focus on institutional pressures and benefits from compliance with regulations. In contrast, we examine the relationship between founders' succession intentions and family firms' environmental investments, which expands the scope of research on the factors influencing environmental investments. Third, we noticed the moderating role of the founder's perceived social status in the relationship between the founder's succession intentions and the family firm's environmental investments. The social status of Chinese business founders has greatly improved in recent decades, which provides a unique context for understanding how social status influences entrepreneurs' strategic decisions on environmental investments.

The remainder of this paper is organized as follows. Section "Literature review and hypothesis development" reviews related literature and presents our hypotheses. Section "Data and empirical methods" describes the data, defines the variables, and presents descriptive statistics and models. Section "Empirical results" reports the empirical results and the results of the robustness tests. Section "Conclusion" concludes the paper.

Literature review and hypothesis development

Succession intention

Scholars proposed the socioemotional wealth (SEW) model to analyze the corporate behavior of family firms. The SEW model suggests that family firms' strategic decisions are made to preserve their SEW (Berrone et al., 2012). SEW refers to non-economic utilities, such as "family control and influence, identification of family members with the firm, binding social ties, emotional attachment of family members, and renewal of family bonds to the firm through dynastic succession" (Berrone et al., 2012: 259). In pursuit of these affective endowments, family firms display a stronger preference for non-economic but socially worthy activities than do non-family firms (Berrone et al., 2010). Several empirical studies have confirmed these findings. For example, Li et al. (2015) suggest that family-controlled firms engage in philanthropic activities to maintain SEW. Gómez-Mejía et al. (2007) show that preference for family control takes priority over higher returns. Schulze et al. (2003) report altruistic conduct for family members in family firms. Intergenerational succession, as a critical dimension of SEW, is of great significance to family firms. There are only a small proportion of family firms that could survive the transition from the first to the second generation (Shen and Su, 2017).

Much of the empirical analysis on intergenerational succession has been devoted to understanding the impacts of family successions on firm performances and business decisions. For example, researchers have shown the vital role of family successions in R&D (Chrisman and Patel, 2012), corporate philanthropy (Li et al., 2015), and internationalization (Yang et al., 2020). However, few studies have discussed the economic consequences of succession intentions. Succession intentions focus on the willingness of founders to pass on the firms' ownership or management to the next generation; it reflects the founders' inclination to continue the family businesses (He et al., 2014). Several internal and external factors can influence founders' succession intentions, such as external system environment (He et al., 2014), population policy (Cao et al., 2015) and founders' religiosity (Shen and Su, 2017). Since founders' succession intentions reflect their perception of firms' long-term development, which can be predictors in inferring firms' strategic decisions.

Environmental investment

Environmental investment is a special type of corporate investment, including pollution-control costs, environmental improvement expenditures, and other expenses related to environmental practices (Ehresman and Okereke, 2015). In the short term, it has high costs and generates low returns (Wei and Zhou, 2020). Thus, firms often lack the incentive to make voluntary environmental investments (Tian et al., 2021). Governments around the world have introduced numerous environmental regulations and policies (Du et al., 2020) and provided various green subsidies for firms to make more environmental investments (Huang et al., 2020). Although, it is sometimes difficult to distinguish whether companies substantially address environmental issues through actions, or simply adopt green-washing strategies by engaging in symbolic communication on environmental problems (Walker and Wan, 2012). In general, environmental investment is considered "seemingly good" in the eyes of the public (Liu et al., 2021). As environmental problems worsen, firms can benefit from making pro-environmental investments. On the one hand, higher environmental investment means lower environmental compliance costs (Maxwell and Decker, 2006). On the other hand, environmental investment, as an act of social responsibility, helps to establish legitimacy, improve corporate image, stabilize partners, and attract consumers (Yang et al., 2022).

Social status

Social status is a concept originating from sociology research and is used widely in management studies (Liu et al., 2021). An entrepreneur's social status is defined as their standing within the social order; it is determined by factors such as education, wealth,

occupation, and political power (Chen and Williams, 2018; Liu et al., 2021). The social status of Chinese business founders in the private sector had not improved until China's economic reforms, announced in 1978 (Au and Sun, 1998). Before that, private firms were not allowed to operate in China, and private business founders were thought to be selfish (Liu et al., 2021). With loosened ideological restrictions and abandoned ownership discrimination in the 1990s, some business founders entered into the political establishment, and some government employees started their own businesses (Liu et al., 2021). This led to an improvement in the social status of Chinese entrepreneurs. With the rapid growth of family businesses after China's economic reforms, more founders have enjoyed a relatively high social status. High-social-status entrepreneurs with respected and honored standing in a social hierarchy enjoy better access to information and resources; correspondingly, they face high expectations from stakeholders and are the targets of stringent scrutiny regarding their CSR activities (Liu et al., 2021). This experience of "being in the spotlight" is also an important part of Chinese culture. Confucianism, which has pervasive influence in China, advocates "relieving the distress of the world once one achieves eminence." In such a unique culture, when entrepreneurs develop a high self-evaluation of social status through interaction and comparison with others in society, their perceived pressure from the public to behave in a prosocial manner increases, and they are motivated to proactively address the environmental demands of the society.

Hypothesis development

We draw upon expectancy theory to explain how founders' succession intentions influence family firms' environmental investments. Expectancy theory is one of the most commonly used theories of motivation among organizational and industrial psychologists to explain the decision-making process of individuals (Vroom, 1964; Chiang and Jang, 2008; Li et al., 2015). According to expectancy theory, expectancy, instrumentality and valence are prerequisites for individuals to make decisions on various behavioral options (Fudge and Schlacter, 1999; Chiang and Jang, 2008). Expectancy measures the perceived correlation between effort and performance (Fudge and Schlacter, 1999). Instrumentality is the belief that a person's rewards are closely tied to the level of performance (Fudge and Schlacter, 1999; Chiang and Jang, 2008). Valence refers to the subjective value placed on rewards (Chiang and Jang, 2008; Li et al., 2015). These elements combine multiplicatively to determine the motivational force for a behavior (Fudge and Schlacter, 1999; Chiang and Jang, 2008; Li et al., 2015).

When founders are willing to pass on their business to the next generation, the family firm is not only an asset that can be easily sold but also a symbol of the family's heritage and traditions (Chen and Chen, 2014). Founders expect to maintain

the values and vision of the family through family firms (Chen and Chen, 2014), and they are inclined to take action to preserve the positive image of the firm for future generations. Thus, founders with succession intentions tend to have a long-term vision and place great value on SEW (Li et al., 2015). As environmental issues become increasingly important, environmental investment, as an act of social responsibility, has been documented to improve corporate social reputation (Aksak et al., 2016), establish legitimacy (Yang et al., 2022), and gain the trust of stakeholders (Tian et al., 2022a), which contributes to corporate sustainable development (Tian et al., 2020). Based on these arguments, it can be inferred that family firms are able to benefit from environmental investments, and the benefits are conducive to family firms' long-term continuance, which is of great significance to founders with succession intentions. In the language of expectancy theory, the motivation force for making environmental investments is high when founders are willing to pass on their business to the next generation; because the expectancy, instrumentality and valence, which are the prerequisites underlying founders' motivation to engage in environmental investments are high. Therefore, founders with succession intentions are motivated to make environmental investments.

Moreover, environmental investment usually takes a long time to materialize (Russo and Harrison, 2005). The long-term vision attached to family firms with succession intentions helps generate patient capital, which is required by environmentally friendly policies. Hence, our first hypothesis is as follows:

H1: Family firms make more environmental investments when founders have succession intentions than when they do not.

Entrepreneurs' social status has been documented to affect firms' strategic decisions (Chen et al., 2012; Liu et al., 2021). We argue a weaker positive relationship between the founder's succession intention and the family firm's environmental investments among founders with a higher subjective social status, compared to those with a lower subjective social status for two reasons. First, society assigns appropriate norms of behavior to different social classes, and in many cases, adherence to social norms of behavior becomes a prerequisite of positive social image and reputation (Niu et al., 2021). Meanwhile, high-social-status entrepreneurs are judged stringently by stakeholders (Merton, 1968), and they are easily recognized and criticized in terms of social irresponsibility (Liu et al., 2021). As a result, founders with a higher perceived social status are faced with greater pressure exerted by these social norms, and are more likely to make environmental investments. Second, founders with higher subjective social status tend to show higher levels of psychological security, and they tend to be more optimistic, confident, and have better self-control (Niu et al., 2021). They may perceive their firms' ability to engage in CSR activities to

be higher than that of their peers of lower social status. Thus, they are less likely to be irresponsible regarding environmental issues. In sum, a higher subjective social status might serve as the intrinsic motivations of entrepreneurs to make more environmental investments. Based on this, we propose the following hypothesis:

H2: Compared to founders with a lower subjective social status, among those with a higher subjective social status, there is a weaker positive relationship between the founder's succession intention and the family firm's environmental investments.

According to Bennesen et al. (2015:7), there are three modes of ownership-control transition for family firms: "family succession of both ownership and management, family ownership with professional management, and exit." Due to the poorly developed financial markets and the underdevelopment of the external managerial markets, Chinese family firms are faced with a higher threshold of management professionalization (Cao et al., 2015). Meanwhile, the non-financial aspects of the firm that satisfy the family's emotional needs (Gómez-Mejía et al., 2007), such as family reputation (Zellweger et al., 2013), social ties (Berrone et al., 2012), and good relationships with stakeholders (Bennesen et al., 2015), are not easily transferred to outside professional managers. Thus, in most cases, the family succession of ownership and management takes precedence over the family succession of ownership with firms managed by outsiders (Cao et al., 2015). If founders intend to transfer both control and ownership to younger heirs, we refer to this as management succession intention. On the other hand, ownership succession intention refers to the founder's expectation that the next generation will succeed to business ownership but will not manage their own firm (Shen and Su, 2017).

Within a firm, all actors are guided by self-interest (Berrone et al., 2010). Their divergent goals lead to contested objectives, and the ultimate decision depends on the interests of the controlling party (Berrone et al., 2010). For most Chinese family firms, substantial discretion is enjoyed by the founder's family because ownership and management are not separate; family management and decision procedures usually take the place of business decision procedures (Cao et al., 2015). The controlling power of the family elevates its right to pursue SEW through substantive responses to environmental demands, which may not be of interest to professional managers who are responsible for profit maximization (Zeng et al., 2020). Thus, founders' expectations of having the next generation succeed to both ownership and management indicate that a firm's environment-friendly policies are more likely to be consistent over a longer period of time. With both ownership and control handed over to younger heirs, firms' environmental strategies are less likely to face conflicts of interest between successors and external

managers in the future. The anticipation of uninterrupted environmental commitment after a dynastic transition is in favor of the founder's current environmental investments. Accordingly, we differentiate between management succession and ownership succession, and propose Hypothesis 3:

H3: The positive relationship between a founder's succession intention and a family firm's environmental investment is more prominent when founders have management succession intentions than ownership succession intentions.

Data and empirical methods

Data

We obtained data from the 12th Chinese Private Enterprises Survey² (CPES) conducted in 2016. The CPES is conducted by a research team, whose member organizations include the United Front Work Department of the Chinese Communist Party Central Committee, the All-China Federation of Industry and Commerce, the State Administration for Market Regulation, the Chinese Academy of Social Sciences, and the Chinese Private Economy Research Association. As a representative large-scale social survey, the CPES collects individual- and firm-level information (Chen et al., 2019). It aims to understand the thoughts, opinions, and requirements of private firm founders and to identify the problems confronting private firms (Jiang et al., 2015). The history and survey method of CPES are comprehensively demonstrated by Chen et al. (2019), so we do not elaborate on them here. In the 12th CPES, there were 8,111 cases. The definition of family firms may differ in the literature; in line with Li et al. (2015), we define family firms as firms with at least 50% family ownership. We use regression analyses to test our hypotheses. We describe all of our variables in more detail in the next section.

Variables

Dependent variable

Our dependent variable (*Env*) is a firm's environmental investments. Referring to Xu and Yan (2019), we measure a firm's environmental investments as their pollution-control investments in 2015, scaled by sales.

Independent variables

Following Li et al. (2015) and Shen and Su (2017), our independent variables are succession intention (*SI*), management succession intention (*SI_M*), and ownership succession intention (*SI_O*). In the survey, founders were asked whether they intended to allocate shares to their children or to have them manage the family firm. *SI* is a dummy variable that equals one if the founder expects to pass ownership or management control to the next generation. *SI_M* and *SI_O* are two dummy variables; *SI_M* equals one if the founder has management succession intentions, and *SI_O* equals one if the founder has ownership succession intentions.

Moderating variable

We take the founder's subjective social status (*SS*) as our moderating variable. According to Weber (1947), a social actor's social status consists of economic, social, and political status, and these elements can be measured by one's wealth, reputation, and power, respectively. In the survey, founders were required to estimate their economic, social, and political hierarchy on a 10-point scale (1 indicates the highest position, 10 indicates the lowest position). Referring to Liu et al. (2021) and Niu et al. (2021), we reversed the values, and *SS* was measured as the mean of the three values.

Control variables

We controlled for the founder's gender, age, educational background, and political connections. We also controlled for the shareholding of the founder and their family as a proxy for family ownership. Firm size and profitability were also included in the model, as were industry dummies; firms in the financial industry were excluded. The measurements for these variables are listed in Table 1.

Descriptive statistics and correlation analysis

The descriptive statistics of the founder- and firm-specific variables are shown in Table 2. Cases with missing data were deleted, and all continuous variables were winsorized at the 1% and 99% levels. Table 2 shows that, in general, our sample of private family firms has a low level of environmental investment. The average value of pollution-control costs to sales is only 0.6%. However, the standard deviation of *Env* is more than three times larger than its mean, indicating that environmental investment among the family firms in our sample varies widely. Furthermore, 16.7% of the founders in our sample have succession intentions; the proportion of founders with management succession intentions is higher than that of founders with ownership succession intentions. On average, the value of the founder's subjective social status is 5.066, and the standard deviation (1.785) is low. In terms of

² Research Centre for Private Enterprises at Chinese Academy of Social Sciences (RCPE-CASS) is the authorized organization that manages and issues the survey data. We appreciate the data support from the above organizations. Any political issue caused by contexts is the sole responsibility of the authors.

TABLE 1 Definition and measurement of variables.

Variables	Measurement
<i>Env</i>	The ratio of pollution-control investments to sales
<i>SI</i>	Value of 1 if the founder intends to give ownership or management control to the next generation; otherwise, 0
<i>SS</i>	Mean of the economic, social, and political 10-point scale measures, reverse-coded
<i>SI_M</i>	Value of 1 if the founder has management succession intention; otherwise, 0
<i>SI_O</i>	Value of 1 if the founder has ownership succession intention; otherwise, 0
<i>Gender</i>	Value of 1 if the founder is a male; otherwise, 0
<i>Age</i>	The natural logarithm of the founder's age
<i>Education background</i>	Value of 1 assigned to junior school or below, 2 to senior high school, 3 to junior college, 4 to bachelor's degree, 5 to master's degree, 6 to doctorate
<i>Political connection</i>	Value of 1 if the founder is a member of the National People's Congress or the Chinese People's Political Consultative Conference; otherwise, 0
<i>Ownership</i>	Proportion of shares held by the controlling family
<i>Firm size</i>	The natural logarithm of sales
<i>Profitability</i>	The ratio of net profits to sales

TABLE 2 Descriptive statistics.

Variables	Observations	Mean	Median	Std. Dev.	Min	Max
<i>Env</i>	3,382	0.006	0.000	0.022	0.000	0.167
<i>SI</i>	3,382	0.167	0.000	0.372	0.000	1.000
<i>SS</i>	3,382	5.066	5.000	1.785	1.000	10.000
<i>SI_M</i>	3,382	0.151	0.000	0.358	0.000	1.000
<i>SI_O</i>	3,382	0.015	0.000	0.123	0.000	1.000
<i>Gender</i>	3,382	0.817	1.000	0.387	0.000	1.000
<i>Age</i>	3,382	3.821	3.850	0.208	2.996	4.394
<i>Education background</i>	3,382	2.750	3.000	1.091	1.000	6.000
<i>Political connection</i>	3,382	0.305	0.000	0.461	0.000	1.000
<i>Ownership</i>	3,382	0.916	1.000	0.156	0.500	1.000
<i>Firm size</i>	3,382	6.078	6.176	2.577	0.788	12.087
<i>Profitability</i>	3,382	0.122	0.058	0.305	-1.500	1.000

other descriptive characteristics, 81.7% of the family founders are male, and their average age was 46 years. At least half of the founders in our sample attended junior college or higher; 30.5% of our founders had political connections, and

at least half of our firms were wholly owned by the founder's family.

In addition, Table 3 reports the pairwise correlation coefficients of all variables. *SI* and *SI_M* are highly correlated, but they are not used in the same model. Although, many of the correlations are statistically significant, the magnitudes of these correlations are substantively small, indicating that our model does not suffer from serious multicollinearity problems.

Regression method

To test the effect of founders' succession intentions on family firms' environmental investments and the moderating effect of social status, we estimate the following regression models:

$$Env = \beta_0 + \beta_1 * SI + \beta_2 * SS + \sum \gamma_i * Control\ Variables + \epsilon \quad (3.1)$$

$$Env = \beta_0 + \beta_1 * SI + \beta_2 * SS + \beta_3 * (SI * SS) + \sum \gamma_i * Control\ Variables + \epsilon \quad (3.2)$$

In our sample, data on family firms' environmental investments are characterized by many zeros, so we fitted a tobit model to run the regression analyses.

Empirical results

Regression results for founders' succession intentions and family firms' environmental investments

Table 4 presents the regression results. Model 1 uses *Env* as the dependent variable. The main independent variable of interest is the founder's succession intention. We also include other founder- and firm-specific variables as control variables along with the industry dummies. Consistent with H1, Model 1 of Table 4 shows that family firms with succession intentions make more environmental investments than family firms without succession intentions. We also find that family firms have a higher ratio of pollution-control investments to sales when founders have a higher subjective social status.

We verify the robustness of these results using alternative measures of the dependent variable in Models 2 and 3. Model 2 of Table 4 measures the family firm's environmental investments using *Lnenv*, which is the natural log of one plus the pollution-control investments a firm made in 2015. The coefficient on *SI* is positive and statistically significant, which means that the absolute amount of family firms' environmental

TABLE 3 Correlations.

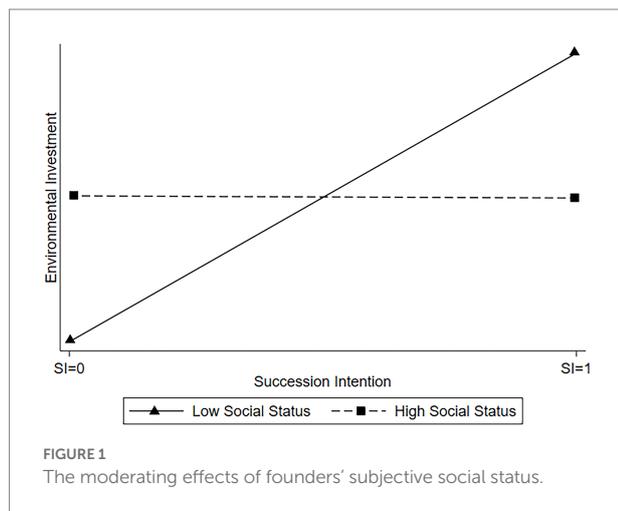
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) <i>Env</i>	1.000											
(2) <i>SI</i>	0.049***	1.000										
(3) <i>SS</i>	0.018	0.157***	1.000									
(4) <i>SI_M</i>	0.041**	0.944***	0.150***	1.000								
(5) <i>SI_O</i>	0.028*	0.280***	0.038**	-0.053***	1.000							
(6) <i>Gender</i>	0.009	0.019	0.079***	0.022	-0.009	1.000						
(7) <i>Age</i>	0.043**	0.305***	0.230***	0.305***	0.038**	0.062***	1.000					
(8) <i>Education background</i>	-0.028*	-0.074***	0.185***	-0.087***	0.029*	0.031*	-0.142***	1.000				
(9) <i>Political connection</i>	0.039**	0.151***	0.388***	0.144***	0.037**	0.085***	0.281***	0.219***	1.000			
(10) <i>Ownership</i>	-0.038**	0.023	-0.049***	0.018	0.016	-0.043**	-0.035**	-0.085***	-0.048***	1.000		
(11) <i>Firm size</i>	-0.030*	0.207***	0.434***	0.202***	0.040***	0.158***	0.280***	0.334***	0.493***	-0.126***	1.000	
(12) <i>Profitability</i>	0.016	-0.055***	-0.069***	-0.055***	-0.006	-0.044**	-0.082***	-0.125***	-0.100***	0.018	-0.223***	1.000

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

TABLE 4 Empirical results.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	<i>Env</i>	<i>Lnenv</i>	<i>Dummyenv</i>	<i>Env</i>	<i>Env</i>	<i>Env</i>
Subgroup					SS \geq mean SS	SS $<$ mean SS
<i>SI</i>	0.006** (0.003)	0.306* (0.163)	0.127* (0.069)	0.032*** (0.009)	0.003 (0.003)	0.015** (0.006)
<i>SS</i>	0.001* (0.001)	0.089** (0.041)	0.037** (0.017)	0.002*** (0.001)		
<i>SI*SS</i>				-0.005*** (0.002)		
<i>Gender</i>	0.003 (0.003)	0.292 (0.179)	0.102 (0.071)	0.003 (0.003)	0.003 (0.004)	0.004 (0.006)
<i>Age</i>	0.007 (0.006)	0.356 (0.363)	0.102 (0.146)	0.006 (0.006)	0.011 (0.008)	-0.001 (0.011)
<i>Education background</i>	-0.001 (0.001)	-0.085 (0.064)	-0.043 (0.026)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.002)
<i>Political connection</i>	0.009*** (0.003)	0.648*** (0.147)	0.244*** (0.061)	0.010*** (0.003)	0.007*** (0.003)	0.014** (0.006)
<i>Ownership</i>	-0.019*** (0.007)	-0.922** (0.387)	-0.364** (0.162)	-0.019*** (0.007)	-0.010 (0.008)	-0.036*** (0.013)
<i>Firm size</i>	0.003*** (0.001)	0.625*** (0.036)	0.184*** (0.014)	0.003*** (0.001)	0.002*** (0.001)	0.005*** (0.001)
<i>Profitability</i>	0.002 (0.004)	0.386 (0.260)	0.060 (0.112)	0.002 (0.004)	0.004 (0.005)	-0.001 (0.007)
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Constant</i>	-0.075*** (0.025)	-6.813*** (1.482)	-2.138*** (0.600)	-0.077*** (0.025)	-0.072** (0.031)	-0.057 (0.045)
<i>N</i>	3,382	3,382	3,382	3,382	1,678	1,704
<i>Pseudo R²</i>	-0.356	0.152	0.225	-0.363	-0.126	-21.672

Standard errors are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.



investments is larger when founders have succession intentions. This result is consistent with that reported in Model 1. Model 3 uses *Dummyenv* as the dependent variable; it is equal to one if a firm made an environmental investment in 2015 and zero otherwise. We fitted a probit model to run the regression. The coefficient on *SI* is still positive and statistically significant, which means that family firms are more likely to make environmental investments when founders have succession intentions. These results support H1.

Regression results for the moderating effect of founders' subjective social status

Model 4 is similar to Model 1 but includes the interaction term between the founder's succession intention and subjective social status. The interaction term is negative and significant ($\beta = -0.005$, $p < 0.01$), which is consistent with H2. For founders with a higher subjective social status, there is a weaker positive relationship between the founder's succession intention and the family firm's environmental investments. The moderating effects are shown in Figure 1. The slope of the line for founders with high subjective social status (i.e., a status that is one standard deviation above the mean) is flatter than that of those with low subjective social status (i.e., a status that is one standard deviation below the mean). For founders with a lower subjective social status, the impact of the founder's succession intention on a firm's environmental investment is more prominent. Therefore, a founder's subjective social status negatively moderates the positive relationship between their succession intention and a firm's environmental investments.

We test the robustness of the moderating effects of the founder's subjective social status on the relationship between

the founder's succession intention and the family firm's environmental investments using seemingly unrelated regression. We divide our sample into two subgroups according to the level of the founder's self-evaluated social status. Model 5 in Table 4 reports the regression results for family firms whose founders have a subjective status no less than the mean of SS. In comparison, Model 6 in Table 4 shows the regression results for family firms whose founders have a subjective social status less than the mean of SS. We tested whether the coefficients on *SI* in these two subgroups were equal. The p value is 0.085; it is estimated based on the null hypothesis that the coefficients on *SI* in Models 5 and 6 are equal. This suggests that the coefficient estimate for *SI* in Model 6 is significantly different from that in Model 5. In other words, when founders have a lower subjective social status, the positive effects of their succession intention on their firm's environmental investments are more prominent. These results are consistent with those reported in Model 4 and support H2.

Comparison between management succession intention and ownership succession intention

We differentiate between management succession and ownership succession, and identify the different effects of the founder's intentions for each on their firm's environmental policies. Model 7 in Table 5 shows the regression results. Model 7 is similar to Model 1 but uses two succession intention dummy variables to replace the variable *SI*: *SI_M* and *SI_O*. The parameter coefficient of *SI_M* is positive and statistically significant, while the positive parameter coefficient of *SI_O* is not statistically significant. This finding suggests that, compared with ownership succession intention, the positive relationship between founders' management succession intention and family firms' environmental investment is more prominent. It supports H3.

H3 was further verified using propensity score matching analysis. We fit a logistic model to predict each subject's propensity score, using the covariates gender, age, educational background, political connection, ownership, firm size, and profitability. To better predict propensity scores, we included both linear and quadratic terms in the estimation function. The average treatment effects are presented in Table 6. Management succession intention has a positive and significant effect on a family firm's environmental investment, which is assessed by the proportion of pollution-control investments to sales in 2015. However, the results for ownership succession intention are not significant. This suggests that the positive relationship between a founder's succession intention and a family firm's environmental investment is more prominent when founders have management succession intentions than ownership succession intentions. The findings support H3.

TABLE 5 Comparison between management succession intention and ownership succession intention.

Model	(7)	(8)
	<i>Env</i>	<i>Env</i>
<i>SI_M</i>	0.006** (0.003)	0.036*** (0.010)
<i>SI_O</i>	0.010 (0.008)	-0.018 (0.033)
<i>SS</i>	0.001* (0.001)	0.002*** (0.001)
<i>SI_M*SS</i>		-0.005*** (0.002)
<i>SI_O*SS</i>		0.005 (0.005)
<i>Gender</i>	0.003 (0.003)	0.003 (0.003)
<i>Age</i>	0.007 (0.006)	0.007 (0.006)
<i>Education background</i>	-0.001 (0.001)	-0.001 (0.001)
<i>Political connection</i>	0.009*** (0.003)	0.009*** (0.003)
<i>Ownership</i>	-0.019*** (0.007)	-0.019*** (0.007)
<i>Firm size</i>	0.003*** (0.001)	0.003*** (0.001)
<i>Profitability</i>	0.002 (0.004)	0.002 (0.004)
<i>Industry</i>	Yes	Yes
<i>Constant</i>	-0.075*** (0.025)	-0.075*** (0.025)
<i>N</i>	3,382	3,382
<i>Pseudo R²</i>	-0.356	-0.366

Standard errors are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

TABLE 6 The average treatment effect using propensity score matching.

	ATE	ATE
	<i>SI_M (1 vs. 0)</i>	<i>SI_O (1 vs. 0)</i>
<i>Env</i>	0.004* (0.002)	0.004 (0.004)

Standard errors are in parentheses. ATE, Average treatment effect. * $p < 0.10$.

Model 8 of Table 5 is similar to Model 7 but includes the interaction term between the founder’s management succession intention and their subjective social status, and the interaction term between the founder’s ownership succession intention and their subjective social status. The parameter coefficient of the interaction term between management succession intention and social status is negative and statistically significant. However, neither the parameter coefficient of ownership succession intention nor the interaction term between ownership succession

intention and subjective social status is statistically significant. Specifically, the negative moderating effect of a founder’s subjective social status only applies to the positive relationship between the founder’s management succession intention and the firm’s environmental investments.

Conclusion

Using the lens of psychology, we explain how founders’ succession intentions influence family firms’ environmental investments. The main finding of this study is that Chinese family firms whose founders have succession intentions make more environmental investments than firms whose founders do not have succession intentions. It supports expectancy theory with empirical evidence. Moreover, it is observed that the founder’s subjective social status negatively moderates the positive relationship between succession intention and environmental investments. Specifically, the positive relationship between succession intention and environmental investments is weaker for founders with high subjective social status than for those with low subjective social status. When differentiating between a founder’s management and ownership succession intentions, we find that the positive effects of succession intention on a firm’s environmental investments are driven mainly by the founder’s management succession intentions. Moreover, the negative moderating effects of the founder’s subjective social status only apply to the relationship between the founder’s management succession intention and the family firm’s environmental investments. Our study enriches the extant environmental research as well as family business studies.

Our findings have several important implications. First, this study expands the scope of research on the factors influencing environmental investments. Except for legal regulations, family firms’ dynastic transition plans can affect their environmental strategies. Government departments can help to establish an institutional environment that improves founders’ willingness to pass on family businesses to the next generation to promote sustainable development of family firms. The long-term vision of family firms is conducive to firms’ environmental investments. Second, high-social-status entrepreneurs face high expectations from stakeholders, they adhere to appropriate social norms of behavior to obtain a positive social image. For founders without succession intentions, a credible public ranking list can help them identify their position in the social hierarchy and guide their self-evaluation of social status, which, in turn, could also encourage their responses to environmental issues. Thus, government departments can use such tools and encourage public scrutiny of corporate pollution practices to drive corporate environmental investments.

This study has some limitations. First, we do not use panel data, and the cross-sectional design may weaken the robustness

of our findings. Second, we focus only on the moderating role of the founder's subjective social status; other institutional-, industry-, firm-, and individual-level variables may also affect the relationship between the founder's succession intention and the firm's environmental investments. These limitations provide opportunities for future research in this area.

Data availability statement

The datasets analyzed for this study are available on the website: <https://cpes.zkey.cc/index.jsp>. Further inquiries can be directed to the corresponding author.

Author contributions

QZ, LX, YY, ZS, and ZW contributed to conception and design of the study. LX organized the database. QZ performed the statistical analysis. All authors contributed to the article and approved the submitted version.

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Funding

This research was supported by the National Social Science Foundation of China (grant number: 20CJY040).

Conflict of interest

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 24 June 2022

ACCEPTED 19 August 2022

PUBLISHED 20 September 2022

CITATION

Xu N, Liu J and Dou H (2022)
Environmental, social, and governance
information disclosure and stock price
crash risk: Evidence from Chinese
listed companies.
Front. Psychol. 13:977369.
doi: 10.3389/fpsyg.2022.977369

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Environmental, social, and governance information disclosure and stock price crash risk: Evidence from Chinese listed companies

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According to information asymmetry theory and stakeholder theory, this article explores the impact and mechanism of environmental, social, and governance (ESG) information disclosure on the company's future stock price crash risk based on the A-share listed companies from 2010 to 2019. We find that ESG information disclosure significantly reduces the company's future stock price crash risk. This conclusion remains robust after a series of robustness tests, such as PSM-DID. The heterogeneity analysis shows that the negative relationship between ESG disclosure and stock price crash risk is more significant in state-owned enterprises, companies with higher agency costs, and when companies in the bull market. The mechanism is that companies choose to disclose ESG information to alleviate information asymmetry problems and enhance corporate reputation capital, thus reducing the future stock price crash risk. This article shows that strengthening ESG construction will help improve the efficiency of China's resource allocation and promote the capital market development.

KEYWORDS

ESG information disclosure, reputational capital, stock price crash risk, information asymmetry theory, stakeholder theory

Introduction

In 2004, the United Nations Global Compact first proposed the concept of environmental, social, and governance (ESG). In 2006, the United Nations Principles for Responsible Investment (UN PRI) incorporated environmental, social, and corporate governance into the investor evaluation system, aiming to help investors understand

the impact of ESG information on value investing. ESG evaluation mainly measures the economic value, social value, and future sustainable development capability of enterprises, which becomes a new standard for high-quality development.

In recent years, the number of listed companies that disclose ESG information in China has increased. According to SynTao Green Finance's ESG Rating Report in 2020, the number of ESG reports¹ disclosed by Chinese A-share listed companies has increased from 471 in 2010 to 1,092 in 2020. The company discloses ESG information to the outside, such as the company's environmental protection, social responsibility, and corporate governance status. The information not only helps stakeholders form a more comprehensive view and optimize the information environment of the company but also is an integral part of a green and low-carbon circular economy system under the background of China's "double carbon" goal.

However, since it is voluntary to disclose ESG information in China until now, and there is no standard information disclosure regulation, the management is given much freedom to choose the ESG information disclosure strategy. Based on the information obfuscation hypothesis, the managers who have the motivation to benefit themselves are willing to use ESG information disclosure as a self-interested tool to conceal negative news about the company, such as poor financial performance and unethical behavior (Kim et al., 2014; Liu et al., 2022). Therefore, whether corporate ESG information disclosure can genuinely improve the information quality of the capital market and optimize resource allocation needs further discussion.

High-quality information disclosure is an essential foundation for the healthy operation of the capital market and the improvement of market pricing efficiency. In recent years, it is common for the stock prices of individual stocks in China's stock market to plummet. For example, in 2015, more than 1,000 stocks fell by the limit, and in 2019, Kangmei Pharmaceutical and Kangdexin committed financial fraud. It has had a tremendous negative impact on the healthy development of China's stock market and investors' wealth. Based on the bad news hiding the hypothesis of Jin and Myers (2006), insiders hide bad news for a long time based on self-interest, which increases the degree of information asymmetry between inside and outside of the company. When the bad news can no longer be concealed and released to the market, it will cause a sharp drop in its stock price or even collapse.

At present, scholars have found that financial reporting opacity (Hutton et al., 2009), primary shareholder control rights-cash flow rights separation (Hong et al., 2017),

exploratory innovation strategy (Jia, 2018), and powerful CEOs (Al Mamun et al., 2020) have a positive impact on stock price crash risk, while female CFOs (Li and Zeng, 2019), internet searching (Xu et al., 2021), green Commitment (Liu et al., 2022), and bank deregulation (Dang et al., 2022) negatively affect stock price crash risk. Based on the strategic development need of China, this article explores whether and how to optimize the efficiency of resource allocation from the perspective of the stock price collapse, which is of great practical significance.

Using the data of China's A-share listed companies from 2010 to 2019, we examine the impact of corporate ESG information disclosure on stock price crash risk. We find that the more complete the company discloses ESG information, the more significant it will reduce the risk of future stock price crashes. Further analysis shows that the negative relationship between ESG disclosure and stock price crash risk is more significant in state-owned enterprises, companies with higher agency costs, and when companies in the bull market. Disclosure of ESG information by companies can alleviate information asymmetry and enhance corporate reputation capital, thus reducing the future stock price crash risk.

The research contributes to the following two aspects. First, compared to foreign countries, China has limited empirical attention to ESG, and little literature examines the relationship between corporate ESG information disclosure and stock price crash risk. The existing literature mostly studies the impact on stock price crash risk from the perspectives of company information quality, management motivation, and characteristics, such as information transparency (Hutton et al., 2009), accounting conservatism (Kim and Zhang, 2016), executive gender (Li and Zeng, 2019), etc. We measure ESG information disclosure from the two dimensions of whether companies disclose ESG information and the degree of its disclosure, and explore its impact on stock price crash risk. It complements the literature on the influential factor of the stock price crash risk.

Second, this article finds that ESG information disclosed by companies can alleviate information asymmetry to a certain extent and improve reputational capital. The existing literature generally believes that information asymmetry (Jin and Myers, 2006), agency problems (Li and Zeng, 2019), and irrational behavior of institutional investors (An and Zhang, 2013; Callen and Fang, 2013; Xu et al., 2013), etc., are the important mechanisms that lead to the crash of the stock price of listed companies. We incorporate information transparency and corporate reputation capital into the same research framework, systematically analyze the transmission mechanism of ESG information disclosure to stock price crash risk from a theoretical level, and reveal the inherent logical relationship between ESG information

¹ The so-called "ESG report" includes the reports issued by the company under the names of "Social Responsibility Report" and "Sustainability Report."

disclosure and stock price crash risk, which will enrich existing research.

Literature review and hypothesis development

Environmental, social, and governance-related research

At present, scholars have been actively exploring the field of ESG. Some scholars believe that the ESG practice of enterprises violates the principle of profit maximization, and the company may miss investment opportunities, resulting in inefficient investment portfolios and destroying enterprise value (Fabozzi et al., 2008; Revelli and Viviani, 2015). However, most scholars have found that ESG practices can improve corporate competitive advantage, bring returns to shareholders (Porter and Kramer, 2006), and improve the performance of enterprises (Friede et al., 2015; Mervelskemper and Streit, 2017; Yu et al., 2018).

In addition, scholars have also paid more attention to the issue of how ESG information affects the allocation of market resources, which can be summarized into the following three aspects: first, improve the information content in the market and alleviate information asymmetry. Yuan et al. (2022) studied the relationship between ESG information disclosure and corporate irregularities from the perspective of non-financial information disclosure and found that ESG disclosure can alleviate information asymmetry, improve information transparency, and restrain corporate financial irregularities. Ellili (2022) found that companies' disclosure of ESG information can not only improve corporate transparency but also help companies make rational investment decisions and improve investment efficiency.

Second, attract the attention of investors and obtain excess investment returns. Cao et al. (2020) found that ESG information disclosed by companies often attracts the attention of social responsibility agencies, which will change investors' trading behavior, and then have an impact on investors' stock return patterns and market pricing of information. Pastor et al. (2021) analyzed a two-factor model driven by green factors and found that a portfolio that considered ESG factors could achieve higher stock returns, and green stocks performed better.

Third, gain reputational advantages, reduce default risk, and improve long-term competitiveness. Jahmane and Brahim (2020) and Lemma et al. (2021) found that the "green" behavior of enterprises can send positive signals, form the reputation capital of enterprises, ease the financing constraints of enterprises, and then obtain economic returns. Some scholars have also found that even if a company's "green" behavior does not yield financial returns immediately (Wan et al., 2021), the

accumulated reputational capital can significantly improve the long-term competitiveness of the company and improve the stability of stock prices (Dhaliwal et al., 2011; Liu et al., 2022).

Hypothesis development

As a kind of non-financial information, ESG reports can enrich the understanding of external investors about the value-relevant information on corporate environmental, social, and corporate governance. This enlightenment can mitigate the degree of information asymmetry, and improve corporate reputation and investor risk tolerance, thus reducing the probability of the company's future stock price crash.

On the one hand, ESG information disclosure is a useful way to provide the information that external investors' need, which relieves the information asymmetry in China's capital market. First, the ESG disclosure integrates the individual information that is beneficial to the company into the stock price, attracts more investor attention (Liu et al., 2022; Tao et al., 2022), and reduces the heterogeneity of investors' expectations for the company's stock in future caused by the lack of information (Yuan et al., 2022). Second, companies with better ESG performance are more willing to disclose ESG information (Jagannathan et al., 2017), showing to the outside that the company has a high level of environmental protection responsibility, cultural conservation, and corporate governance. Due to the widespread information discrepancy between inside management and outside investors, company managers have an incentive to use such advantages to benefit themselves. When a company voluntarily discloses ESG information to the outside, the motivation to conceal information is scarce. Therefore, companies' disclosure of ESG information will help alleviate the agency problem caused by insider control (Liu et al., 2022), improve the transparency of information disclosure, and reduce the information risk faced by investors (Eccles et al., 2014). Third, better communication between the company and investors helps investors obtain a clearer company image alleviating the degree of information asymmetry between inside and outside the company, thereby reducing the risk of future stock price crashes. Further, the company's ESG performance is relatively good, and it will force companies to improve the level and transparency of ESG information disclosure, which will play a more substantial role in suppressing the collapse of stock prices.

On the other hand, ESG information disclosure is a signal for outsiders that the company cares about the interests of stakeholders, such as employees and customers, which may improve employee satisfaction (Lyon and Montgomery, 2015; El Akremi et al., 2018) and attract more high-quality employees and clients, giving organizations a competitive advantage. First, environmental problems such as global warming caused

by excessive carbon emissions endanger the normal life and economic activities of about 1 billion people (Tian et al., 2022). Therefore, when companies disclose ESG information in line with the concept of green and low-carbon development to stakeholders, they not only demonstrate their commitment to environmental and social responsibilities to stakeholders but also send a non-self-interested signal to stakeholders. It helps corporates form an excellent citizenship image. The accumulation of this long-term positive image can improve the enterprise's reputation (Cho et al., 2012) and form a critical intangible asset in the information asymmetry environment. When negative news flows out of the company, this reputational capital may increase investors' tolerance for bad news, which will have a specific buffering effect on stock price fluctuations caused by negative news (Cao et al., 2020), like a protection mechanism, to prevent the collapse of the company's stock price in future. In addition, unlike social responsibility reports, companies that disclose ESG information pursue social benefits and pay attention to their corporate governance level, that is, considering both corporate value and social value. To a certain extent, this can avoid the decline of corporate productivity and the impairment of corporate value due to over-emphasis on social benefits and truly satisfy the interests of multiple stakeholders, including shareholders. ESG information disclosure shows a better governance level and alleviates the information asymmetry problem, which helps attract multiple stakeholders. Under such circumstances, the stock price can reflect the actual production and operation of the company timely, thereby restraining the collapse caused by the excessive deviation between the stock price and the company's intrinsic value. We propose the following hypothesis:

Hypothesis 1: Environmental, social, and governance (ESG) information disclosure can help reduce the company's future stock price crash risk.

Research design

Data and sample selection

Our initial sample consists of all Chinese A-share listed firms in the period 2010–2019. The sample collection processes are as follows: (1) delete firms operating in the financial industry. (2) Delete firms that are ST (special treat) or PT (particular transfer) in the current year. (3) Delete firms with fewer than 30 trading weeks in a year (as per the requirements for calculating the stock price crash risk). (4) Delete firms with missing financial data. (5) All continuous variables are winsorized at the 1 and 99% levels. This process yields a sample comprising 19,056 firm-year observations. The company's ESG information disclosure score comes from the Bloomberg database, and other data are from the CSMAR database. We use Stata 15.1 to process data.

Variables definition

Stock price crash risk

We follow the literature (Kim et al., 2011; Kim and Zhang, 2016) by using the negative conditional skewness of returns and the down-to-up volatility of returns to measure the stock price crash risk. The specific calculation process is as follows.

First, model (1) eliminates the impact of market factors on the return on individual stocks. Use the weekly rate of return data for stock *i* to calculate the weekly rate of return for stock *i* after excluding market influences.

$$R_{i,t} = \beta_0 + \beta_1 R_{m,t-2} + \beta_2 R_{m,t-1} + \beta_3 R_{m,t} + \beta_4 R_{m,t+1} + \beta_5 R_{m,t+2} + \varepsilon_{i,t} \tag{1}$$

where $R_{i,t}$ is the stock return on firm *i* at week *t*, $R_{m,t}$ is the return on the value-weighted market index to which this firm belongs at week *t*, and $\varepsilon_{i,t}$ represents an error term. In this article, the lag and advance of the market rate of return are added to model (1) to adjust the impact of non-synchronous transactions. Residual represents a portion of a stock's yield that cannot be explained by fluctuations in the market's yield. Following the existing literature, we define the firm-specific weekly returns for firm *j* in week *w* ($W_{i,t}$) as the natural logarithm of 1 plus the residual [i.e., $W_{i,t} = \ln(1 + \varepsilon_{i,t})$].

$$NCSKEW_{i,t} = -[n(n-1)^{3/2} \sum W_{i,t}^3] / [(\sum W_{i,t}^2)^{3/2}] \tag{2}$$

$$DUVOL_{i,t} = \log\left\{ \frac{\sum_{Down} W_{i,t}^2}{\sum_{Up} W_{i,t}^2} \right\} \tag{3}$$

Our first proxy for stock price crash risk is the negative conditional firm-specific skewness of weekly return ($NCSKEW_{i,t}$). $NCSKEW_{i,t}$ is calculated by taking the negative of the third moment of firm-specific weekly returns for each sample year and dividing it by the standard deviation of firm-specific weekly returns raised to the third power. A higher value for $NCSKEW_{i,t}$ indicates a higher crash risk.

Our second proxy for stock price crash risk is the down-to-up volatility ($DUVOL_{i,t}$), which is the log of the ratio of the standard deviation on the down weeks to the standard deviation on the up weeks. In model (3), n_u is the number of "up" weeks and n_d is the number of "down" weeks. A higher value for $DUVOL_{i,t}$ also indicates a higher crash risk.

Environmental, social, and governance information disclosure

Following Lokuwaduge and De Silva (2022), we use the binary dummy variables of whether the company discloses ESG information (ESG_if_t) and ESG information disclosure

score (ESG_score_t) as the proxy variable for ESG information disclosure.² If Bloomberg gives an ESG score to a listed Chinese company i in year t , ESG_if_t is 1; otherwise, it is 0; we measure the ESG information disclosure degree (ESG_score_t) by using the ESG score released by Bloomberg. The higher the ESG score, the better the completeness and compliance of ESG information disclosed by the company.

Other variables

We follow the extant literature (Xu et al., 2013; Kim and Zhang, 2016; Liu et al., 2022), and choose the following variables as our control variables, such as $OTurnover_t$, $Sigma_t$, Ret_t , $Size_t$, and so on. In addition, we control for industry and year-fixed effects. The specific variable definitions are listed in Appendix A.

Empirical model

In order to test the relationship between ESG information disclosure and stock price crash risk, we construct model (4) for empirical test:

$$Crash_{i,t+1} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum_{k=3}^m \gamma_k Controls_t + Industry + Year + \epsilon_{i,t} \quad (4)$$

where $Crash_{i,t+1}$ represents the stock price crash risk of individual stock i in year $t+1$, respectively, using the negative yield skewness coefficient ($NCSKEW_{i,t+1}$) of stock i in year $t+1$ and the yield fluctuations in rates of stock ($DUVOL_{i,t+1}$) as the proxy variable; $ESG_{i,t}$ represents the company's ESG information disclosure, which is measured by whether the company discloses ESG information (ESG_if_t) and the degree of ESG information disclosure (ESG_score_t); $Controls$ represent the control variables in Appendix A, $Industry$ and $Year$ are dummy variables for industry and year, respectively.

Empirical results

Descriptive statistics

Table 1 reports the results of descriptive statistics. The means of $NCSKEW_{t+1}$ and $DUVOL_{t+1}$ are -0.309 and -0.202 , respectively. The standard deviations are 0.729 and 0.482 , respectively. It suggests differences in the degree of stock price crash risk faced by different companies. The mean value of ESG_if_t is 0.425 , the minimum value is 0 , and the median value

is 0 , indicating that more than half of the sample companies have not disclosed ESG information. The standard deviation of ESG_if_t is 0.494 , indicating that there are differences in whether the company chooses to disclose ESG information. The mean value of ESG_score_t is 0.087 , the minimum value is 0 , the maximum value is 0.397 , and the standard deviation is 0.109 , among the companies that disclose ESG information, there are also differences in the degree of disclosure of ESG information. The distributions of the remaining variables are all within a reasonable range.

Regression analysis

Table 2 shows the results of testing the relationship between ESG information disclosure and stock price crash risk using model (4). Columns (1) and (2) are the regression results of whether to disclose ESG information (ESG_if_t) and stock price crash risk ($NCSKEW_{t+1}$ and $DUVOL_{t+1}$). The results show that the regression coefficient of ESG_if_t is significantly negative at the 5% level, indicating that companies choosing to disclose ESG information can reduce the future stock price crash risk; Columns (3) and (4) are the regression results of ESG information disclosure score (ESG_score_t) and stock price crash risk ($NCSKEW_{t+1}$ and $DUVOL_{t+1}$). The coefficients of ESG_score_t are -0.154 and -0.103 , respectively, and are significant at the 5% level, indicating that the better the company's disclosure of ESG information is, the more significant it will reduce the risk of future stock price crashes. The results demonstrate our hypothesis. That is, ESG information disclosure is negatively related to the company's future stock price crash risk. Economically, for each standard deviation increase in the ESG information disclosure score of a company, the company's future stock price crash risk $NCSKEW_{t+1}$ ($DUVOL_{t+1}$) correspondingly decreases by 0.017 (0.011), which is equivalent to 5.5% (5.4%) of the mean. From the perspective of control variables, the sign and significance of $OTurnover_t$, Ret_t , $NCSKEW_t$, and BM_t are consistent with previous studies (Kim et al., 2011; Callen and Fang, 2013; Liu et al., 2022).

Robustness check

In this section, we will conduct a battery of robustness checks on the empirical results, including PSM-DID, instrumental variable method, and alternative measures of dependent variables.

Propensity score matching-DID

To mitigate potential endogeneity problems caused by sample selection bias, we adopt the propensity score matching

² The so-called "ESG report" includes the reports issued by the company under the names of "Social Responsibility Report" and "Sustainability Report."

TABLE 1 Summary statistics.

Variable	N	Mean	STD	Min	25%	50%	75%	Max
<i>NCSKEW_{t+1}</i>	19056	-0.309	0.729	-2.472	-0.710	-0.266	0.125	1.747
<i>DUVOL_{t+1}</i>	19056	-0.202	0.482	-1.385	-0.522	-0.200	0.117	1.077
<i>ESG_if_t</i>	19056	0.425	0.494	0	0	0	1	1
<i>ESG_score_t</i>	19056	0.087	0.109	0	0	0	0.190	0.397
<i>OTurnover_t</i>	19056	-0.127	0.442	-1.962	-0.264	-0.054	0.085	0.898
<i>Sigma_t</i>	19056	0.061	0.023	0.025	0.045	0.055	0.070	0.144
<i>Ret_t</i>	19056	0.002	0.009	-0.016	-0.004	0.001	0.007	0.031
<i>Size_t</i>	19056	22.356	1.29	19.889	21.447	22.189	23.102	26.245
<i>BM_t</i>	19056	0.642	0.246	0.122	0.454	0.649	0.832	1.151
<i>NCSKEW_t</i>	19056	-0.271	0.719	-2.396	-0.665	-0.240	0.154	1.747
<i>Lev_t</i>	19056	0.46	0.206	0.063	0.300	0.458	0.616	0.918
<i>ROA_t</i>	19056	0.04	0.059	-0.22	0.013	0.036	0.067	0.211
<i>ABACC_t</i>	19056	0.062	0.064	0	0.019	0.043	0.083	0.35
<i>Growth_t</i>	19056	0.172	0.425	-0.563	-0.017	0.104	0.255	2.822
<i>Age_t</i>	19056	2.139	0.887	0	1.609	2.398	2.833	3.258
<i>Indep_t</i>	19056	0.373	0.053	0.333	0.333	0.333	0.429	0.571
<i>Board_t</i>	19056	8.787	1.732	5	8	9	9	15
<i>Dual_t</i>	19056	0.227	0.419	0	0	0	0	1
<i>State_t</i>	19056	0.448	0.497	0	0	0	1	1

(PSM) method for robustness check. The dependent variables in the benchmark regression in this article are lagged by one period, which can alleviate the endogenous problem caused by reverse causality to a certain extent. This article constructs a time-varying DID model (5) to control possible endogenous problems.

$$Crash_{i,t+1} = \alpha_0 + \alpha_1 Treat_{i,t} + \sum_{k=3}^m \gamma_k Controls_t + Industry + Year + \epsilon_{i,t} \quad (5)$$

where *Crash-Risk_{i,t+1}* represents two measures of stock price crash risk (*NCSKEW_{t+1}* and *DUVOL_{t+1}*), *Treat_{i,t}* is a binary dummy variable that changes with individuals and time, if company *i* discloses ESG information in year *t*, then treat *Treat_{i,t}* as 1 for the current year and subsequent years; otherwise, it is assigned as 0. Since different companies have significant differences in company characteristic variables such as size and profitability, this article draws on the research of Rosenbaum and Rubin (1983) to use propensity score matching (PSM) to perform nearest neighbor 1:1 caliper matching to obtain the treatment group and the control group. Then we use model (5) to regress.

Table 3 displays the results. The regression coefficients of *Treat_t* are all negative and significant at the 10% level at least. It shows that after controlling the possible endogeneity problems, the negative relationship between ESG information disclosure and the future stock price crash risk is still significant, indicating the robustness of the baseline regression results in this article.

Instrumental variable method

In order to alleviate the interference of endogenous problems such as measurement error and sample self-selection in the conclusions of this article, we adopt the ratio of the number of ESG information disclosures (IV1) that belong to the same year-industry to the total number of companies and the ratio of the number of ESG information disclosed belong to the same year-province to the total number of companies (IV2) as an instrumental variable for whether to disclose ESG information (*ESG_if_t*). In addition, we use the mean value of ESG information disclosure scores (IV3) belonging to the same year-industry and the mean value of ESG information disclosure score belonging to the same year-province (IV4) as the instrumental variables of ESG information disclosure degree (*ESG_score_t*).

Table 4 presents the regression results of the instrumental variable method. From the regression results of the first stage, the coefficients of the instrumental variables are all significantly positive at the level of 1%, indicating that the instrumental variables can well-explain ESG information disclosure variables (*ESG_if_t* and *ESG_score_t*); the second-stage regression results show that the regression coefficients between *ESG_if_t* and stock price crash risk (*NCSKEW_{t+1}* and *DUVOL_{t+1}*) are significantly negative at the 5% level. The regression coefficient of *ESG_score_t* and stock price crash risk (*NCSKEW_{t+1}* and *DUVOL_{t+1}*) are significantly negative

TABLE 2 Baseline regression results.

Variable	(1)	(2)	(3)	(4)
	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}
<i>ESG_if_t</i>	-0.028** (-2.143)	-0.019** (-2.269)		
<i>ESG_score_t</i>			-0.154** (-2.525)	-0.103** (-2.540)
<i>OTurnover_t</i>	-0.006 (-0.376)	-0.003 (-0.319)	-0.006 (-0.377)	-0.003 (-0.322)
<i>Sigma_t</i>	-0.580 (-1.520)	-0.589** (-2.322)	-0.597 (-1.564)	-0.600** (-2.362)
<i>Ret_t</i>	10.853*** (11.271)	7.062*** (10.976)	10.877*** (11.301)	7.079*** (11.008)
<i>Size_t</i>	0.026*** (3.536)	0.007 (1.396)	0.029*** (3.737)	0.008 (1.621)
<i>BM_t</i>	-0.325*** (-9.367)	-0.192*** (-8.323)	-0.328*** (-9.458)	-0.193*** (-8.382)
<i>NCSKEW_t</i>	0.073*** (9.466)	0.046*** (8.989)	0.073*** (9.465)	0.046*** (8.989)
<i>Lev_t</i>	0.034 (0.955)	0.027 (1.160)	0.031 (0.873)	0.025 (1.086)
<i>ROA_t</i>	-0.248** (-2.195)	-0.248*** (-3.307)	-0.254** (-2.243)	-0.252*** (-3.359)
<i>ABACC_t</i>	0.366*** (4.251)	0.236*** (4.168)	0.364*** (4.225)	0.234*** (4.142)
<i>Growth_t</i>	-0.009 (-0.674)	-0.006 (-0.692)	-0.010 (-0.717)	-0.006 (-0.733)
<i>Age_t</i>	-0.065*** (-8.110)	-0.048*** (-9.264)	-0.065*** (-8.121)	-0.048*** (-9.285)
<i>Indep_t</i>	-0.082 (-0.741)	-0.051 (-0.703)	-0.079 (-0.713)	-0.049 (-0.677)
<i>Board_t</i>	-0.006 (-1.616)	-0.004* (-1.883)	-0.006 (-1.606)	-0.004* (-1.877)
<i>Dual_t</i>	0.008 (0.621)	0.003 (0.375)	0.008 (0.600)	0.003 (0.356)
<i>State_t</i>	-0.044*** (-3.511)	-0.023*** (-2.771)	-0.043*** (-3.434)	-0.022*** (-2.694)
<i>Constant</i>	-0.341** (-2.177)	-0.007 (-0.064)	-0.393** (-2.425)	-0.037 (-0.338)
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes
<i>N</i>	19056	19056	19056	19056
<i>Adj-R²</i>	0.065	0.069	0.065	0.069

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

at the 1% level. Moreover, the instrumental variables have passed the weak instrumental variables and over-identification tests. It shows that after alleviating the possible endogenous, the benchmark regression results in this article remain robust.

Alternative measures

Following the studies of Hutton et al. (2009) and Dang et al. (2022), we change the criteria for judging stock price slumps and set the threshold to 1%. Specifically, we compare

TABLE 3 Propensity score matching+DID method.

Variable	PSM+DID	
	(1)	(2)
	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}
<i>Treat</i> _{<i>t</i>}	-0.032* (-1.892)	-0.021** (-1.969)
<i>Controls</i>	Yes	Yes
<i>Constant</i>	-0.886** (-2.300)	-0.557** (-2.045)
<i>Year</i>	Yes	Yes
<i>Industry</i>	Yes	Yes
<i>N</i>	19023	19023
<i>Adj-R</i> ²	0.069	0.072

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

the company's weekly idiosyncratic return with the average annual idiosyncratic return minus 3.09 standard deviations. If the former is lower than the latter, *CRASH* is assigned a value of 1; otherwise, it is 0. Since *CRASH* is a binary dummy variable, we use the logit model to regress. The regression

results are shown in Table 5. The results found that the regression coefficients of ESG information disclosure are all significantly negative at the 1% level. The benchmark results remain robust.

Heterogeneity analysis

Capital market condition

Following Kao et al. (1998), if the average monthly market return of stock within 12 months of the current year is greater than 0, the market condition is a bull market. Otherwise, it is a bear market. We determine the sample data years 2012–2015, 2017, and 2019 as bull markets and the remaining years as bear markets. Table 6 shows the results of regression according to differences in market conditions. The results show that the regression coefficient of ESG information disclosure is significantly negative in the bull market, while the coefficient is not significant in the bear market. It shows that ESG information disclosure in a bull market can further alleviate information asymmetry, restrain investors' irrational investment decisions, and reduce the irrational bubbles in

TABLE 4 Instrumental variables method.

Variable	First stage		Second stage			
	(1)	(2)	(3)	(4)	(5)	(6)
	<i>ESG_if</i> _{<i>t</i>}	<i>ESG_score</i> _{<i>t</i>}	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}
<i>ESG_if</i> _{<i>t</i>}			-0.303*** (-3.648)	-0.134** (-2.452)		
<i>ESG_score</i> _{<i>t</i>}					-1.317*** (-4.089)	-0.622*** (-2.948)
<i>IV1</i>	0.488*** (5.250)					
<i>IV2</i>	0.569*** (20.349)					
<i>IV3</i>		0.323*** (13.389)				
<i>IV4</i>		0.533*** (21.820)				
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Constant</i>	-5.369*** (-69.153)	-1.223*** (-73.935)	-1.779*** (-3.922)	-0.603** (-2.020)	-1.870*** (-4.335)	-0.696** (-2.453)
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	19056	19056	19056	19056	19056	19056
<i>Adj-R</i> ²	0.372	0.440	0.042	0.060	0.047	0.061
<i>F statistics</i>	—	—	241.727	241.727	375.200	375.200
<i>Hansen J</i>	—	—	0.420 (<i>p</i> = 0.5171)	1.595 (<i>p</i> = 0.2066)	0.083 (<i>p</i> = 0.7738)	0.013 (<i>p</i> = 0.9107)

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

TABLE 5 Sensitivity tests for dependent variables.

Variable	(1)	(2)
	$CRASH_{t+1}$	$CRASH_{t+1}$
ESG_if_t	-0.162*** (-2.777)	
ESG_score_t		-1.125*** (-4.053)
Controls	Yes	Yes
Constant	-0.142 (-0.192)	-0.689 (-0.906)
Year	Yes	Yes
Industry	Yes	Yes
N	19056	19056
Pseudo R ²	0.021	0.022

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

TABLE 6 Capital market condition.

Variable	Bull market				Bear market			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$NCSKEW_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$
ESG_if_t	-0.030* (-1.816)	-0.019* (-1.724)			-0.017 (-0.814)	-0.014 (-1.056)		
ESG_score_t			-0.173** (-2.194)	-0.100* (-1.923)			-0.089 (-0.920)	-0.078 (-1.212)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.194 (0.988)	0.411*** (3.093)	0.131 (0.646)	0.382*** (2.786)	-1.348*** (-5.333)	-0.773*** (-4.661)	-1.373*** (-5.247)	-0.796*** (-4.649)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11724	11724	11724	11724	7332	7332	7332	7332
Adj-R ²	0.068	0.072	0.069	0.072	0.062	0.066	0.063	0.066

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

company stock prices, thereby restraining future stock price crashes.

Property rights nature

The environmental part of ESG information belongs to public goods with unclear property rights. The related problems cannot be entirely solved by market mechanisms but need the government’s intervention (Huang, 2021). Therefore, compared with non-state-owned enterprises, SOEs are more likely to disclose ESG information (Weber, 2014), provide more information about the company’s characteristics to outside the company, and improve the transparency of market information. Meanwhile,

compared with non-state-owned enterprises, SOEs have to undertake specific policy tasks and social responsibilities in addition to pursuing economic interests (Leippold et al., 2022).

Table 7 presents the regression results. According to the different nature of property rights, the sample enterprises are divided into state-owned and non-state-owned enterprises, and then model (4) is regressed. The coefficients of ESG_if_t and ESG_score_t are significantly negative at least at the 10% level in Columns (1) to (4), and the coefficients of ESG_if_t and ESG_score_t are not significant in Columns (5) to (8), indicating that compared with non-state-owned enterprises, ESG information disclosure has a more significant effect on reducing stock price crash risk in SOEs.

TABLE 7 Property rights nature.

Variable	SOE				Non-SOE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	NCSKEW _{t+1}	DUVOL _{t+1}						
ESG_if _t	-0.038** (-2.059)	-0.030** (-2.505)			-0.018 (-1.015)	-0.010 (-0.808)		
ESG_score _t			-0.161* (-1.879)	-0.121** (-2.162)			-0.145 (-1.645)	-0.083 (-1.391)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.282 (-1.277)	0.052 (0.357)	-0.309 (-1.334)	0.041 (0.267)	-0.539** (-2.250)	-0.122 (-0.762)	-0.608** (-2.510)	-0.166 (-1.022)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	8542	8542	8542	8542	10514	10514	10514	10514
Adj-R ²	0.062	0.065	0.061	0.065	0.058	0.064	0.058	0.064

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

Agency costs

The existence of the agency problem makes the management generally have the motive to hide negative news, and the information asymmetry between inside and outside the enterprise will aggravate the accumulation of negative information and increase the risk of a stock price crash (Kim et al., 2011; Kim and Zhang, 2016). ESG information incorporate more idiosyncratic information into the stock price, which help alleviate the information asymmetry, thus decrease the agency costs. Therefore, we use the company’s total asset turnover rate to measure agency costs and divide the sample into a high agency cost group and a low agency cost group according to the median to explore the difference in agency costs. The above treatment will help explore differences in agency costs on the relationship between ESG information disclosure and stock price crash risk.

Table 8 shows the regression results. In the higher agency cost group, the coefficients of ESG information disclosure variables (ESG_if_t and ESG_score_t) are significantly negative at least at the 5% level, and in the lower agency cost group, their coefficients are negative but not significant. It shows that ESG information disclosure has a more significant inhibitory effect on stock price crash risk in companies with more severe agency problems.

Mechanism analysis

In this section, we try to provide the mechanism about why the ESG information disclosure is negatively related to stock price crash risk.

Degree of information asymmetry

The disclosure of ESG information by companies may alleviate the information asymmetry between inside and outside the company to a certain extent (Lyon and Montgomery, 2015; Yuan et al., 2022), improve the pricing efficiency of the capital market, and then reduce the company’s future stock price crash risk. Therefore, we draw on the mediation effect test procedure of Wen et al. (2004) to examine whether information asymmetry plays a mediating role in the relationship between ESG information disclosure and stock price crash risk. Specifically, following Kaeck et al. (2022), we adopt relative bid-ask spread (ESP) as proxy variables for the degree of information asymmetry. The specific calculation is shown in formulas (6).

$$ESP_{i,t} = \left(\sum_{d=1}^n \frac{|Price_{i,d} - mid(Ask_{i,d}, Bid_{i,d})| \times 2}{mid(Ask_{i,d}, Bid_{i,d})} \right) / n \quad (6)$$

where Ask_{i,d} represents the selling price on the d-th trading day, calculated by the time interval weighted by the time interval between two adjacent transaction records. Bid_{i,d} represents the bid price on the d-th trading day, weighted by the time interval between two adjacent transaction records. mid(Ask_{i,d}, Bid_{i,d}) represents the midpoint price. n represents the actual number of trading days in year t. The larger the relative effective spread, the higher the degree of information asymmetry.

The regression results are shown in Table 9. The results of the first two columns show that the regression coefficients of ESG information disclosed (ESG_if_t and ESG_score_t) and ESP_{t+1} are significantly negative at the 1% level. It shows that the company’s disclosure of ESG information alleviates the degree of information asymmetry. Columns (3) to (6) are the regression results of ESG information disclosed (independent

TABLE 8 Agency costs.

Variable	High agency cost				Low agency cost			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}						
<i>ESG_if_t</i>	-0.054*** (-2.812)	-0.031*** (-2.531)			-0.004 (-0.256)	-0.009 (-0.736)		
<i>ESG_score_t</i>			-0.251*** (-2.756)	-0.150** (-2.520)			-0.062 (-0.749)	-0.057 (-1.043)
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Constant</i>	-0.710*** (-3.041)	-0.207 (-1.352)	-0.746*** (-3.095)	-0.232 (-1.471)	0.172 (0.809)	0.284* (1.945)	0.115 (0.521)	0.254* (1.690)
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	9528	9528	9528	9528	9528	9528	9528	9528
<i>Adj-R²</i>	0.062	0.069	0.062	0.069	0.071	0.072	0.071	0.072

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

TABLE 9 Mechanism analysis: Information asymmetry.

Variable	Information asymmetry					
	(1)	(2)	(3)	(4)	(5)	(6)
	<i>ESP</i> _{<i>t</i>+1}	<i>ESP</i> _{<i>t</i>+1}	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}	<i>NCSKEW</i> _{<i>t</i>+1}	<i>DUVOL</i> _{<i>t</i>+1}
<i>ESG_if_t</i>	-0.004*** (-3.554)		-0.029** (-2.234)	-0.020** (-2.360)		
<i>ESG_score_t</i>		-0.021*** (-4.155)			-0.160*** (-2.617)	-0.106*** (-2.632)
<i>ESP_{t+1}</i>			0.682*** (6.371)	0.450*** (6.494)	0.682*** (6.376)	0.450*** (6.499)
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Constant</i>	0.418*** (30.028)	0.411*** (29.047)	-0.013 (-0.077)	0.210* (1.892)	-0.066 (-0.383)	0.179 (1.573)
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Industry</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	19056	19056	19056	19056	19056	19056
<i>Pseudo R²/Adj-R²</i>	0.371	0.372	0.067	0.071	0.067	0.071
<i>Sobel test</i>	-	-	0.075	0.074	0.091	0.090

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

variable) and *ESP_{t+1}* (mediating variable) with stock price crash risk (dependent variable). It shows that the company's disclosure of ESG information alleviates the degree of information asymmetry in the market, thereby reducing the company's future stock price crash risk.

Reputation capital

The company's disclosure of ESG information reflects the company's commitment to the environment and social

responsibility, which can improve the confidence and recognition of stakeholders in the company, help the company to establish a good corporate citizenship image, and form the reputation capital of the company to deal with the company's future stock price fluctuations. Therefore, we use the mediation effect model to examine whether reputational capital plays a mediating role in the relationship between ESG information disclosure and stock price crash risk. Regarding the measurement of corporate reputation capital, we collect the "Most Admired Chinese Companies" All-Star List and Industry List released by Fortune (Chinese version) magazine

TABLE 10 Mechanism analysis: Reputation capital.

Variable	Reputation capital			
	(1)	(2)	(3)	(4)
	SY_{t+1}	SY_{t+1}	$NCSKEW_{t+1}$	$DUVOL_{t+1}$
ESG_if_t	0.266 (1.039)			
ESG_score_t		2.856*** (3.516)	-0.151** (-2.476)	-0.101** (-2.492)
SY_{t+1}			-0.094*** (-2.673)	-0.062** (-2.503)
Controls	Yes	Yes	Yes	Yes
Constant	-56.029*** (-24.666)	-53.232*** (-22.586)	-0.487*** (-2.903)	-0.098 (-0.877)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	16470	16470	19056	19056
Pseudo R ² /Adj-R ²	0.513	0.516	0.065	0.069
Sobel test	-	-	0.033	0.041

***, **, and * are significant at the level of 0.01, 0.05, and 0.1, respectively.

in 2010 as the basis for judgment. Specifically, if the company enters any list in year t, the reputation capital SY_t is taken as 1; otherwise, it is 0.

The regression results are shown in Table 10. Column (1) is the regression result of ESG_if_t (independent variable) and reputation capital (dependent variable). The regression coefficient of ESG_if_t is positive but not significant. It shows that in the early stage of China's ESG construction, it may be difficult to form reputation capital only based on whether companies disclose ESG information. Column (2) is the regression result of ESG_score_t (independent variable) and SY_{t+1} (dependent variable), indicating that the more ESG information disclosed by the company, the higher the integrity, and the more significant the improvement of corporate reputation capital; Columns (3) and (4) are the regression results of ESG_score_t (independent variable) and SY_{t+1} (mediating variable) with stock price crash risk (dependent variable). The results show that the more ESG information disclosure, the lower the stock price crash risk; the higher the company's reputational capital, the lower the stock price crash risk. The p-values of Sobel's mediating effect test are 0.033 and 0.041, indicating that the mediating effect of reputation capital exists. Reputation capital plays a partial intermediary role between the degree of ESG information disclosure and stock price crash risk.

Conclusion

The "14th Five-Year Plan" clearly puts forward requirements for society to coordinate environmental, social, and governance benefits, improve the ESG construction system, and in-depth

ESG practice. As the first step of the ESG construction system, ESG information disclosure is also a critical step. Whether it can promote the high-quality development of the capital market is worth exploring. Therefore, we take China's Shanghai and Shenzhen A-share listed companies from 2010 to 2019 as the research object and examine the impact and role of corporate ESG information disclosure on stock price crash risk. The results show that: (1) the more complete the company discloses ESG information, the more significant it will reduce the risk of future stock price crash; (2) in the bull market, SOEs and companies with high agency costs, ESG information disclosure has a more significant impact on reducing the risk of stock price crash; (3) the higher the company's ESG information disclosure, the lower the information asymmetry and the enhancement of corporate's reputation capital, thereby restraining the company's stock price crash risk.

The inspiration for this article mainly includes the following two aspects. First, ESG is an essential part of the construction of a green and low-carbon circular economy system under the background of "double carbon" in China, and it is the starting point for implementing the new development concept and promoting high-quality development of the capital market. Therefore, accelerating the construction of ESG is an urgent need to implement China's green development concept and adapt to the international environment. This article sorts out the micro-action mechanism of ESG information disclosure and provides new empirical evidence for researching the economic consequences of ESG information disclosure in Chinese academic circles. Further, considering the differences in the nature of property rights and improving the level of corporate governance are both important ways to strengthen the

ESG construction system. This will lay the foundation for the sustainable development of enterprises.

Second, in China, where the capital market is developing, the stock price crash has always been the focus of scholars. In our study, we have some suggestions. First, the companies should change the view that disclosing ESG information is just a burden but realize the benefits of lowering the future stock price crash risk and promoting the company's sustainable development. Second, from the perspective of external market participants, the information disclosed by the company should be treated appropriately. At the same time, it is necessary to strengthen the study of ESG evaluation-related knowledge. Investors should try to avoid excessive interpretation or insufficient analysis of the information disclosed by the company, which will reduce the quality of market information and distort the capital market. Finally, regulators should strengthen the construction of ESG information disclosure evaluation system and review system, and improve the formulation of standard ESG reports as soon as possible.

Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

NX and JL organized the database and performed the statistical analysis. All authors contributed to the conception and design of the manuscript, wrote the first draft of the

manuscript, contributed to manuscript revision, read, and approved the submitted version.

Funding

This research is supported by the First Batch of New Liberal Arts Research and Reform Practice Projects of the Ministry of Education of China (Grant No. 202111007), the National Natural Science Foundation of China (Grant No. 72072070), the Natural Science Foundation of Guangdong Province (Grant No. 2020A1515010402), the Fundamental Research Funds for the Central Universities (Grant No. 19JNQM17), and Postgraduate Innovative Research Projects of Hainan Province (Grant No. Qhys2021-104).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix A

TABLE A1 Variable definitions.

Variable type	Variable name	Variable definitions
Dependent	$NCSKEW_{t+1}$	The negative yield skewness coefficient of the company's stock in year t+1, see the text and formula (2) for the algorithm
	$DUVOL_{t+1}$	The yield fluctuations in rates of the company's stock return in year t+1, see the text and formula (3) for the algorithm
Independent	ESG_if_t	The ESG information disclosed by the company in year t is 1, otherwise it is 0
	ESG_score_t	Bloomberg's ESG score for companies in year t/100
Controls	$OTurnover_t$	The company's average monthly turnover rate in year t - the average monthly turnover rate in year t-1
	σ_t	The standard deviation of the company's weekly returns in year t
	Ret_t	The company's average weekly rate of return in year t
	$Size_t$	The natural logarithm of the firm's total assets in year t
	BM_t	Net assets of the company in year t/(stock price at the end of year t * number of tradable shares + net assets per share * number of non-tradable shares)
	$NCSKEW_t$	The firm's negative yield skewness coefficient in period t
	Lev_t	The company's total liabilities/total assets in year t
	ROA_t	The company's net profit/total assets in year t
	$ABACC_t$	Absolute value of the modified Jones model residuals
	$Growth_t$	The company's main business revenue growth rate in year t
	Age_t	Ln (ESG information disclosure year-listed year)
	$Indep_t$	Number of independent directors/number of directors of the company in year t
	$Board_t$	The total number of directors of the company in year t
	$Dual_t$	If the chairman of the company concurrently serves as the general manager in year t, it will be 1, otherwise 0
	$State_t$	If the company is a state-owned enterprise in year t, it will be 1, otherwise 0
	$Year$	Dummy variables based on year of ESG disclosure
	$Industry$	According to the dummy variables set by the China Securities Regulatory Commission in 2012, the first two codes are used as the classification standard for manufacturing, and the first code is used as the classification standard for non-manufacturing industries.



OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 30 June 2022

ACCEPTED 01 September 2022

PUBLISHED 30 September 2022

CITATION

Su X and Fu W (2022) Impact of multiple
performance feedback and regional
institutional development on enterprises'
exploratory innovation.
Front. Psychol. 13:982211.
doi: 10.3389/fpsyg.2022.982211

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Impact of multiple performance feedback and regional institutional development on enterprises' exploratory innovation

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With the increasing uncertainty in the external environment, exploratory innovation has gradually become the key path for enterprises to obtain core competitiveness and achieve sustainable growth. According to the behavioral theory of the firm, performance feedback is an essential driving factor affecting corporate innovation decisions. However, previous studies have ignored the consistency or inconsistency between historical and industry performance feedback, and its impact on exploratory innovation. Based on the data of Chinese companies listed from 2008 to 2019, this paper explores the impact of consistency and inconsistency between historical and industry performance feedback on enterprises' exploratory innovation. In the cases of consistency, this study finds that the scenario of historical performance shortfall-industry performance shortfall is more likely to promote enterprises' exploratory innovation than the industry performance surplus-historical performance surplus; in the cases of inconsistency, compared with historical performance surplus-industry performance shortfall, the scenario of historical performance shortfall-industry performance surplus is more likely to promote enterprises' exploratory innovation. Further research shows that regional institutional development enhances these relationships. This study enriches the driving factors of enterprises' exploratory innovation from the perspective of multiple performance feedback, which can provide decision-making references for enterprises' exploratory innovation strategies.

KEYWORDS

historical performance feedback, industry performance feedback, regional institutional development, exploratory innovation, corporate behavior

Introduction

In the context of increasing uncertainty, volatility, complexity, and ambiguity in the external environment, technological innovation has become the core driving force for enterprises to enhance competitiveness and achieve sustainable development (Bonaime et al., 2018; Su et al., 2020; Honig and Samuelsson, 2021). Exploratory innovation (EI) is

essential for enterprises to adapt to dynamic changes in the external environment and maintain a continuous competitive advantage (Tian and Wang, 2014; Tian et al., 2020; Wang N. et al., 2021). EI disrupts organizational inertia by introducing new knowledge, methods, and designs, making it conducive to the fundamental transformation of production technology (Slavova and Jong, 2021). EI can not only change the original performance and characteristics of products and create new products for enterprises, but can also open up new consumer markets and help enterprises obtain excess profits (Gao et al., 2015; Lin and Patel, 2019). Especially in the shortening product life cycle and rapidly changing market competition patterns, EI is conducive to meeting the enterprises' development needs and promoting enterprises' sustainable and healthy growth (Wang et al., 2020).

According to the behavioral theory of the firm, an enterprise is an organizational system oriented by a goal decision that will establish a reference point (aspiration level) that satisfies the decision-maker when evaluating the operating status of the enterprise (Cyert and March, 1963; Chen et al., 2022) and adjust the organizational decision according to the gap between the actual performance and the aspiration level to change the enterprise innovation strategy (Zajac and Kraatz, 1993). Some scholars consider that enterprises usually become problem-oriented, and actively seek solutions to promote innovation and change the current situation of poor management when the actual performance is lower than the aspiration level (Gaba and Joseph, 2013; Choi et al., 2019). Conversely, when the actual performance is higher than the aspiration level, enterprises usually continue with the previous strategy rather than risk innovation (Barnett and Pontikes, 2008).

Other scholars hold the opposite view that when the actual performance exceeds the aspiration level, abundant redundant resources provide sufficient funds for innovation activities, trigger the redundancy-driven search mechanism of enterprises, and improve the enthusiasm of enterprises for innovation (Parker et al., 2017; Eggers and Suh, 2019). However, enterprises face greater resource constraints when the actual performance is lower than the aspiration level and take conservative or prudent measures to inhibit innovation (Chng et al., 2015). There is no consensus in the literature regarding the impact mechanism of performance feedback on enterprise innovation. Most studies regard enterprise innovation as a comprehensive concept and ignore the differences in innovation behaviors with different characteristics. Enterprise innovation depends on the profit return effect of innovation behavior (Wang and Wang, 2020). Enterprises' EI is characteristic of high-risk and high-profit, which bring new technologies to enterprises, seize the market, and obtain excess returns. Enterprises' EI has a more profound impact on the long-term sustainable development of enterprises (Wang et al., 2019; Yi et al., 2022). Considering the high-risk and high-profit characteristics of EI, enterprises may follow the decision-making logic of "performance shortfall leads to change" and actively carry out EI, as the actual performance is lower than the aspiration level, to change the performance dilemma. Enterprises may follow the decision-making logic of "performance surplus leads to strategy

persistence" to avoid the high opportunity cost of innovation decision transformation, as the actual performance is higher than the aspiration level. Thus, we explore the impact of performance feedback on enterprises' EI and provide theoretical references for enterprise innovation strategies.

In the actual decision-making process of enterprises, decision-makers judge the operating status of enterprises based on both historical and industry aspiration levels rather than a single aspiration level (Kim et al., 2015). There are essential differences in the information contained in historical and industry aspiration levels. The historical aspiration level represents the enterprise's operation and management goal, while the industry aspiration level represents the enterprise's competitive position within the market. However, analyzing the relationship between performance feedback and enterprise innovation by focusing on a single reference point in a historical or industry context is too idealistic to describe the connotation of performance feedback and may weaken the explanatory power of the performance feedback mechanism (Wang and Lou, 2020; Chung and Shin, 2021). We can obtain a more complete insight into the relationship between performance feedback and enterprises' EI only by distinguishing between historical and industry performance feedback and examining how their complex interaction influences EI (Lv et al., 2019).

Complex performance feedback situations are the norm in corporate decision-making, which run through the entire process. According to the multiple performance expectations of historical and industry contexts, there are two possibilities regarding consistency and inconsistency, historical performance shortfall-industry performance shortfall and historical performance surplus-industry performance surplus; historical performance shortfall-industry performance surplus and historical performance surplus-industry performance shortfall. Especially in the cases of inconsistency, the business status of the enterprise cannot be defined as loss or gain, and decision-makers need to analyze the above information (Joseph and Gaba, 2015). Inconsistent performance feedback is ambiguous, and decision-makers must clearly analyze the state. Decision-makers make different judgments according to inconsistent feedback information affecting the enterprises' EI.

We systematically explore the impact of the consistency and inconsistency between historical and industry performance feedback on EI based on the behavior theory of the firm. We believe that, in the cases of consistency, the historical performance shortfall-industry performance shortfall is more likely to promote enterprises' EI than industry performance surplus-historical performance surplus. When both the historical and the industry performance feedback are in shortfall, decision-makers recognize that there are some problems within the enterprise. This creates an impetus within enterprises to change the status quo and enhance competitive advantage, and necessitates enterprises to implement high-profit EI (Lu and Wong, 2019). However, enterprises have stable revenue expectations when both the historical and the industry performance feedback are surplus. In this context, although enterprises have ample redundant funds, the opportunity cost of

strategic adjustment is high to change the existing innovation decisions, disrupt organizational practices, and carry out EI with high-risk and high-profit. Therefore, decision-makers continue to implement the past innovation strategies, which is not conducive to EI.

In the cases of inconsistency, historical performance shortfall-industry performance surplus is more likely to promote EI than historical performance surplus-industry performance shortfall. Compared with industry performance feedback, historical performance feedback reflects the management ability of enterprise decision-makers more directly. In the cases of historical performance shortfall-industry performance surplus, decision-makers consider that historical performance shortfall may damage their reputation. To prove their leadership ability, enterprise managers actively use the advantages brought by the industry performance surplus to solve existing problems. Consequently, decision-makers actively seek organizational innovation, enhance enterprises' EI, and obtain more benefits, thereby reducing the historical performance shortfall and maintaining their reputation and image. In the cases of historical performance surplus-industry performance shortfall, decision-makers attribute the industry performance shortfall to the uncertainty factors in the external environment, avoiding personal image and evaluation damage, which stimulates self-enhancement motivation (Jordan and Audia, 2012; Audia et al., 2015). Decision-makers interpret the historical performance surplus-industry performance shortfall as a state of benefit, strengthening the strategic rigidity, which is not conducive to the enterprises' EI.

Furthermore, the impact of consistency and inconsistency of performance feedback on EI may be restricted by the external environment, primarily regional institutional development. Regional institutional environment development change decision-makers' understanding and response to feedback signals and affect the relationship between performance feedback and enterprises' EI (Ben-Oz and Greve, 2015; Su and Si, 2015). As an important form of the soft power of national or regional economic development, regional institutional development (RI) provide ideal conditions for enterprises' technological innovation by optimizing the policy, market, and factor environments, thereby changing the mechanism of performance feedback on enterprises' EI (Davis and North, 1970). On the one hand, RI can reduce the organizational transaction cost of the enterprise's problem searching activities and effectively alleviate the level of information asymmetry between enterprises, improving the efficiency of enterprise resource allocation, promoting the flow and integration of enterprise innovation elements, and thus promote EI (Wu et al., 2019). On the other hand, RI provide a fair, competitive market, thereby enhancing the confidence of decision-makers in innovation in the case of performance feedback shortfall, and stimulating the vitality of enterprises' EI (Yang et al., 2012). In conclusion, we believe that the impact of performance feedback consistency and inconsistency on enterprises' EI is enhanced with the improvement of the RI level.

China is the world's second-largest economy, and innovation is the core of China's modernization drive. To build an innovation-oriented country, it is necessary to realize high-quality

development of the national economy so that enterprises conduct EI and improve their core competitiveness actively. In addition, China is in a critical period of transformation and upgrading, and the development of the market mechanism is still incomplete. As the main component of the modern market economy, enterprises are the key force for the country to improve its innovation capability and implement the innovation-driven development strategy. Thus, China provides a suitable environment for examining the EI of enterprises.

Based on the sample data of Chinese companies listed from 2008 to 2019, we examine the impact of multiple performance feedback on enterprises' EI. This study finds that after controlling for variables at the level of corporate characteristics and corporate governance, the empirical evidence for the abovementioned theoretical viewpoints holds. In the cases of consistency of performance feedback, historical performance shortfall-industry performance shortfall is more likely to promote enterprises' EI. In the cases of inconsistency, historical performance shortfall-industry performance surplus is more likely to promote enterprises' EI. RI strengthens the abovementioned positive relationship. In addition, we replace the measurement indicator of the independent variable, change the measurement method of the independent variable, and used the systematic GMM model to perform an endogeneity test, and the results remain robust.

In summary, this paper has three theoretical contributions: First, we enrich relevant research on the driving factors of enterprises' EI from the perspective of multiple performance feedback. Considering the impact of performance feedback on enterprise innovation prior studies mainly focused on a single reference point, namely, historical performance feedback or industry performance feedback (Chen et al., 2021); few studies have explored the impact of consistency between history and industry performance feedback on enterprise innovation (Lucas et al., 2015; Lv et al., 2019). In the cases of inconsistency, negative historical and positive industry performance feedback positively affected the enterprises' innovation (Ye and Zhao, 2021). Enterprises' EI can bring new technologies and products and has a high-value return effect. Existing studies lack an in-depth discussion on the relationship between multiple performance feedback and enterprises' EI. To fill this gap, we include both historical and industry performance feedback in the same research framework to further analyze the consistency and inconsistency of situation combinations of multiple performance feedback influences on EI decision-making.

Second, our research expands the existing theoretical model of performance feedback and enterprises' EI decision-making. Previous studies focused on the influence of internal factors on the relationship between performance feedback and enterprise innovation while ignoring the vital role of the external environment for enterprises' survival and development (Zhong et al., 2022). We explore the contingency effect of RI on the impact of performance feedback on EI, which could help enterprise decision-makers pay more attention to changes in external RI and optimize enterprises' EI strategy.

Third, this study provides concrete empirical evidence of enterprises' EI decision-making. From the multiple reference points of historical and industry performance expectation, we explore the differential influences of combination situations with multiple performance feedback on EI of enterprises, providing a practical reference for enterprises to improve EI strategy and achieve sustainable development.

The rest of this paper is organized as follows. In the section "Theoretical Analysis and Hypotheses," we discuss the hypothesis development. In the section "Research Design," we introduce the data and methods. In the section "Results," we discuss the empirical results, and in the last section "Conclusion and Discussion," we conclude the study.

Theoretical analysis and hypotheses

Multiple performance feedback

Bounded rational decision-makers usually judge the current operating state of an organization based on experience to simplify decision-making. In evaluating the actual performance, a satisfactory reference point, namely the aspiration level, is determined and enterprise decisions are adjusted according to the reference point (Hart and Moore, 2008). Reference points for decision-making are mainly affected by two factors: their historical performance and the average performance of other organizations in the same industry (Kim et al., 2015). Decision-makers of enterprises explore corresponding innovative decision-making schemes and adjust rules based on their historical performance feedback and industry performance feedback (Denrell and March, 2001). An enterprise's actual performance that is higher than the aspiration level is called performance feedback surplus, while its performance lower than the aspiration level is called performance feedback shortfall. Decision-makers with bounded rationality define performance feedback surplus as the benefits state of the organization, and performance feedback shortfall as the loss state.

When an enterprise has a multiple reference point for historical performance expectation and industry performance expectation, there are two possibilities (consistency and inconsistency) in the performance evaluation results, presenting four different combinations of scenarios, as shown in Table 1. The consistency of performance feedback means that the two groups of performance feedback signals are in the same direction, such as in the scenario of historical performance surplus-industry performance surplus and the scenario of historical performance shortfall-industry performance shortfall. When the feedback of historical and industry performance is presented in the scenarios of consistency, the dual information feedback standard provides a clear, accurate and credible signal for enterprises, and decision-makers of enterprises do not need to further interpret the feedback results but need to respond quickly. According to consistent performance feedback signals, decision-makers timely adjust the current strategic decision, prompt enterprises to quickly search

TABLE 1 The cases of historical-industry performance feedback.

Concept	Cases	
Consistency	Historical performance surplus-industry performance surplus	Historical performance shortfall-industry performance shortfall
	Historical performance surplus	Historical performance shortfall
	Historical performance shortfall-industry performance surplus	Historical performance surplus
Inconsistency	Historical performance surplus-industry performance shortfall	Historical performance surplus
	Historical performance surplus	Historical performance surplus
	Historical performance shortfall-industry performance surplus	Historical performance surplus

and reallocate limited resources, and seize opportunities to establish advantages, which is conducive to the development of EI activities of enterprises (Lucas et al., 2015). Inconsistent performance feedback implies that the two groups of performance feedback signals are in opposite directions, such as in the scenario of historical performance surplus-industry performance shortfall and the scenario of historical performance shortfall-industry performance surplus. When the feedback of historical and industry performance is presented inconsistently, it is difficult for enterprises to clearly define the current business situation, which increases the difficulty of decision-making and reduces the adaptive change response of enterprises (Joseph and Gaba, 2015). In the face of consistent and inconsistent performance feedback signals, there is a significant difference in the decision-making behavior of enterprises. It is necessary to further discuss the relationship between performance feedback and EI of enterprises under the two sets of performance reference points of history and industry. Therefore, we explore the differential impact of combinations of multiple performance feedback consistency and inconsistency on enterprises' EI.

Multiple performance feedback and enterprises' exploratory innovation

In the cases of consistency between historical and industry performance feedback, multiple performance reference points provide enterprises with more accurate feedback signals. When both the historical and the industry performance feedback are in surplus, the enterprise is defined as being in an absolute benefit state. This situation leads to behavioral inertia in enterprises, which is not conducive to EI. First, the performance feedback surplus proves to some extent that the current strategic decision is suitable for the development of enterprises and bring higher profits for enterprises. At the same time, considering stakeholders' demands for organizational stability, enterprises tend to give up EI activities with high risks and high returns to maintain existing benefits (Lin, 2014). EI needs great reform, requiring organizational breakthrough and transformation. In particular, the opportunity cost of EI is higher when the enterprise has stable income expectations. Even in the cases of historical performance surplus-industry performance surplus, enterprises have abundant redundant resources. Consequently, they are unwilling to change the existing innovation strategy to carry out EI. Second, performance feedback surplus enhances decision-makers'

perception of business benefits and breeds overconfidence, thus strengthening the soundness of experience and organizational practices. Decision-makers of enterprises in this situation assume that past decisions and experience are conducive to enterprise growth, and become unwilling to increase R&D investment and change the existing innovation strategy planning. To avoid unnecessary losses caused by risky changes or innovative investments, enterprises may choose initial strategic planning to maintain the status quo (Joseph et al., 2016; Yang et al., 2017). Third, when the business performance is higher than the aspiration level, the enterprise lacks the motivation to search for external information, which reduces the scope of the organizational search and is not conducive to generating valuable new knowledge and new ideas. This is mainly because the previous successful experience reduces the perception of decision-makers of environmental uncertainty risks. Decision-makers believe that the current operation and management decisions are in line with the development of enterprises, neglecting the in-depth mining of external information, and reducing enterprises' ability for EI.

When both the historical and the industry performance feedback are in shortfall, it indicates that the actual operating performance of the enterprise is lower than the aspiration level and that the organization's current business strategy, resource allocation, or market competition mechanism is not perfect; further, the enterprise is defined as being in an absolute loss state. Multiple performance feedback shortfall makes decision-makers realize that there are problems in organizational operation. Thus, enterprises improve their core competitiveness and obtain higher returns only by disrupting organizational inertia and choosing EI with high risks and high returns (Saraf et al., 2021).

On the one hand, a performance lower than the aspiration level will trigger the enterprise problematic search mechanism, according to the existing problems targeted innovation strategy adjustment. Decision-makers optimize the internal resource allocation of enterprises, acquire external novel knowledge, and stimulate a forward-looking thinking mode, thereby enhancing enterprises' EI to adapt to customer and product market competition and improving enterprise benefit ability (Greve, 2003). Enterprises obtain information, knowledge, and technology in various ways, and actively integrate and innovate knowledge, adjust the operation mode of enterprises promptly, and improve the ability of enterprises to deploy and utilize resources, which is conducive to optimizing the existing production and operation processes and improving the efficiency of production technology, putting more operating profits into innovation and research and development, and strengthening enterprises' EI capabilities.

On the other hand, when the performance feedback shortfall threatens the organization's reputation and external legitimacy, decision-makers of enterprises need to make reasonable explanations. When the performance of an organization continues to decline and decision-makers fail to propose corresponding solutions, stakeholders will question the organizational development strategy (Desai, 2014). The simultaneous existence of internal and external crisis threats forces enterprise decision-makers to rethink the organization's business strategy and

innovation decisions and actively promote EI of enterprises to seize the opportunity to occupy the market (Oliver, 1992; O'Brien and David, 2014; Xue et al., 2021). In addition, to decrease their performance shortfall, decision-makers of enterprises tend to prefer high-profit and high-risk projects and try to change the status quo of adventure and innovation investment in a willingness to strengthen which is advantageous to the enterprise to reposition in the market. They further try to increase R&D investment, develop new products, obtain higher usefulness or value of innovation, and strengthen enterprises' EI. Therefore, we propose the following hypothesis H1:

H1: In the cases of consistency of performance feedback, compared with the historical performance surplus-industry performance surplus, historical performance shortfall-industry performance shortfall is more likely to promote enterprises' EI.

Inconsistent performance feedback includes two scenarios: historical performance surplus-industry performance shortfall and historical performance shortfall-industry performance surplus. The inconsistent feedback information can help them identify the operating state and industry situation under the multiple performance evaluation criteria to conduct targeted innovation strategy adjustments (Zhang and Gong, 2018). Compared with industry performance feedback, historical performance feedback reflects the decision-maker's management ability more directly. The historical performance feedback is in surplus, while the industry performance feedback is in shortfall, indicating that although the enterprise does not meet the average performance of the industry, its performance is higher than its performance expectation. Decision-makers believe that the enterprise is in a rising and progressive trend, defined as a state of relative benefit. In this scenario, decision-makers tend to prefer to pursue the favorable direction, hide the negative evaluation of industry performance shortfall, and stimulate the motivation of self-enhancement. Decision-makers are driven by the psychological need to affirm themselves and avoid negative assessments to maintain their reputation and image. Decision-makers regard the feedback status of historical performance surplus of enterprises and industry performance shortfall in a positive way, which leads to the strategic rigidity of enterprises and is not conducive for the breakthrough innovation of enterprises (Audia et al., 2015; Wan et al., 2022).

In addition, the scenario of the historical performance feedback being in a surplus indicates that the current enterprise innovation strategy will lead to higher profits in the future. Enterprises will continue to keep the original technology, skills, and management style, and discontinue developing new products and technology, and expand product lines to meet more customer needs, thereby lowering the EI of enterprises.

When the historical performance shortfall and industry performance surplus occur simultaneously, it indicates that the actual performance is higher than the industry average but does not achieve the self-expected goals, and the enterprise is said to

be in a relative loss state. Decision-makers may actively perform EI to obtain excess returns in order to reduce the current situation of historical performance shortfall and maintain their reputation and image proving their leadership and management ability (Kacperczyk et al., 2015). On the one hand, the historical performance shortfall leads to inadequate resource investment, and the original competitive advantage is difficult to sustain. Under the influence of the reputation incentive mechanism, enterprise decision-makers will actively change the existing business strategy and seek new competitive advantages to narrow the historical performance feedback shortfall and stabilize the position of enterprises in the industry (Yu et al., 2022). Here, the enterprise actively implements a series of breakthrough changes and perform technology, product, and service innovations to enhance the EI of the enterprise (Xiao et al., 2021). Decision-makers conduct problematic search activities within the organization, actively update and reorganize existing knowledge, skills, and experience, reduce production and operating costs, and improve product skills, which are conducive to disrupting the conventional cognitive model of the organization and propose improvements. From a new knowledge perspective, they offer solutions to improve the status quo of poor performance, thereby enhancing the level of EI of enterprises.

On the other hand, the historical performance shortfall-industry performance surplus may also indicate that with the increasing uncertainty of the external environment, the development of the whole industry is depressed. Although the industry performance is in a surplus, the enterprise cannot be said to be in an excellent state. The decline or recession of the overall industry can cause enterprise decision-makers to be aware of crises, improve enterprises' risk tolerance, enhance the confidence and ability of enterprises to seize the market, and stimulate enterprises to perform EI (Blagoeva et al., 2020). Therefore, we propose the following hypothesis H2:

H2: In the cases of inconsistency of performance feedback, the scenario of historical performance shortfall-industry performance surplus is more likely to promote EI than the scenario of historical performance surplus-industry performance shortfall.

The moderating effect of regional institutional development

New institutional economics indicates that one of the critical factors affecting technological progress and innovation behavior is the development of the regional institutional environment. The development of a regional system includes a series of external environmental factors that include policy, market, and factor environment that enterprises face in the production and management domains. In particular, China is in the process of economic transformation and upgrading, and the interaction between changes in the regional institutional environment and organizational strategic decision-making is more closely related.

RI is an essential factor affecting corporate innovation decision-making (Alam et al., 2019).

RI can not only ease the impact of uncertain factors on enterprises and give full play to the external governance effect, stimulating enterprises to perform EI activities, but can also reduce their operating cost by optimizing the allocation of innovation resources, thus increasing innovation and helping the sustainable growth of the enterprise (Szczygielski et al., 2017). Specifically, on the one hand, RI provides market signals for enterprises. An excellent institutional development environment means a fair and reasonable market competition atmosphere, enables enterprise decision-makers to obtain more sufficient information, optimize resource allocation, and weaken the impact of information asymmetry. On the other hand, the development of regional institutions allows the positioning of enterprises in the innovation network and reduces the investment risk of EI (Liu et al., 2022). Relevant policies such as direct financial subsidies and low-interest loans effectively reduce the cost of enterprises' EI and enable them to invest more capital in R&D innovation (Donbesuur et al., 2020).

RI affects decision-makers' cognition and judgment of performance feedback information. It determines whether an enterprise will perform the EI behavior of active search and disruptive change. In regions with developed institutions, enterprises attach more importance to the guiding role of the performance feedback mechanism in operation decision-making, and can timely adjust strategic decisions based on feedback signals. Especially in the scenario of historical performance shortfall-industry performance shortfall, RI provides more convenience for enterprises' EI, strengthens the motivation of enterprises' EI, and enhances the positive relationship between historical performance shortfall-industry performance shortfall and enterprises' EI (Wang et al., 2015).

On the one hand, when the enterprise is in shortfall, enterprise managers actively disrupt the initial organizational inertia and prevalent management thinking and search for existing problems in the enterprise. RI can effectively reduce the cost of problem-driven search to help enterprises improve the current situation. RI can not only provide enterprises with more external resources and information and reduce the difficulty of obtaining external information, but can also optimize the allocation of resources and improve the efficiency of enterprises in creating new knowledge and technology (Shu et al., 2016). On the other hand, RI brings more institutional environment support to enterprises and increases the risk preference of enterprise decision-makers under the condition of the shortfall. In an optimized institutional environment, the market occupies a dominant position in resource allocation, and relevant policies regulate and constrain the behavior of enterprises, creating a relatively fair and free competitive environment, which is conducive to stimulating the innovation vitality of enterprises. RI provide effective information for the market system of regional development guidance, while perfect factors and the market environment alleviate the enterprise investment risk, promote the flow of innovation between enterprises, and enhance the high-risk, high-income EI ability

(Aghion et al., 2005), which helps the enterprise obtain excess returns and long-term competitive advantage. Therefore, the enterprise maintains its reputation and external legitimacy. We propose the following hypothesis H3:

H3: In the cases of consistency of performance feedback, RI positively moderates the relationship between the scenario of historical performance shortfall-industry performance shortfall and enterprises' EI.

When faced with inconsistent performance feedback, especially in the scenario of historical performance shortfall-industry performance surplus, RI can improve the effectiveness of the performance feedback mechanism, strengthen the reputation incentive effect of decision-makers, and enhance the EI of enterprises. In regions where regional institutions are well developed, enterprises face fewer difficulties or obstacles and operate more smoothly, which is conducive to maintaining the reputation of enterprises' decision-makers and improving their leadership (Tang et al., 2019). When an enterprise is in a state of historical performance shortfall, decision-makers' reputation is damaged. It is necessary to detect the problems of the enterprise in time and change the state of historical performance shortfall. Thus, the external resources brought by RI reduce the uncertainty of an enterprise's operations and strengthen the management confidence of decision-makers. The positive environment created by RI for enterprises enhance decision-makers' enthusiasm to seek innovative breakthroughs and promote enterprises' EI (Xu et al., 2012).

Additionally, RI reduces decision-makers' worries about the uncertain industrial environment and improves their risk tolerance, promoting enterprises to actively reform and innovate (Wang Y. et al., 2021). Some enterprise decision-makers believe that the surplus of industry performance does not mean that the enterprise develops well because the uncertainty of the external environment makes the industry competition fluctuate significantly, and causes the whole industry to decline or recession, thereby reducing the credibility of the industry performance feedback. Although enterprises are in the industry performance surplus state, they still need to perform innovation in regions with better RI actively. The development of regional systems is conducive to creating orderly market rules, injecting new vitality into the market, and bringing more development opportunities to enterprises. Market and competition mechanisms become fair, thereby relieving the operating pressure of decision-makers facing environmental uncertainty and enhancing confidence of enterprise development (He et al., 2021; Tian et al., 2022). Under the combined action of positively promoted RI and reverse-promoted performance feedback, enterprises actively seize external opportunities, create new products, and obtain new markets to improve the level of EI of enterprises (Ciftci and Cready, 2011). Therefore, we propose the following hypothesis H4:

H4: In cases of inconsistency of perform feedback, RI positively moderates the relationship between the scenario of

historical performance shortfall-industry performance surplus and enterprises' EI.

Research design

Sample and data

We selected Chinese A-share listed companies from 2008 to 2019 as the research samples to explore the impact of performance feedback on enterprises' EI. We chose 2008 as the starting year because China implemented new accounting standards in 2007. To ensure the rationality of sample selection and follow the results of previous studies, we strictly screened research samples according to the following exclusion criteria (Zhong et al., 2021): (1) the samples of regulated financial companies such as banks, security companies and insurance companies were excluded leading to the deletion of data of 235 companies; (2) special treatment and particular transfer company samples were excluded leading to the deletion of data of 221 companies; (3) the company samples with serious missing data were removed, leading to 786 companies being excluded. Through the above screening steps, unbalanced panel data of 14,825 listed companies were finally obtained during the sample period, involving 2,313 companies. The basic characteristic data of the enterprise and the characteristic data of the corporate governance level used in this study were obtained from the CSMAR and WIND databases, which are authoritative and comprehensive data sets of Chinese listed firms and widely used by strategic management scholars. In addition, to overcome the influence of outliers and ensure the quality and accuracy of data, a 1% tail reduction was applied to all continuous variables.

Definition of variables

Exploratory innovation

There are many ways to measure EI. Arzubigi et al. (2019) and Berraies (2019) used the questionnaire survey method to measure the EI of enterprises with relevant items. We referred to the research Gao et al. (2021) and Guan and Liu (2016) to measure EI using the International Patent Classification (IPC) number. Using the IPC number to measure EI can eliminate the subjectivity brought by the questionnaire to a certain extent. EI is an innovative activity that brings new knowledge, technology, and products to the enterprise, and has vital creativity and innovation. The IPC number four represents patent technology of classification, if the patent applied by the enterprise in the current year is different from the IPC number in the previous 5 years. In that case, the number of patents whose classification number is not repeated is recorded as EI (Gilsing et al., 2008). The measurement method is the log of the number of patent applications plus 1.

Historical performance feedback and industry performance feedback

Drawing on the practice of [Joseph and Gaba \(2015\)](#), we measured the historical performance feedback (HAP) and industry performance feedback (IAP) by the difference between actual performance and aspiration level. We used exponential smoothing to calculate the historical performance aspiration level (HA) and industry performance aspiration level (IA). The actual performance of enterprise *I* in period *T* is $P_{i,t}$, which is measured by return on assets (ROA). The historical performance expectation of enterprise *I* in period *T* is $HA_{i,t}$. The historical performance desire level can be formulated as $HA_{i,t} = aP_{i,t-1} + (1-a)HA_{i,t-1}$. The historical performance feedback can be expressed as $HAP = P_{i,t} - HA_{i,t}$. Based on the same method, $IA_{i,t}$ was set the actual median performance of all enterprises in the industry of company *I* in period *T*. The industry performance expectation of enterprise *I* in period *T* is $IA_{i,t}$. The IA can be formulated as $IA_{i,t} = aI_{i,t-1} + (1-a)IA_{i,t-1}$. The industry performance feedback expression is $IAP = P_{i,t} - IA_{i,t}$; where *a* is an adjustment parameter between [0,1] and represents the weight between the performance of the current period and the aspiration level of the previous period in the HA level of the current period. This is based on research of [Chen \(2008\)](#), where the weight is designated 0.6 ([Zhong et al., 2022](#)).

According to [Lucas et al. \(2015\)](#), we multiplied the feedback values of the two performance dimensions to represent the interaction of different performance feedback. In the cases of consistency, the multiple performance feedback of historical performance shortfall-industry performance shortfall and historical performance surplus-industry performance surplus was defined as a dummy variable HAPIAP1, historical performance shortfall-industry performance shortfall with the expression $(P_{i,t} - HA_{i,t} < 0) \times (P_{i,t} - IA_{i,t} < 0)$ was defined as 1, and historical performance surplus-industry performance surplus with the expression $(P_{i,t} - HA_{i,t} > 0) \times (P_{i,t} - IA_{i,t} > 0)$ was defined as 0. In the cases of inconsistency, the multiple performance feedback of historical performance shortfall-industry performance surplus and historical performance surplus-industry performance shortfall was defined as a dummy variable HAPIAP2, historical performance shortfall-industry performance surplus with the expression $(P_{i,t} - HA_{i,t} < 0) \times (P_{i,t} - IA_{i,t} > 0)$ was defined as 1, historical performance surplus-industry performance shortfall with the expression $(P_{i,t} - HA_{i,t} > 0) \times (P_{i,t} - IA_{i,t} < 0)$ was defined as 0.

Regional institutional development

Regional institutional development (RI) as a comprehensive external environment may play a moderating role in the impact of performance feedback on enterprises' EI. [Gao et al. \(2015\)](#) used questionnaires to measure the RI environment and divided the institutional environment into formal and informal institutional environments. The formal institutional environment mainly includes innovation policies, procurement policies, tax policies, and the legal environment provided by the government that are conducive to the development of enterprises. The informal

institutional environment mainly includes the social and cultural backgrounds. Regional system development mainly includes the policy, market, legal, factor environments, and others. The indexes found in The Report of Market Index by Provinces in China, such as the relationship between the government and the market and the development degree of the product and factor markets and the legal environment, can better reflect the overall level of RI, and can be used as proxy indexes to evaluate RI. Considering the consistency and continuity of the research sample period, we adopted the corresponding indicators in the China Provincial Marketization Index Report published in 2021 by Wang Xiaolu et al. to measure the development level of regional institutions.

Control variables

To account for alternative explanations, we include a comprehensive set of control variables from the level of corporate characteristics and governance ([Wang et al., 2019](#); [Chu et al., 2021](#)). At the level of company characteristics, firm size denotes the logarithm of the total assets of an enterprise. As an aggregate of different resources, the enterprise scale will directly affect the EI of enterprises. The ownership structure has a significant impact on EI. If the enterprise is a state-owned enterprise, we defined it as 1, and if the enterprise is a non-state-owned enterprise, as 0. The leverage ratio, that is, the ratio of total liabilities to total assets at the end of the period, reflects the debt and risk-bearing capacity of enterprises. Corporate debt brings not only resources to enterprises, also high risks. However, it is not conducive to EI with high-risk characteristics. The fixed asset ratio is the ratio of fixed assets to total assets at the end of the period. The intangible assets ratio refers to the ratio of intangible assets to total assets at the end of the period. Fixed asset ratio and intangible asset ratio can indicate the utilization of enterprise capital, and then affect the breakthrough innovation of enterprises. Precipitate slack resources denote the sum of sales and administrative expenses and the ratio of enterprise operating income. Non-precipitate slack resources are measured by the ratio of current assets to current liabilities. Redundant resources provide enterprises with continuous capital investment to promote enterprise innovation, but different redundant resources may have a different impact on enterprises' EI.

At the level of corporate governance, board size represents the natural logarithm of the number of directors after adding 1, and the board of directors decides the strategies and their scale influences the EI of enterprises. The ownership concentration refers to the shareholding ratio of the largest shareholder of an enterprise, which reflects the internal control problems of the enterprise. Additionally, we controlled for the individual effect (ID) and time effect (YEAR) to eliminate the factors that do not change with time at the enterprise level and the influence of common time trends on the EI of enterprises.

Model setting

We constructed the following regression model to test the impact of multiple performance feedback on enterprises' EI ([Liu](#)

et al., 2021; Shi et al., 2022) and the moderating role of RI (Xu et al., 2022; Xue et al., 2022; Zhang et al., 2022).

$$EI_{i,t} = a_0 + a_1 HAPIAP1_{i,t} + Control_{i,t} + e_{i,t} \quad (1)$$

$$EI_{i,t} = a_0 + a_2 HAPIAP2_{i,t} + Control_{i,t} + e_{i,t} \quad (2)$$

$$EI_{i,t} = b_0 + b_{11} HAPIAP1_{i,t} + b_{12} RI_{i,t} + b_{13} RI_{i,t} \times HAPIAP1_{i,t} + Control_{i,t} + e_{i,t} \quad (3)$$

$$EI_{i,t} = b_0 + b_{21} HAPIAP2_{i,t} + b_{22} RI_{i,t} + b_{23} RI_{i,t} \times HAPIAP2_{i,t} + Control_{i,t} + e_{i,t} \quad (4)$$

where $EI_{i,t}$ represents the EI of enterprises with dependent variable, $Control_{i,t}$ represents the control variables, and $e_{i,t}$ is the random error term. $HAPIAP1_{i,t}$ represents the multiple performance feedback in the cases of consistency, $HAPIAP2_{i,t}$ represents the multiple performance feedback in the cases of inconsistency, $RI_{i,t}$ represents RI. $RI_{i,t} \times HAPIAP1_{i,t}$ represents the interaction term between the multiple performance feedback in the cases of consistency and RI, and $RI_{i,t} \times HAPIAP2_{i,t}$ represents the interaction term between the multiple performance feedback in the cases of inconsistency and RI. In addition, we used a panel fixed-effects model for regression analysis to reduce bias for potential omitted variables.

Results

Table 2 lists the descriptive statistics of the main variables. The mean value of EI is 2.3428 and the standard deviation is 1.5268, indicating that the average level of EI of enterprise is relatively weak, and there are great differences in the level of EI among the various enterprises; the mean value of historical performance feedback is -0.0065 , the standard deviation is 0.0486, the minimum value is -0.4235 , and the maximum value is 0.2445; the mean value of industry performance feedback is -0.0002 , the standard deviation is 0.0638, the minimum value is -0.4961 , and the maximum value is 0.1986, and there are significant differences among different companies. The average value of RI is 8.3730, the maximum value is 12.1900, and the minimum value is 3.1500. The overall level of RI in China is not high, and the RI index of different regions has a big gap. We conducted a variance inflation factor test for all variables in the model, and the VIF value of the model was less than 2. There was no severe multicollinearity interference, indicating that our variable setting was reasonable.

Analysis of regression results

Table 3 lists the test results of the relationship between multiple performance feedback and EI. Model 2 indicates that the

multiple performance feedback in the cases of consistency has a significant positive impact on the EI of enterprises ($a_1 = 0.1196$, $p < 0.01$), indicating that in the cases of consistency, the historical performance shortfall-industry performance shortfall is more conducive to the enterprises' EI, H1 is supported. Model 4 indicates that multiple performance feedback in the cases of inconsistency has a significant positive impact on the EI of enterprises ($a_2 = 0.2516$, $p < 0.01$), indicating that in the cases of inconsistency, the historical performance shortfall-industry performance surplus is more conducive to the enterprises' EI, supporting H2.

The test results of the moderating effect of RI are shown in Table 4. Model 2 analyzes the moderating effect of RI on the relationship between the multiple performance feedback in the cases of consistency and enterprises' EI. The empirical analysis results of Model 2 show that it has a significant positive moderating effect ($b_{13} = 0.0440$, $p < 0.01$), indicating that in the cases of consistency, the RI positively enhances the relationship between the historical performance shortfall-industry performance shortfall and the enterprises' EI, H3 is supported. Model 4 analyzes the moderating effect of RI on the relationship between the multiple performance feedback in the cases of inconsistency and enterprises' EI. The empirical analysis results of Model 4 show that it has a significant positive moderating effect ($b_{23} = 0.0669$, $p < 0.01$), indicating that in the cases of inconsistency, RI positively enhances the relationship between the historical performance shortfall-industry performance surplus and enterprises' EI, supporting H4.

Robustness tests

We also conducted the following tests to ensure the robustness of the research conclusions. First, we replaced the measurement indicator of the independent variable. We used ROA to measure the performance of the enterprise. To ensure the robustness of the research conclusions, we change the performance measurement indicator to further test the hypothesis. We replace the enterprise performance measurement indicator with OROA, namely, the operating profit margin on total assets. Table 5 shows the regression results of the robustness tests. Model 2 indicates that the multiple performance feedback in the cases of consistency has a significant positive impact on enterprises' EI ($a_1 = 1.8230$, $p < 0.01$), indicating that a positive relationship exists between the historical performance shortfall-industry performance shortfall and enterprises' EI. Model 4 indicates that the multiple performance feedback in the cases of inconsistency has a significant positive impact on enterprises' EI ($a_2 = 0.1559$, $p < 0.01$), indicating a positive relationship between the historical performance shortfall-industry performance surplus and enterprises' EI, which was similar to our assumptions. This indicates that our research conclusions have high robustness.

Second, we modified the measurement method of the independent variable. When we measured the performance feedback, the actual performance weight in the calculation

TABLE 2 Descriptive statistics and correlation coefficients.

Variables	Mean	SD	Min	P50	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	
1. EI	2.3428	1.5268	0	2.3025	6.8997	1													
2. HAP	-0.0065	0.0486	-0.4235	-0.0007	0.2445	-0.0249***	1												
3. IAP	-0.0002	0.0638	-0.4961	0.0007	0.1986	0.0331***	0.0674***	1											
4. RI	8.3730	2.0849	3.1500	8.3800	12.1900	0.1978***	-0.0284***	0.0331***	1										
5. SCALE	21.9816	1.2592	19.4454	21.7842	26.3684	0.2327***	0.0117	0.0148**	-0.0036	1									
6. STATE	0.3436	0.4749	0	0	1	-0.0185***	0.0370***	-0.0884***	-0.2886***	0.3592***	1								
7. DEBT	0.4051	0.2076	0.0282	0.3933	1.4486	0.0176**	-0.0643***	-0.3270***	-0.1193***	0.4870***	0.3486***	1							
8. FA	0.2200	0.1526	0.0021	0.1902	0.6984	-0.0513***	0.0062	-0.0982***	-0.1860***	0.11358***	0.2001***	0.1737***	1						
9. IA	0.0328	0.0755	0	0.0010	0.5060	0.0442***	-0.0339***	-0.0559***	0.2305***	0.0160**	-0.2168***	-0.1278***	-0.2977***	1					
10. PR	0.1706	0.1258	0.0153	0.1368	0.7907	0.0269***	0.0342***	-0.0245***	-0.0171**	-0.3093***	-0.1847***	-0.2977***	-0.1848***	0.1616***	1				
11. NPR	2.7687	3.2177	0.2001	1.7426	34.6088	-0.0413***	0.0223***	0.1832	0.0226***	-0.3330***	-0.2199***	-0.6199***	-0.2681***	-0.0572***	0.2371***	1			
12. BOARD	2.3708	0.2199	1.7917	2.3025	2.9957	0.0275***	0.0011	-0.0617***	-0.0984***	0.2512***	0.2502***	0.1719***	0.1341***	-0.0340***	-0.0649***	-0.1335***	1		
13. TOPI	34.7250	14.5272	8.3200	32.9800	76.9500	-0.0137**	0.0262***	0.1267***	-0.0389***	0.1791***	0.1835***	0.0422***	0.0818***	-0.1803***	-0.1239***	-0.1239***	-0.0173**	1	

*, **, and *** indicate significant correlation at the level of 10%, 5%, and 1%, respectively.

formula of the aspiration level was set to 0.6. Considering that different weight settings will affect the results of the aspiration level, we set the actual performance weight in the aspiration level to 0.5. The results were still significant. Table 6 shows the regression results of robustness tests. Model 2 indicates that the multiple performance feedback in the cases of consistency has a significant positive impact on enterprises' EI ($a_1 = 0.1345, p < 0.01$), indicating that the historical performance shortfall-industry performance shortfall is more conducive to the enterprises' EI. Model 4 shows that the multiple performance feedback in the cases of inconsistency has a significant positive impact on enterprises' EI ($a_2 = 0.2171, p < 0.01$), indicating that the historical performance shortfall-industry performance surplus is more conducive to the enterprises' EI.

Finally, considering the problem of endogeneity, the performance feedback of the enterprise affects the EI of the enterprise. In turn, the EI of the enterprise affects the business performance, and subsequently affects the performance feedback. To reduce the impact caused by endogeneity, we constructed a dynamic panel model with a lag of one period of enterprise EI and used the systematic GMM estimation method, which can control endogeneity (Wan et al., 2021). Table 7 shows the regressions results of the robustness tests. Model 1 indicates that the multiple performance feedback in the cases of consistency has a significant positive impact on enterprises' EI ($a_1 = 0.2163, p < 0.05$), and Model 2 shows that the multiple performance feedback in the cases of inconsistency has a significant positive impact on enterprises' EI ($a_2 = 0.2609, p < 0.05$), which is the same as our assumptions, indicating that our research conclusions are still highly robust after controlling endogeneity to a certain extent.

Conclusion and discussion

Conclusion

We used the data of Chinese A-share listed companies from 2008 to 2019 as samples for hypothesis testing and drew the following conclusions: (1) In the cases of consistent performance feedback, compared with the scenario of historical performance surplus-industry performance surplus, historical performance shortfall-industry performance shortfall is more likely to promote EI, which is conducive to sustainable growth. In the scenario of historical performance shortfall-industry performance shortfall, enterprises need to adjust innovation strategy to adapt to the competition of customers and the product market. To actively change the shortfall state of enterprises and obtain excess profits, decision-makers are more willing to try risk-taking or innovative behaviors, thus promoting the EI of enterprises. (2) In the cases of inconsistent performance feedback, compared with the scenario of historical performance surplus-industry performance shortfall, historical performance shortfall-industry performance surplus is more likely to promote

TABLE 3 Multiple performance feedback and enterprises' exploratory innovation.

Variables	(M1)	(M2)	(M3)	(M4)
	EI	EI	EI	EI
HAPIAP1	0.2022*** (0.018)	0.1196*** (0.018)		
HAPIAP2			0.6309*** (0.031)	0.2516*** (0.033)
SCALE		0.5478*** (0.013)		0.7185*** (0.022)
STATE		-0.0218 (0.059)		-0.1830** (0.091)
DEBT		-0.0776 (0.072)		-0.4594*** (0.122)
FA		0.1362 (0.096)		0.5813*** (0.147)
IA		-1.0906*** (0.140)		-1.2624*** (0.215)
PR		0.0002 (0.000)		0.0006* (0.000)
NPR		-0.0231*** (0.004)		-0.0304*** (0.004)
BOARD		0.1566*** (0.042)		0.1185* (0.062)
TOP1		-0.0143*** (0.001)		-0.0130*** (0.002)
Constant	2.1865*** (0.013)	-9.7004*** (0.309)	2.1841*** (0.012)	-13.0793*** (0.495)
ID	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
Observations	8,815	8,815	6,010	6,010
R-squared	0.012	0.251	0.074	0.366

*, **, and *** indicate significant correlation at the level of 10%, 5%, and 1%, respectively.

EI. In the scenario of historical performance shortfall-industry performance surplus, enterprises may lack sufficient resource input, resulting in an unsustainable competitive advantage. To narrow the historical performance shortfall and secure the position of the industry, enterprises will actively conduct EI to provide the impetus for the healthy development of enterprises. (3) In the cases of consistent performance feedback, especially in the scenario of historical performance shortfall-industry performance shortfall, decision-makers of enterprises make full use of the RI to obtain more policy support and market information, which can effectively reduce the cost of enterprise problematic search and improve the enthusiasm of enterprises' EI. RI strengthens the positive impact of the historical and industry performance shortfall on enterprises' EI. (4) In the cases of inconsistent performance feedback, especially in the scenario of historical performance shortfall-industry performance surplus, the optimized RI weakens decision-makers' perception of external environment uncertainty and improves enterprises' confidence in EI. RI enhances the positive

TABLE 4 Multiple performance feedback, regional institutional development, and enterprises' exploratory innovation.

Variables	(M1)	(M2)	(M3)	(M4)
	EI	EI	EI	EI
HAPIAP1	0.0896*** (0.015)	0.0771*** (0.017)		
HAPIAP1*RI	0.0356*** (0.007)	0.0440*** (0.008)		
HAPIAP2			0.1342*** (0.027)	0.1091*** (0.032)
HAPIAP2*RI			0.0998*** (0.012)	0.0669*** (0.014)
RI	0.4889*** (0.008)	0.3870*** (0.012)	0.5546*** (0.011)	0.3547*** (0.018)
SCALE		0.2341*** (0.016)		0.3763*** (0.027)
STATE		0.0564 (0.055)		-0.0979 (0.086)
DEBT		0.0230 (0.067)		-0.2536** (0.116)
FA		0.1902** (0.090)		0.3042** (0.141)
IA		-0.8909*** (0.131)		-1.0524*** (0.205)
PR		0.0002 (0.000)		0.0005 (0.000)
NPR		-0.0096*** (0.004)		-0.0203*** (0.004)
BOARD		0.1136*** (0.039)		0.0740 (0.059)
TOP1		-0.0060*** (0.001)		-0.0081*** (0.002)
Constant	2.2703*** (0.011)	-2.9893*** (0.353)	2.3065*** (0.011)	-5.6244*** (0.602)
ID	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
Observations	8,815	8,815	6,010	6,010
R-squared	0.323	0.342	0.377	0.424

*, **, and *** indicate significant correlation at the level of 10%, 5% and 1%, respectively.

impact of the historical performance shortfall-industry performance surplus on enterprises' EI.

Management implications

Our study has the following implications for management: (1) Enterprises usually revise strategic decisions based on the experience of learning as an adaptive rational system. The performance feedback mechanism provides an important reference point for enterprises. In the actual operation of enterprises, decision-makers should adopt a positive attitude when selecting the reference points, and rationally change the

TABLE 5 Robustness test: replacing the measurement indicator of performance feedback.

Variables	(M1)	(M2)	(M3)	(M4)
	ORO A	ORO A	ORO A	ORO A
	EI	EI	EI	EI
HAPIAP1	3.1069*** (0.507)	1.8230*** (0.551)		
HAPIAP2			0.4700*** (0.028)	0.1559*** (0.029)
SCALE		0.6418*** (0.016)		0.7230*** (0.022)
STATE		-0.0250 (0.069)		-0.1552* (0.091)
DEBT		-0.2486*** (0.086)		-0.3872*** (0.121)
FA		0.2119** (0.108)		0.6792*** (0.146)
IA		-1.2430*** (0.179)		-1.1970*** (0.215)
PR		0.0002 (0.000)		0.0006* (0.000)
NPR		-0.0217*** (0.004)		-0.0304*** (0.004)
BOARD		0.1497*** (0.046)		0.1255** (0.062)
TOP1		-0.0160*** (0.001)		-0.0138*** (0.002)
Constant	2.3152*** (0.007)	-11.5481*** (0.366)	2.2644*** (0.011)	-13.1807*** (0.497)
ID	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
Observations	8,815	8,815	6,010	6,010
R-squared	0.004	0.257	0.049	0.361

*, **, and *** indicate significant correlation at the level of 10%, 5%, and 1%, respectively.

strategic decision of enterprises according to the performance feedback. Concerning the reference to the multiple enterprise expectation gap, enterprises should constantly optimize resource allocation and actively obtain external information, knowledge, and other resources to achieve the target aspiration level. (2) Decision-makers must treat the inconsistent performance feedback rationally. When faced with fuzzy performance feedback signals, decision-makers should reduce the self-enhancing effect. Considering self-reputation, managers attach great importance to historical performance feedback. Industry performance feedback can reflect the industry's competitive position, which plays an essential role in the long-term development of enterprises. Decision-makers should pay attention to the impact of historical performance feedback on enterprises and improve the importance of industry performance feedback. Enterprise should make full use of the feedback results of consistency and inconsistency to promote EI and enhance the ability of enterprises to adapt to the external

TABLE 6 Robustness test: replacing the measurement method of performance feedback.

Variables	(M1) 0.5	(M2) 0.5	(M3) 0.5	(M4) 0.5
	EI	EI	EI	EI
HAPIAP1	0.2516*** (0.017)	0.1345*** (0.017)		
HAPIAP2			0.5823*** (0.030)	0.2171*** (0.031)
SCALE		0.5410*** (0.013)		0.7160*** (0.022)
STATE		-0.0205 (0.059)		-0.1635* (0.091)
DEBT		-0.0721 (0.071)		-0.4137*** (0.121)
FA		0.1301 (0.096)		0.6319*** (0.146)
IA		-1.0752*** (0.140)		-1.2369*** (0.215)
PR		0.0002 (0.000)		0.0006* (0.000)
NPR		-0.0230*** (0.004)		-0.0305*** (0.004)
BOARD		0.1523*** (0.042)		0.1193* (0.062)
TOP1		-0.0141*** (0.001)		-0.0136*** (0.002)
Constant	2.1680*** (0.012)	-9.5510*** (0.310)	2.2160*** (0.012)	-13.0222*** (0.497)
ID	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
Observations	8,815	8,815	6,010	6,010
R-squared	0.021	0.253	0.067	0.364

*, **, and *** indicate significant correlation at the level of 10%, 5%, and 1%, respectively.

TABLE 7 Robustness test: GMM model.

Variables	(M1)	(M2)
	EI	EI
L.EI	1.0189*** (0.005)	1.0002*** (0.014)
HAPIAP1	0.2163** (0.102)	
HAPIAP2		0.2609** (0.125)
Control	YES	YES
ID	YES	YES
YEAR	YES	YES

*, **, and *** indicate significant correlation at the level of 10%, 5%, and 1%, respectively.

environment, achieving sustainable growth of enterprises. (3) In the scenario of industry performance surplus-historical performance feedback surplus, the enterprise is in a state of absolute benefit. In this scenario, decision-makers should make

full use of the redundant resource search motivation, improve the EI ability of enterprises, and change the tendency of invariability when enterprises are flourishing. In the scenario of industry performance shortfall-historical performance shortfall, the enterprise is in a state of complete loss. In this scenario, decision-makers should take advantage of the problem to search for motivation and actively seek breakthroughs. Enterprises should further optimize the allocation of resources, acquire external knowledge and technology, and enhance their EI ability. (4) When making innovation decisions, enterprises should not only consider the impact of performance feedback on EI, but also pay attention to external regional institutional development, actively use the convenience brought by RI for EI, and reduce the cost of EI and promote the sustainable development of the enterprise.

Limitations and future research

Our study has the following limitations. We divided the cases of inconsistency based on the direction of surplus or shortfall, exploring the impact of different cases of historical performance feedback and industry performance feedback on enterprises' EI. However, performance feedback is not only inconsistent in terms of direction, but may also be inconsistent in intensity. For example, in the case of surplus or shortfall, there are differences in the intensity of historical and industry performance surplus, which should be discussed in future research. When selecting the regulatory variable, we perform an in-depth analysis of the RI of the relationship between performance feedback and EI, from the perspective of transformation in China. However, we did not fully consider the contingency influence of internal factors, such as precipitated redundant resources or non-precipitated redundant resources, this issue can be taken up by future research.

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Data availability statement

The data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

XS collected literature. WF designed the research and wrote the manuscript. XS and WF performed the empirical analysis. All authors contributed to the article and approved the submitted version.

Funding

This research was supported by the National Social Science Foundation of China (19BGL150).

Conflict of interest

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 23 July 2022

ACCEPTED 04 November 2022

PUBLISHED 28 November 2022

CITATION

Ma H, Tang S and Zhao C (2022) CEOs' leadership behaviors and new venture team stability: The effects of knowledge hiding and team collectivism.
Front. Psychol. 13:1001277.
doi: 10.3389/fpsyg.2022.1001277

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CEOs' leadership behaviors and new venture team stability: The effects of knowledge hiding and team collectivism

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Purpose: The reasons for new venture team instability gradually have become a vital issue in the entrepreneurship literature. While chief executive officers' (CEOs) leadership behaviors is regarded as a critical element of governance within new venture teams, few studies explored the role played by CEOs' leadership behaviors in new venture team stability. Drawing on the transactional-transformational leadership model, this study divides CEOs' leadership behaviors in new ventures into two categories, namely, transformational and transactional leadership behaviors. Based on the social exchange theory and the social information processing theory, this study constructs a moderating mediation model to understand how transformational and transactional leadership affects new venture team stability. In this model, knowledge hiding is used as mediating role and team collectivism is used as moderating role.

Design/methodology/approach: Three-wave and two-source data was collected from 66 new ventures in China and an ordinary least squares hierarchical regression model and Hayes' moderated-mediation approach were applied to test the hypotheses.

Findings-The results show transformational leadership and transactional leadership are positively related to new venture team stability. Knowledge hiding mediates the association between transformational leadership and new venture team stability and that between transactional leadership and new venture team stability. Moreover, a high level of team collectivism corresponds to a stronger relationship between transformational leadership and knowledge hiding and a greater indirect effect of transformational leadership on new venture team stability through knowledge hiding.

Originality/value: This study explores the mechanisms and boundary conditions of the effect of transformational leadership, transactional leadership, and new venture team stability, which is an enrichment to the study of governance within new venture teams. It enlightens managers to take effective measures to reduce knowledge hiding and maintain team stability in new venture teams.

KEYWORDS

transformational leadership, transactional leadership, knowledge hiding, new venture team stability, team collectivism

Introduction

Instability of new venture team (NVT instability) emerges as a vital issue in the entrepreneurship literature (Shepherd et al., 2021). NVT are often unstable (Gregori and Parastuty, 2020). Specifically, some team members might doubt whether their teammates are the right people to jointly work with and whether they can push their venture to success, which may trigger conflicts in the team and push some members to leave (Patzelt et al., 2021). Such NVT instability entails serious consequences for the venture. The CB Insights has analyzed 101 failed ventures and found that disharmony among teams is one of the top 20 reasons for failure. Hence, what factors affect NVT instability presents an important research question.

Prior studies have indicated that NVT instability depends on the governance within the team (Slotegraaf and Atuahene-Gima, 2011; Breugst et al., 2015). As a vital element of governance, chief executive officers' (CEOs) leadership behaviors may affect NVT instability (Shepherd et al., 2021). In particular, CEOs' leadership behaviors shape individuals' perceptions, attitudes, and behaviors and strongly influence interpersonal relations, trust, and cooperation among team members (Reid et al., 2018; Yam et al., 2018), all of which are of importance for NVT instability (Gregori and Parastuty, 2020; Lazar et al., 2020). However, few studies explored the role played by CEOs' leadership behaviors in NVT instability, which reflects a serious research gap.

We address this gap in three aspects. First, we draw on the transactional-transformational leadership model, which is dominating leadership research. Transformational and transactional are two distinct dimensions of leadership behaviors (Avolio et al., 1999). Researchers on entrepreneurship argued that CEOs' behaviors in new ventures tend to vary across these two dimensions (Ensley et al., 2006; Kang et al., 2015). Moreover, previous studies suggested that these leadership behaviors are related to interpersonal relations and cooperation among team members (Kovjanic et al., 2013; Gao et al., 2021). Accordingly, this study focuses on testing the impacts of transformational leadership (TFL) and transactional leadership (TAL) on NVT stability. Second, knowledge hiding refers to a deliberate effort on individuals to withhold or conceal important information that coworkers have asked for (Connelly et al., 2012). Recent research in NVTs has highlighted that it is an important process variable that affects team stability (Ma et al., 2022). Based on the social exchange theory, knowledge hiding is regarded as a critical intervention in reciprocal exchange relationships (Wang et al., 2019), which significantly reduces NVT stability (Lee et al., 2017). Moreover, previous research has already corroborated that knowledge hiding is an important underlying influencing mechanism through which leaders reveal their effects on followers' attitudinal and behavioral outcomes, such as followers' turnover intentions (Syed et al., 2021). According to the social information processing theory, CEOs' leadership behaviors can provide cues that inform NVT members about whether knowledge hiding is expected and appropriate behavior (Burmeister et al., 2020). Therefore, this study focuses on knowledge hiding as the

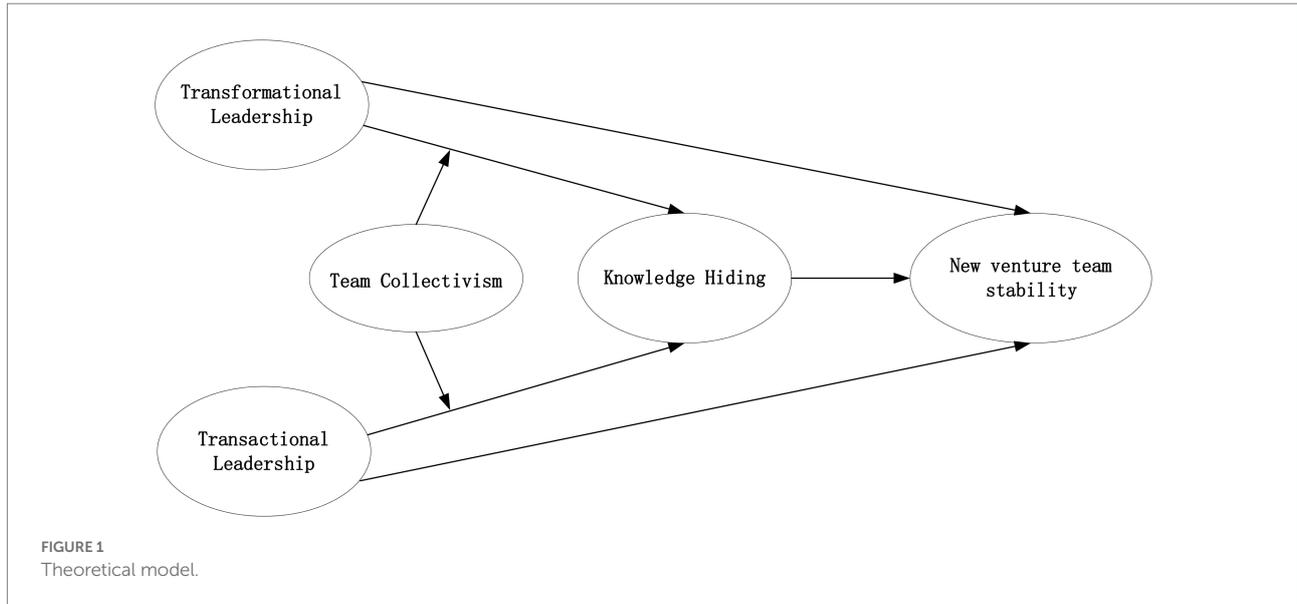
important link to examine how TFL and TAL influence NVT stability. Third, collectivism has been identified as a significant moderator in different relationships between leadership and members' perceptions, attitudes, and behaviors (Walumbwa and Lawler, 2003; Yang et al., 2020). To obtain a more complete understanding of when the association may or may not occur, we take a team collectivism perspective to consider the contextual boundary conditions. As another vital information cue perceived by NVT members, team collectivism influences NVT members' priority on the needs (Lai et al., 2013), which in turn affects team members' responses to the CEO's leadership behaviors (Salancik and Pfeffer, 1978). Therefore, this study examines the moderating effect of team collectivism on the linkage of TFL and TAL to knowledge hiding, and further investigates the moderating role of team collectivism on the indirect effect of TFL and TAL on NVT stability through knowledge hiding. In conclusion, based on the social exchange theory and the social information processing theory, this study constructs a moderating mediation model to explore the influence mechanism between TFL and TAL and NVT stability. The theoretical framework is presented in Figure 1.

This study generates four contributions to the literature. First, our research supplements the emerging field of the governance of NVTs by linking TFL and TAL with team stability through the important mechanism of knowledge hiding in NVTs. Second, this study provides empirical evidence for the positive effects of active leadership on team outcomes in NVTs by examining the impacts of TFL and TAL on knowledge hiding and NVT stability. Third, our study contributes to the knowledge hiding literature by focusing on TFL and TAL as antecedents of knowledge hiding and examining NVT stability as a consequence of knowledge hiding. Last, our study provides a more nuanced understanding of social information processing theory by examining how team collectivism affects team members' responses to the TFL and TAL behaviors.

Theoretical background and hypothesis development

Leadership behaviors and NVT stability

Team stability refers to the extent to which the members of the team remain from beginning to end (Slotegraaf and Atuahene-Gima, 2011). We extend this definition to NVT. NVT is the group of individuals that is chiefly responsible for the strategic decision-making and ongoing operations of a new venture (Klotz et al., 2014). In an NVT, the CEO has central power position and has a more substantial influence on other NVT members and team outcomes (Carmeli et al., 2021). Moreover, this study focuses on what negatively influences NVT members' perceptions and attitudes and leads them to leave. Hence, we use the term NVT stability to describe the extent to which the members of NVT remain since joining the new venture. If NVT members stay on the team and no changes are made since joining the new venture, then the team is implied fully stable. By contrast, the NVT is



considered much less stable if many NVT members exit or some members exit the venture but come back later.

NVT members' negative attitudes related to interpersonal relations, work, and new venture success leads them to leave (Sun and Wang, 2017; Patzelt et al., 2021). Therefore, TFL and TAL may affect team stability by influencing the perceptions and attitudes of NVT members (Shepherd et al., 2021). Transformational leadership is described by Bass (1985) as a meaningful relationship between the leader and the followers that generates a vision-driven change in followers, goes beyond short-term objectives, and concentrates subordinates' higher order intrinsic needs (Berraies and Zine El Abidine, 2019). Through the TFL process, NVT members understand the contents and values of entrepreneurial goals, would like to transcend their own interests to pursue collective goals, and thus establish organizational identification (Su et al., 2020). Hekman et al. (2009) argued that team members who have a high level of organizational identification tend to view other team members as "like them" and "on their side." Therefore, TFL might reduce NVT members' behaviors that trigger interpersonal disharmony and make team members believe that they are the right people to jointly work and realize entrepreneurial goals. In establishing and realizing collective goals, NVT members can sense that their organization is concerned about their well-being and voices through participative decision-making style and individual consideration practiced by the transformational CEO (Fu et al., 2010; Choi et al., 2016). As a result, they are more committed to their jobs and have higher levels of job satisfaction, reflecting team members' positive perceptions of work (Choi et al., 2016). Additionally, NVT members will be more optimistic about the new venture's success by perceiving the CEO's confidence in their competencies (Nübold et al., 2013). Overall, TFL might enhance NVT stability by reducing team members' negative attitudes. Hence, we propose the following:

Hypothesis 1a: TFL is positively related to NVT stability.

TAL is considered a control-oriented, effective leadership strategy in NVTs (Ensley et al., 2006; Gao et al., 2021). Through the TAL process, each member clears his or her roles, work tasks, and goals (Bass, 1985). Meanwhile, to achieve organizational goals and improve operational efficiency, a transactional CEO tends to establish coordination mechanisms to form some common understanding within the NVT (Gao et al., 2021). As a result, NVT members could experience less conflict with teammates and have a high level of job satisfaction (Chen et al., 2017). Moreover, the effective coordination and explicit roles of team members contribute to making solid decisions in a highly competitive environment and can reduce team members' anxiety about failure (Hamstra et al., 2014; Hansen and Pihl-Thingvad, 2019; Gao et al., 2021). Additionally, a proactive transactional CEO tends to monitor and rectify any divergence from cooperation in team members' work (Vaccaro et al., 2012). In this sense, NVT members are more likely to respond to teammates' requirements and collaborate with teammates, which positively influences team members' perceptions of interpersonal certainty. Overall, TAL might enhance NVT stability by reducing team members' negative attitudes about work, venture success, and interpersonal relations. Therefore, we propose the following:

Hypothesis 1b: TAL is positively related to NVT stability.

Mediating role of knowledge hiding

Leadership behaviors and knowledge hiding

According to the social information processing theory (Salancik and Pfeffer, 1978), team members' perceptions, attitudes, and behaviors are shaped by information cues from the social

environment. Researchers recently suggested that the CEO can provide cues by his or her leadership behaviors that inform followers about expected and appropriate behaviors (Burmeister et al., 2020), and thus influence knowledge hiding behaviors in the team (Syed et al., 2021; Ma et al., 2022). Based on the transformational–transactional leadership model, the CEO's TFL and TAL behaviors transfer different information cues to NVT members (excluding the CEO; Kovjanic et al., 2013). A CEO who adopted TFL behaviors would create a common vision in teams, express confidence that goals will be achieved, and inspire team members to transcend their own interests to pursue collective goals (Bass, 1985). In addition, a transformational CEO encourages team members to rethink how they perform their work and provides them with individualized support by developing and coaching each individual in a unique manner (Avolio et al., 1999). Unlike TFL behaviors, a CEO who adopted TAL behaviors would clarify NVT members' roles, task requirements, and rewards when they complete their work tasks and meet expectations (Bass, 1985). TAL behaviors also include that the CEO monitors team members' process of completing tasks and solves problems if team members encounter mistakes in completing tasks (Avolio et al., 1999). Therefore, NVT members (excluding the CEO) obtain information about goals, tasks, and rewards in the NVT by observing the CEO's TFL and TAL behaviors. Through further processing these information, they could know whether knowledge hiding is an expected and appropriate behavior and adjust their behaviors accordingly.

By processing the CEO's TFL behaviors, NVT members (excluding the CEO) realize that collective goals are emphasized and that individuals are encouraged to enact and realize collective goals with teammates (Choi et al., 2016). As a result, team members tend to think of other teams as rivals and their teammates as allies (Zhu et al., 2019). To deal with complex and creative tasks, they should integrate knowledge by cooperating with allies (Ma et al., 2022). In addition, NVT members (excluding the CEO) are motivated to adopt new methods to complete assignments (Bass, 1985). In this case, team members think that they should seek different views and express new ideas in the NVT (Detert and Burris, 2007; Gao et al., 2021). Integrating knowledge with teammates and emphasizing openness to opinions imply that knowledge hiding is not expected behavior, leading to less knowledge hiding. Therefore, we propose the following:

Hypothesis 2a: TFL is negatively related to knowledge hiding among members of NVTs.

Given that valuable knowledge transfer is important for the new venture to gain competitive advantages (Ma et al., 2022), a transactional CEO is more likely to devise incentive systems that recognize individuals' efforts to create or share knowledge (Du et al., 2013). In this case, getting rewards for knowledge sharing can let NVT members (excluding the CEO) understand that knowledge hiding is not expected behavior in the NVT (Abubakar et al., 2019). In addition, a transactional CEO tends to provide

immediate feedback to team members when he or she monitors team members' processes of completing tasks (Chang et al., 2015). Hence, NVT members (excluding the CEO) might get immediate negative feedback from the CEO when they commit knowledge hiding behavior. Thus, they would think that knowledge hiding is not expected behavior in the workplace. Furthermore, team members know that inappropriate and unethical behaviors are monitored, and thus, they are more likely to reduce the inappropriate knowledge hiding behavior. Therefore, we propose the following:

Hypothesis 2b: TAL is negatively related to knowledge hiding among members of NVTs.

Knowledge hiding and NVT stability

Social exchange theory posits that members develop relationships based on transactional experience when communicating with coworkers, and they look forward to establishing reciprocal exchange relationships (Blau, 1964). Suppose all members abide by reciprocal norms and have a sense that all exchanges will reach a fair equilibrium over time. In that case, high-quality relationships will be generated among members and evolve into trusting and mutual commitments (Cropanzano and Mitchell, 2005). However, team members assume that those who do not comply are punished, and they adapt their attitudes and behaviors when interventions in the reciprocal exchange process occur (Abubakar et al., 2019). Previous research found that unbalanced social exchange relationships negatively influence individuals' psychological well-being (Jiang Z. et al., 2019), which may compel them to leave their organizations (Lee et al., 2017).

In recent years, unethical knowledge hiding behavior is regarded as a critical intervention in the reciprocal exchange process and results in unbalanced social exchange relationships between team members (Serenko and Bontis, 2016; Wang et al., 2019). Accordingly, knowledge hiding might exert an important influence on NVT stability. In an NVT context, if knowledge seekers perceive knowledge hiding by teammates, then they may also be reluctant to cooperate and share knowledge with them in the future and even impose social sanctions on them (Zhu et al., 2019). This event results in a reciprocal distrust loop between knowledge seekers and hidiers that might undermine good relationships and shared cognition among teammates (Cropanzano and Mitchell, 2005). This reciprocal distrust loop results in team members' lower perceptions of NVT viability, thereby reducing NVT stability (Klotz et al., 2014; Chen et al., 2017). Moreover, when knowledge hidiers experience conflict with reciprocal norms within the NVT and realize that they may be punished as a result, they may experience tension, strain, and reduced job satisfaction, which could encourage them to leave the team (Offergelt et al., 2019). Overall, knowledge hiding might reduce NVT stability by negatively influencing team members' attitudes related to interpersonal relations, new venture success, and work. Therefore, we propose the following:

Hypothesis 3: Knowledge hiding is negatively related to NVT stability.

As stated above, we propose that leadership behaviors influence knowledge hiding behavior among NVT members (excluding the CEO), thereby affecting team stability. The model we develop in Hypotheses 1a, 2a, and 3 allows for the prediction of an indirect relationship between TFL and NVT stability. Specifically, we propose that TFL reduces knowledge hiding by providing cues that inform team members about expected and appropriate behaviors. This case in turn positively influences team members' attitudes related to interpersonal relations, new venture success, and work and ultimately leads NVT members to stay. Our developed model in Hypotheses 1b, 2b, and 3 leads us to expect an indirect association between TAL and NVT stability. Specifically, we propose that TAL reduces knowledge hiding by providing cues that inform team members about expected and appropriate behaviors and supervision from the CEO, thereby maintaining stability. In sum, we offer the following hypotheses:

Hypothesis 4a: Knowledge hiding mediates the relationship between TFL and NVT stability.

Hypothesis 4b: Knowledge hiding mediates the relationship between TAL and NVT stability.

Moderating effect of team collectivism

In addition to expected and appropriate behaviors, NVT members also know which needs could be satisfied while they are doing the expected behaviors by processing the CEO's TFL and TAL behaviors (Kovjanic et al., 2013). Individuals are more likely to do the expected behaviors when their prioritized needs could be satisfied in the workplace (Salancik and Pfeffer, 1978). Hence, NVT members' responses to the CEO's leadership behaviors depend on whether their prioritized needs can be satisfied.

A team is likely to be infiltrated by a collectivist culture when team members stress teamwork in performing team activities and making collective decisions (He et al., 2014). Therefore, NVT members tend to place more priority on the need for relatedness (feeling connected and significant to others) when team collectivism is high (Lai et al., 2013). If team members' need for relatedness can be satisfied in the NVT, then team members in a high level of team collectivism are more likely to implement the expected behaviors (Salancik and Pfeffer, 1978). From this perspective, team collectivism might affect the effectiveness of leadership behavior and thus influence the relationship between TFL and TAL and knowledge hiding.

A transformational CEO encourages NVT members to enact and realize collective goals with others (Choi et al., 2016) but does not clarify each member's role and task. By processing these cues, team members understand that cooperation with teammates is important to accomplish creative tasks (Kovjanic et al., 2013; Burmeister et al., 2020), thereby thinking that the need for

relatedness can be satisfied when they implement the expected behaviors in the NVT. As a result, we propose that team collectivism may increase the effectiveness of TFL, which strengthens the negative influence of TFL on knowledge hiding. Hence, we suggest the following:

Hypothesis 5a: Team collectivism moderates the negative relationship between TFL and knowledge hiding in that the relationship is stronger when team collectivism is high rather than low.

From another aspect, a transactional CEO tends to provide material rewards for team members who implement expected behaviors and complete tasks (Hansen and Pihl-Thingvad, 2019). Thus, NVT members in a high level of team collectivism might not enjoy reducing the inappropriate knowledge hiding because of the gap between the need for material and relatedness. In addition, TAL emphasizes that individuals get rewards for their own performance so that individuals focus on their own tasks and ignore their teammates' needs in the NVT (Gao et al., 2021). In this case, team members would think that they are not connected with teammates and cannot get support when in trouble. Hence, NVT members would know that their need for relatedness cannot be satisfied in the NVT by processing the CEO's TAL behaviors, which negatively influences individuals' motivation to implement the expected behaviors (Deci and Ryan, 2000). Accordingly, we propose that team collectivism may reduce the effectiveness of TAL, which weakens the negative influence of TAL on knowledge hiding. Therefore, we propose the following:

Hypothesis 5b: Team collectivism moderates the negative relationship between TAL and knowledge hiding in that the relationship is weaker when team collectivism is high rather than low.

Earlier, we proposed indirect associations between TFL and TAL and NVT stability *via* knowledge hiding (Hypothesis 4a and 4b). Integrating our theorization for the moderating role of team collectivism in the TFL and TAL–knowledge hiding association, team collectivism will likely influence the strength of the indirect relationship between TFL and TAL and NVT stability through knowledge hiding conditionally (Edwards and Lambert, 2007; Wang et al., 2016). When team collectivism is high rather than low, TFL has a stronger effect on NVT stability because NVT members enjoy reducing knowledge hiding behaviors by processing the CEO's leadership behaviors; TAL has a weaker effect on NVT stability because NVT members have insufficient incentives to reduce knowledge hiding behaviors by processing the CEO's leadership behaviors. This notion indicates a moderated mediation model of the relationship between the study's variables, as depicted in Figure 1. Thus, we set forth the following hypotheses:

Hypothesis 6a: Team collectivism moderates the indirect effect of TFL on NVT stability through knowledge hiding in that the

indirect relationship is stronger when team collectivism is high rather than low.

Hypothesis 6b: Team collectivism moderates the indirect effect of TAL on NVT stability through knowledge hiding in that the indirect relationship is weaker when team collectivism is high rather than low.

The theoretical model of this study is shown in [Figure 1](#).

Research methods

Sample

Zahra and Bogner (2000) defined new venture as a company that is 8 years old and under. Therefore, we selected NVTs from companies younger than 8 years of age. We collected data from 66 new ventures in the Jilin province of China (45 manufacturing enterprises and 21 non-manufacturing companies). We approached members of NVTs engaged with a research project in cooperation with Jilin Provincial Science and Technology Department. In the final sample, team size ranged from four to eight members (Mean = 5.79, Standard Deviation (SD) = 0.95). Among the 382 member respondents, 31.6% joined or started a business, 63.9% were male, and 86.3% had a bachelor's degree or higher. The average age of the members was 35.4 years of age (SD = 6.77), and the average age of the CEOs who underwent individual interviews was 40.14 years (SD = 4.9), of which 25.8% were female.

Procedures

A cross-sectional study may introduce deviations, such as consistency motifs and illusionary correlations; thus, a three-stage longitudinal research design was adopted. However, one cannot take advantage of such a research design if the time lag is too short or too long as it is not conducive to studying the accuracy of the relationship between the measured variables (Peng, 2013). Thus, the present study used a two-month lag to compensate for this fact. As this study adopted team-level data to analyze the relationship between the constructs, we scheduled meetings with the CEOs of 98 new ventures who agreed to participate before our survey. In these meetings, we explained the purpose of the survey, made a commitment to information security for the respondents, and asked for their help in identifying NVT members, distributing the questionnaires at their firms, and then collecting the data. In the first stage (Time 1), the NVT members (excluding CEOs) completed the survey about leadership behaviors. A total of 585 members belonging to 98 teams returned the questionnaires. Two months later (Time 2), we asked all 585 respondents to accomplish a second questionnaire on team collectivism, knowledge hiding, and demographic information. In Time 2, 480 members belonging to

82 teams completed the second-stage survey, representing an 82.05% response rate. Approximately another 2 months later (Time 3), the CEOs of the 82 teams (one per team) were asked to answer a third-stage questionnaire about the basic situation of the firm and team stability; 74 CEOs returned the questionnaires (90.24% response rate). To increase data quality and reliability, we also illustrated the purpose of this study and assured anonymity and confidentiality by a cover letter attached to the questionnaires. Each survey featured an anonymous code so that we could identify the three waves of the questionnaires. After removing incomplete and unmatched surveys, a final matched sample of 382 team members nested within 66 NVTs was obtained.

Measures

Given that the respondents are from China, we used a back-translation procedure (Brislin, 1986) for the English questionnaire, which we translated into Chinese and then retranslated into English for comparison to ensure accuracy. We used measuring instruments from the extant literature and a Likert-type response scale for all items (Appendix A) ranging from 1 ("strongly disagree") to 5 ("strongly agree"). As shown in the following section, four variables (i.e., TFL, TAL, team collectivism, and knowledge hiding) measured at the individual level have acceptable consistency and reliability and are aggregated on the team level.

Leadership behaviors

The study adopted Avolio et al. (1999) measures for TFL and TAL. We used a 20-item scale to measure TFL (12 items on charisma and inspirational leadership, four items on intellectual stimulation, and the remaining four items on individualized consideration). Examples of sample items include "On our team, the CEO goes beyond self-interest for the good of the group" and "On our team, the CEO re-examines critical assumptions." The resulting Cronbach's alpha value confirmed the good internal consistency and reliability of the scale ($\alpha = 0.90$). The intraclass correlations (ICCs) were also computed to evaluate agreement between team members; ICC(1) was 0.18, and ICC(2) was 0.56. The mean and median r_{wgs} were 0.96 and 0.97, respectively. In addition, we used an eight-item scale to measure TAL, where four of which are for contingent rewards, and the remaining four are for management by exception. Examples of sample items include "On our team, the CEO clarifies what I can expect to receive when goals are achieved" and "On our team, the CEO focuses on my mistakes." The scale showed a reliability value of 0.84, an ICC(1) of 0.27, and an ICC(2) of 0.67. The mean and median r_{wgs} were 0.93 and 0.95, respectively.

Team collectivism

We adopted He et al. (2014) seven-item scale to measure team collectivism, with sample items, such as "The CEO is protective of

and generous to loyal workers.” The scale had a reliability of 0.94, an ICC(1) value of 0.26, and an ICC(2) value of 0.66. The mean and median r_{wgs} were 0.92 and 0.94, respectively.

Knowledge hiding

We used 12 items adapted from Connelly et al. (2012) to measure knowledge hiding (including playing dumb, evasive hiding, and rationalized hiding). Examples of sample items include “When my teammates asked for some information, I pretended that I did not know the information” and “When my teammates asked for some information, I agreed to help them but never really intended to.” The scale showed a reliability value of 0.83, an ICC (1) value of 0.39, and an ICC(2) value of 0.78. The mean and median r_{wgs} were 0.92 and 0.94, respectively.

NVT stability

We measured NVT stability using three items adapted from the team stability scale of Slotegraaf and Atuahene-Gima (2011). An example of a sample item is “NVT members (excluding the CEO) remained since joining the new venture.” The Cronbach’s alpha value was 0.88.

Control variables

This study controlled for firm age (years since founding) and team size and industry variables that have been selected as factors influencing team stability in previous research (Ucbasaran et al., 2003). We coded team size as a continuous variable and industry as a dummy variable (1 = manufacturing, 0 = non-manufacturing). Considering that the age of a new venture is 8 years old and under, we classified all new ventures according to firm age; a firm age of less than 2, 2–4, 4–6, and 6–8 years, thereby controlling for venture firm age.

Results

Analysis

Exploratory factor analysis on TFL, TAL, team collectivism, knowledge hiding, and NVT stability was conducted to examine the discriminant validity of the measures. Table 1 shows the analysis results. Factor analysis using principal component extraction with orthogonal rotation extracted nine clear factors with eigenvalues greater than 1.0. Two types of CEOs’ TAL behaviors were extracted as a factor. The factor loading coefficient of the item on the corresponding factor exceeded 0.40 and was thus significant (Hair et al., 1998). As Cronbach’s alpha values were >0.70, the resulting scales have good reliability (Hair et al., 1998).

To test these hypotheses, we employed and examined a series of hierarchical regression models (1) to (4), using SPSS 20.0.

Model (1) was constructed based on H1a and H1b to detect the impact of TFL and TAL on NVT stability. If the main coefficient β_1 of TFL and β_2 of TAL are significantly positive, it would confirm that TFL and TAL can improve NVT stability.

$$NVT\ stability_i = \beta_0 + \beta_1 TFL_i + \beta_2 TAL_i + \beta_3 Firm\ age + \beta_4 Industry + \beta_5 Team\ size_i + \varepsilon_i \quad (1)$$

Model (2) was constructed based on H2a and H2b to detect the impact of TFL and TAL on knowledge hiding. If the main coefficient β_1 of TFL and β_2 of TAL are significantly negative, it would confirm that TFL and TAL can reduce knowledge hiding.

$$Knowledge\ hiding_i = \beta_0 + \beta_1 TFL_i + \beta_2 TAL_i + \beta_3 Firm\ age + \beta_4 Industry + \beta_5 Team\ size_i + \varepsilon_i \quad (2)$$

Model (3) was constructed based on H3 to detect the impact of knowledge hiding on NVT stability. If the main coefficient β_1 of knowledge hiding is significantly negative, it would confirm that knowledge hiding can reduce NVT stability

$$NVT\ stability_i = \beta_0 + \beta_1 Knowledge\ hiding_i + \beta_2 Firm\ age + \beta_3 Industry + \beta_4 Team\ size_i + \varepsilon_i \quad (3)$$

To test the moderating effect of team collectivism proposed by H5a and H5b, we introduced the intersections term TFL× team collectivism and TAL× team collectivism in the model (4). The coefficient β_3 and β_4 in the model (4) was expected to be significantly negative if H5a and H5b were confirmed.

$$Knowledge\ hiding_i = \beta_0 + \beta_1 TFL_i + \beta_2 TFL_i \times Team\ collectivism_i + \beta_3 TFL_i \times Team\ collectivism_i + \beta_4 TAL_i \times Team\ collectivism_i + \beta_5 Team\ collectivism_i + \beta_6 Firm\ age_i + \beta_7 Industry_i + \beta_8 Teamsize_i + \varepsilon_i \quad (4)$$

Where, i = firm; ε_i is the observation error.

Considering the advantages of the bootstrapping method, Hayes (2009) bootstrapping-based (moderated) mediation analysis was adopted to assess the mediating effect of knowledge hiding. Moreover, we performed the bootstrapping method of Preacher et al. (2007) to test the moderated mediation.

Hypotheses testing

Table 2 presents the descriptive statistics and correlations for all of the variables. TFL was positively related to team collectivism ($r=0.27$, $p<0.05$) and NVT stability ($r=0.38$, $p<0.01$) and negatively related to knowledge hiding ($r=-0.56$, $p<0.01$). TAL was positively related to NVT stability ($r=0.35$, $p<0.01$) and negatively related to knowledge hiding ($r=-0.29$, $p<0.05$). Knowledge hiding was negatively related to NVT stability ($r=-0.51$, $p<0.01$). We used ordinary least squares regression analysis to test the hypotheses. The maximum value of the variance inflation factor from the analyses is 1.278, which is substantially below the general cut-off value of 10. This result suggests that the likelihood that multicollinearity is a problem is minimal.

TABLE 1 Factor analysis.

Items	CH	IS	IC	TAL	TC	PD	EH	RH	NVTS
Transformational leadership (TFL)									
CH1	0.79	0.01	-0.09	0.08	0.08	-0.18	0.03	-0.11	0.1
CH2	0.80	0.21	-0.07	-0.00	0.13	-0.06	-0.19	-0.07	0.08
CH3	0.75	0.26	0.01	-0.09	-0.04	-0.01	0.06	-0.21	0.11
CH4	0.75	0.07	0.20	-0.03	0.03	-0.06	-0.10	0.04	-0.02
CH5	0.73	0.2	0.19	0.10	0.12	-0.17	-0.05	0.08	0.12
CH6	0.72	-0.12	0.13	0.26	0.13	-0.08	-0.14	0.06	-0.03
CH7	0.69	0.16	0.02	0.06	0.08	0.02	-0.01	-0.42	0.13
CH8	0.85	0.21	0.07	0.04	0.10	-0.15	-0.22	-0.04	0.15
CH9	0.81	0.23	-0.12	0.03	0.11	-0.1	-0.08	-0.20	0.12
CH10	0.85	0.04	0.09	0.16	0.11	-0.16	-0.11	-0.22	0.10
CH11	0.85	0.11	0.21	0.11	0.11	-0.14	-0.21	-0.07	0.06
CH12	0.88	0.10	0.09	0.16	0.08	-0.11	-0.08	-0.22	0.12
IS1	0.44	0.75	-0.03	0.12	-0.01	-0.01	-0.11	-0.14	-0.06
IS2	0.06	0.81	0.06	0.07	0.05	-0.11	-0.15	-0.14	-0.02
IS3	0.39	0.87	0.07	0.05	0.03	-0.13	-0.06	-0.10	-0.04
IS4	0.32	0.75	0.18	0.02	0.10	-0.23	0.01	-0.00	0.15
IC1	0.08	0.13	0.83	-0.05	0.19	-0.07	0.04	-0.07	-0.02
IC2	0.15	0.04	0.87	-0.07	0.10	-0.02	0.01	-0.06	0.07
IC3	0.17	0.03	0.83	0.02	0.15	-0.04	0.03	-0.08	0.03
IC4	0.02	0.02	0.85	0.01	0.11	0.01	-0.10	-0.13	-0.01
Transactional leadership (TAL)									
CR1	0.03	0.04	0.07	0.90	0.06	-0.05	0.02	-0.06	0.07
CR2	-0.07	0.19	-0.09	0.82	-0.05	0.05	0.08	0	0.1
CR3	0.04	0.03	-0.12	0.78	0.02	-0.11	0.01	0.17	0.17
CR4	-0.01	0.08	-0.03	0.88	-0.03	-0.08	0.05	0.12	0.20
ME1	0.30	-0.07	0.04	0.75	-0.01	-0.09	-0.19	-0.03	-0.04
ME2	0.02	0.12	0.10	0.81	0.00	-0.09	-0.28	-0.16	0.03
ME3	0.30	-0.13	-0.13	0.69	0.16	-0.07	-0.23	-0.11	0.16
ME4	0.24	-0.05	0.02	0.82	0.07	-0.08	-0.14	-0.13	0.03
Team collectivism									
TC1	0.09	-0.06	0.14	0.04	0.92	-0.09	-0.04	-0.03	-0.03
TC2	0.04	0.02	0.14	0.07	0.91	-0.08	-0.07	0.02	0.08
TC3	0.14	-0.01	0.07	0.07	0.89	-0.14	-0.09	-0.02	-0.03
TC4	0.05	-0.02	0.02	0.03	0.94	-0.16	0.04	-0.04	0.07
TC5	0.11	0.03	0.04	-0.06	0.94	-0.06	-0.06	-0.05	-0.01
TC6	0.13	0.08	0.12	-0.00	0.90	-0.06	-0.06	-0.02	0.02
TC7	0.08	0.12	0.07	-0.01	0.93	-0.03	0.02	-0.02	0.00
Knowledge hiding									
PD1	-0.08	-0.17	-0.08	-0.07	-0.18	0.80	0.12	0.32	-0.08
PD2	-0.30	-0.01	-0.03	-0.12	-0.08	0.80	0.17	0.16	-0.15
PD3	-0.21	-0.16	0.04	-0.11	-0.22	0.78	0.16	0.19	-0.01
PD4	-0.21	-0.11	-0.09	-0.12	-0.21	0.84	0.17	0.27	-0.15
EH1	-0.14	-0.17	0.01	-0.17	-0.19	0.33	0.49	0.33	-0.24
EH2	-0.37	-0.05	-0.04	-0.23	0.02	0.19	0.66	0.13	-0.25
EH3	-0.29	-0.17	-0.02	-0.11	-0.13	0.23	0.79	0.12	-0.16
EH4	-0.29	-0.13	0.03	-0.10	-0.15	0.38	0.63	0.14	-0.36
RH1	-0.11	-0.12	-0.11	0.02	-0.04	0.39	0.06	0.80	-0.08
RH2	-0.11	0.03	-0.19	0.01	-0.00	0.24	0.02	0.77	-0.23
RH3	-0.31	-0.1	-0.05	-0.14	0.07	0.09	0.17	0.77	0.08
RH4	-0.17	-0.18	-0.08	0.01	-0.14	0.22	0.13	0.78	-0.09

(Continued)

TABLE 1 (Continued)

Items	CH	IS	IC	TAL	TC	PD	EH	RH	NVTS
New venture team (NVT) stability									
ETS1	0.19	0.07	-0.02	0.20	0.02	0.00	-0.27	-0.16	0.78
ETS2	0.13	-0.07	0.01	0.23	0.01	-0.16	-0.06	-0.09	0.82
ETS3	0.27	0.03	0.10	0.15	0.02	-0.18	-0.19	-0.07	0.83

CH, charisma and inspirational leadership; IS, intellectual stimulation; IC, individualized consideration; CR, contingent rewards; ME, management by exception; TC, team collectivism; PD, playing dumb; EH, evasive hiding; RH, rationalized hiding; NVTS, new venture team stability; TAL, transactional leadership; The values in italics are loadings for each item that are above the recommended value of 0.4.

TABLE 2 Means, standard deviations, correlations, and reliability values.

Variables	Mean	SD	1	2	3	4	5	6	7	8
1 Firm age	3.15	1.11	–							
2 Industry	0.73	0.45	0.21	–						
3 Team size	5.79	1.20	-0.02	0.03	–					
4 TFL	3.75	0.33	-0.04	0.11	0.12	(0.90)				
5 TAL	3.43	0.36	0.13	0.12	0.03	0.22	(0.84)			
6 Team collectivism	3.78	0.51	-0.02	-0.10	-0.02	0.27*	0.07	(0.94)		
7 Knowledge hiding	3.29	0.45	0.23	0.07	-0.08	-0.56**	-0.29*	-0.27*	(0.83)	
8 NVT stability	3.70	0.89	0.13	0.03	0.08	0.38**	0.35**	0.10	-0.51**	(0.88)

N = 66; Reliability is shown on the diagonal within parentheses; TFL, transformational leadership; TAL, transactional leadership; NVT stability, new venture team stability; SD: standard deviation; * $p < 0.05$; ** $p < 0.01$.

Hypothesis 1a predicts a positive relationship between TFL and NVT stability, which is confirmed by the regression analysis results in Table 3 (model 5; for TFL, $\beta = 0.33$, $p < 0.01$). Meanwhile, Hypothesis 1b proposes that TAL would be positively related to NVT stability, which is also confirmed by the results in Table 3 (model 5; for TAL, $\beta = 0.27$, $p < 0.05$). Specifically, the results show that an increase of one standard deviation in TFL (0.33) and TAL (0.36) will lead to increases in the level of NVT stability of 10.89 percent (0.33×0.33) and 9.72 percent (0.36×0.27).

Hypothesis 2a predicts that TFL would be negatively associated with knowledge hiding. The results in Table 3 confirm this relationship (model 2; for TFL, $\beta = -0.52$, $p < 0.001$), thereby supporting Hypothesis 2a. Similarly, Hypothesis 2b expects a negative relationship between TAL and knowledge hiding. Again, Table 3 validates such an association (model 2; for TAL, $\beta = -0.22$, $p < 0.05$), thereby supporting Hypothesis 2b. Specifically, the results show that an increase of one standard deviation in TFL (0.33) and TAL (0.36) will lead to decreases in the level of knowledge hiding of 17.16 percent (0.33×0.52) and 7.92 percent (0.36×0.22).

By comparing TFL and TAL, we further find that the effect of TFL on NVT stability (model 5; for TFL, $\beta = 0.33$, $p < 0.01$) is greater than TAL (model 5; for TAL, $\beta = 0.27$, $p < 0.05$). Meanwhile, the effect of TFL on knowledge hiding (model 2; for TFL, $\beta = -0.52$, $p < 0.001$) is greater than TAL (model 2; for TAL, $\beta = -0.22$, $p < 0.05$). The results indicate that both TFL and TAL can reduce knowledge hiding and maintain NVT stability, but their degree is different.

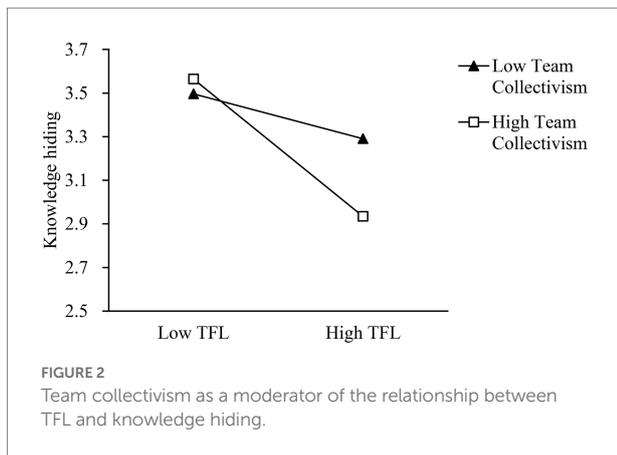
Hypothesis 3 predicts a negative association between knowledge hiding and NVT stability. According to Table 3, knowledge hiding negatively affects NVT stability (model 6, $\beta = -0.57$, $p < 0.001$), supporting Hypothesis 3. Specifically, the result shows that an increase of one standard deviation in knowledge hiding (0.45) will lead to a decrease in the level of NVT stability of 25.26 percent (0.45×0.57). Hypothesis 4a and 4b propose that TFL and TAL would indirectly influence NVT stability through knowledge hiding. This study used a bootstrapping-based mediation analysis approach (Hayes, 2009) to test the indirect effect. Using the SPSS 20.0 macro program Process 3.3, we found a significant indirect effect of TFL on NVT stability through knowledge hiding (based on 5,000 iterations at the 95% bootstrap confidence interval $CI = [0.37, 1.30]$, not containing zero). Thus, Hypothesis 4a is supported. The bootstrapping test also indicates a significant indirect effect of TAL on NVT stability through knowledge hiding (based on 5,000 iterations at the 95% bootstrap confidence interval $CI = [0.02, 0.85]$, not containing zero), which, in turn, supports Hypothesis 4b.

According to Hypothesis 5a, team collectivism moderates the relationship between TFL and knowledge hiding. The results in Table 3 indicate that team collectivism significantly strengthens the effect of TFL on knowledge hiding (model 3; for TFL \times TC, $\beta = -0.27$, $p < 0.05$), thereby supporting Hypothesis 5a. Figure 2 shows this significant interaction (Aiken and West, 1991). The simple slope increases with the increase of the value of moderation variable, and is significantly not 0. Consistent with Hypothesis 5a, the TFL-knowledge hiding relationship is stronger for teams with

TABLE 3 Regression analysis and tests of Hypotheses 1a, 1b, 2a, 2b, 3, 5a, and 5b.

	Knowledge hiding			New venture team stability		
	M1	M2	M3	M4	M5	M6
Firm age	0.22	0.22*	0.25*	0.13	0.12	0.26*
Industry	0.02	0.10	0.03	-0.01	-0.07	0.01
Team size	-0.08	-0.01	-0.03	0.08	0.04	0.04
TFL		-0.52***	-0.40***		0.33**	
TAL		-0.22*	-0.26*		0.27*	
Team collectivism			-0.15			
Knowledge hiding						-0.57***
TFL × Team collectivism			-0.27*			
TAL × Team collectivism			0.03			
Overall model F	1.31	8.49**	7.07**	0.49	3.69**	7.39**
R ²	0.06	0.41	0.50	0.02	0.24	0.33
Adjusted R ²	0.01	0.37	0.43	-0.02	0.17	0.28

N = 66; Standardized regression coefficients are reported; TFL, transformational leadership; TAL, transactional leadership; **p* < 0.05. ***p* < 0.01; ****p* < 0.001.



a high level of collectivism than those with a low level of collectivism. Hypothesis 5b supposes that team collectivism weakens the relationship between TAL and knowledge hiding. However, the results in Table 3 show a non-significant interaction term for TAL and team collectivism (model 3; for TAL × TC, β = 0.03, *p* > 0.05), which rejects Hypothesis 5b. The results indicate that team collectivism cannot strengthen or weaken the association between TAL and knowledge hiding.

Hypothesis 6a and 6b propose that team collectivism would moderate the indirect effects of TFL and TAL on NVT stability through knowledge hiding. Table 4 represents the conditional indirect effects of TFL on NVT stability through knowledge hiding across different levels (i.e., mean - 1 SD, mean, and mean + 1 SD) of team collectivism. The results show that the conditional indirect effect of TFL significantly strengthened when the degree of team collectivism is higher (low = 0.12, non-significant; medium = 0.25, significant; high = 0.34, significant). Therefore, team collectivism also reinforces the indirect effect of TFL on NVT stability through knowledge hiding. Hypothesis 6a is supported. The precondition for Hypothesis 6b

TABLE 4 Conditional indirect effect testing for Hypothesis 6a.

Level	TC	Conditional Indirect effect	BootSE	LLCI 95%	ULCI 95%
Low = mean - 1SD	-0.97	0.12	0.10	-0.09	0.32
Medium = mean	0.13	0.25	0.09	0.10	0.43
High = mean + 1SD	0.88	0.34	0.10	0.15	0.55

N = 66; Bootstrap sample size = 5,000; 95% bias-corrected confidence intervals are reported; TC, team collectivism; SE, standard error; LLCI, lower limit confidence interval; ULCI, upper limit confidence interval.

is dismissed because of Hypothesis 5b, and Hypothesis 6b is also rejected.

Discussion

As noted, stability is important for NVTs, but investigation of the antecedents of NVT stability is limited, specifically from the leadership behavior perspective. However, CEOs' leadership behaviors have significant impacts on the operation of new ventures (Reid et al., 2018). To bridge the gap, this study examines whether, how, and when TFL and TAL influence NVT stability by integrating social exchange theory and social information processing theory. Our empirical results suggest that TFL and TAL are facilitators of NVT stability and are inhibitors of knowledge hiding among NVT members (excluding the CEO), but TFL has effects on NVT stability and knowledge hiding beyond the effects of TAL. Moreover, TFL and TAL can improve NVT stability by reducing knowledge hiding. When team collectivism is high rather than low, TFL has a stronger indirect effect on NVT stability through knowledge hiding. However, team collectivism cannot moderate the negative association between TAL and knowledge hiding. Some team collectivism traits may explain these phenomena. On the one hand, as previously mentioned, team

members with a high level of team collectivism know that their prioritized needs cannot be satisfied in the NVT by processing the CEO's TAL behaviors, which may not reduce inappropriate knowledge hiding. On the other hand, Jiang et al. (2016) argued that conflict avoidance, compromise, and endurance are deeply rooted in highly collectivistic cultures. Therefore, NVT members in a high level of team collectivism tend to do expected behaviors to avoid conflict and maintain interpersonal harmony. As a result, members' preference of conflict avoidance, compromise, and endurance may mitigate the effects caused by the unsatisfied need.

Theoretical contributions

This study makes four sets of unique contributions. First, this study extends the literature on the governance of NVTs from social exchange theory and social information processing theory by estimating how TFL and TAL stimulate NVT stability. The extant literature on the antecedents of NVT stability focused on individuals' feelings of loss in power over the direction of the venture (Shepherd et al., 2021), interpersonal relationships and conflicts at the team level, and investors' influence at the organizational level (Gregori and Parastuty, 2020). Research on how antecedents related to leadership influence NVT stability is limited but highly important. Therefore, our finding enriches existing literature about NVT stability by revealing the positive effects of TFL and TAL on NVT stability. In addition, our empirical results indicate that knowledge hiding is an important bridge between TFL and TAL and NVT stability. Thus, this study also introduces the underlying mechanism for understanding the relationship between CEOs' leadership behaviors and NVT stability.

Second, this study provides empirical evidence for the positive effects of active leadership on team outcomes in NVTs by examining the impacts of TFL and TAL on NVT stability and knowledge hiding. TFL and TAL are regarded as active leadership, but they have different influences on outcomes (Ryan and Tipu, 2013). Previous studies have consistently supported the positive relationships between TFL and outcomes such as knowledge management process, performance, satisfaction, engagement, and turnover (Birasnav, 2014; Siangchokyoo et al., 2020), but have revealed mixed results with regard to the relationships between TAL and these outcomes (Jiang L. et al., 2019; Lee et al., 2019; Young et al., 2021). The results from our research demonstrate that active leadership (including TFL and TAL) can reduce knowledge hiding and maintain team stability in NVTs and the effects of TFL on NVT stability and knowledge hiding beyond the effects of TAL. Thus, this study extends the literature on the effects of active leadership in the NVT context.

Third, this study explores the antecedents and consequences of knowledge hiding by examining the impacts of TFL and TAL on NVT stability. According to social exchange theory (Blau, 1964), knowledge hiding destroys positive reciprocal exchange relationships and negatively influences individuals' psychological

well-being. Therefore, researchers exerted major effort to identify the consequences of knowledge hiding, such as individuals' innovative behavior (Guo et al., 2022), individual and team creativity (Wang et al., 2019), and team performance (Zhang and Min, 2019). However, the negative consequences of knowledge hiding in NVTs have been overlooked. The results from our research demonstrate that knowledge hiding negatively affects NVT stability by negatively influencing team members' attitudes related to interpersonal relations, venture success, and work. Therefore, this study attempts to bridge the gap between knowledge management and NVT governance literature. About the antecedents relevant to CEOs of knowledge hiding, the abusive supervision of leaders (Feng and Wang, 2019), leader-member exchanges (Zhao et al., 2019), and exploitative leadership (Syed et al., 2021) are related to knowledge hiding at mature firms. However, investigation of the relationship between TFL and TAL and knowledge hiding is still limited. From a social information processing perspective, this study regards TFL and TAL as inhibitors of knowledge hiding. The results reveal that TFL and TAL can significantly reduce knowledge hiding in the NVT context. Therefore, this study provides a basic and solid foundation for future studies regarding knowledge hiding.

Last, this study offers a deeper understanding of social information processing theory by combining two important cues in the social environment (i.e., TFL, TAL, and team collectivism) that affect the knowledge hiding behaviors among NVT members (excluding the CEO). Previous studies focused more on the effect of CEOs' leadership behaviors and team culture on individuals' behaviors, respectively. However, little is known about how individuals' behaviors are simultaneously influenced by these two informational cues, particularly for knowledge hiding behaviors of NVT members (Yam et al., 2018; Lei et al., 2021). The study confirms that team collectivism enhances the effectiveness of TFL and reduces knowledge hiding in NVTs. Thus, our study implies that individuals are more likely to implement expected behaviors when the CEO's leadership behaviors show that NVT members' prioritized needs shaped by information cues at the team level can be satisfied in the workplace. Hence, this study extends the literature on social information processing theory by exploring the moderating effect of team collectivism on the relationship between TFL and TAL and knowledge hiding in NVTs.

Managerial implications

This study also offers four practical implications for NVT members. First, the study found that TFL and TAL are positively associated with NVT stability. Therefore, CEOs could improve NVT stability by adopting TFL and TAL behaviors depending on the specific context. Furthermore, the study indicates TFL has an effect on NVT stability beyond the effect of TAL. Hence, TFL could be prioritized by CEOs. Moreover, CEOs could participate in training sessions in which they can reflect on their own leadership behaviors and learn how to effectively implement TFL

and TAL behaviors to realize some leadership functions (Burmeister et al., 2020).

Second, given the importance of knowledge hiding for NVT stability, NVT members should pay more attention to the knowledge management process, particularly to knowledge hiding. Peng (2013) suggested that members who have strong territorial feelings regarding their own knowledge are more likely to withhold knowledge. Therefore, NVT members can reduce knowledge hiding by changing the layout of offices (e.g., demolishing physical walls; Singh, 2019) to maintain team stability.

Third, our results suggest that knowledge hiding mediates the association between TFL and TAL and NVT stability. On the one hand, CEOs could reduce knowledge hiding within their NVTs through TFL behaviors, such as involving their teams in the goal formation process during planning meetings and utilizing software to build internal communication channels (Burmeister et al., 2020). On the other hand, CEOs could devise a short-term incentive mechanism to reward team members for sharing knowledge to suppress knowledge hiding and improve NVT stability. For example, CEOs can clearly and formally compensate knowledge sharers by giving them stock ownership and economic rewards (Van Dijk et al., 2020).

Fourth, this study indicates that team collectivism strengthens the indirect effect of TFL on NVT stability through knowledge hiding. TFL behaviors may be operated alongside a high level of team collectivism to improve the effectiveness of leadership behaviors. On the one hand, CEOs could adopt more TFL behaviors to realize leadership functions when team collectivism is high. On the other hand, team collectivism stems from members' experience of working alone or collaboratively (Wagner III et al., 2012). Thus, a transformational CEO could intervene in their members' practice with managerial measures to intentionally cultivate team collectivism or select collectivist members to form the NVT. For example, the CEO could evidently and frequently involve other NVT members in decision-making, pursue collective goals and share responsibility, and plan informal social events for the team, such as dinners and travel activities (He et al., 2014).

Limitations and future research

Several limitations should be noted and addressed in future research. First, the current study uses a three-wave longitudinal research design with data collected from multiple sources (i.e., CEOs and other members of NVTs) using a questionnaire. This method has its own advantages, but all of the study variables were not collected and computed at all periods. Thus, future researchers can use a full longitudinal research design in which all of the research model variables are measured in all periods. They can use an experimental design to validate this study's findings. Second, considering that data were collected from a sample of 66 new ventures in China, the results may not apply to other countries and regions. Future research may be conducted in countries and

regions with different cultural backgrounds to validate our theoretical model. The research would be useful for testing the cross-cultural generalizability of the results of this study. Third, in this study, we paid attention to general knowledge and did not distinguish between different types of knowledge (e.g., job knowledge, social knowledge, cultural or political knowledge, explicit knowledge, and tacit knowledge; Peng, 2013; Burmeister et al., 2020). Although the model explains that TFL and TAL reduce general knowledge hiding, and hiding general knowledge is harmful to NVT stability. Future studies would contribute more if they could specify the different types of knowledge. Last, this study only explores how TFL and TAL affect knowledge hiding and NVT stability. In the future, analyzing how other leadership behaviors, such as entrepreneurial leadership behaviors, which focus on leaders' opportunity-oriented behaviors (Renko et al., 2015), affect knowledge hiding and NVT stability would provide interesting insights for NVT research.

Conclusion

Based on social exchange theory and social information processing theory, this study proposes a framework to examine whether, how, and when TFL and TAL affect NVT stability. The results show that TFL and TAL are positively related to NVT stability and are negatively related to knowledge hiding, but TFL has effects on NVT stability and knowledge hiding beyond the effects of TAL. Knowledge hiding mediates the relationship between leadership behaviors and NVT stability. Furthermore, the study reveals an important finding—a high level of team collectivism corresponds to a stronger relationship between TFL and knowledge hiding and a greater indirect effect of TFL on NVT stability through knowledge hiding. Future research may use different research methods to verify our theoretical models in different cultural settings and distinguish among different types of knowledge. Future studies may also examine how other leadership behaviors that reflect NVT characteristics, such as entrepreneurial leadership behaviors, affect knowledge hiding and NVT stability.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

HM: conceptualization, funding acquisition, project administration, investigation, and writing—review and supervision. ST: investigation, validation, and writing—original draft. CZ: formal analysis, methodology, and writing—review and editing. All authors contributed to the article and approved the submitted version.

Funding

This work was supported by the National Natural Science Foundation of China (Grant Number 71972084), the project of innovation team for the Jilin University (Grant Number 2022CXTD10), the Fundamental Research Funds for the Sichuan university (Grant No. 2021CXC23).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1001277/full#supplementary-material>

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 25 September 2022

ACCEPTED 16 November 2022

PUBLISHED 05 December 2022

CITATION

Wang D, Luo Y, Hu S and Yang Q (2022)
Executives' ESG cognition and enterprise
green innovation: Evidence based on
executives' personal microblogs.
Front. Psychol. 13:1053105.
doi: 10.3389/fpsyg.2022.1053105

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Executives' ESG cognition and enterprise green innovation: Evidence based on executives' personal microblogs

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Based on cognitive theory, we investigated the influence of executives' ESG cognition on corporate green innovation using data from Chinese manufacturing listed companies from 2010 to 2019. The paper first constructs a metric of ESG cognition of company executives by presenting a quantitative analysis of data from their personal microblogs using textual analysis. The findings show that executive ESG perceptions significantly improve corporate green innovation. After addressing the endogeneity issue through a series of robustness tests, the findings of this paper still held true. Further research found that the enhancement effect of executive ESG perceptions on firms' green innovation level was mainly found in the sample without heavy pollution and with lower financing constraints and a higher marketization process. This study makes an important contribution to the research on corporate green innovation based on the perspective of executive ESG cognition while also providing a theoretical basis and practical reference for corporate green innovation practices.

KEYWORDS

ESG cognition, green innovation, microblogs, China, text analysis

Introduction

Cognition is an important psychological concept; it is an individual's ability to perceive, reason about, and construct ideas in response to environmental and organizational stimuli and is the basis for decision-making and behavior (Bandura, 1989; Beauchamp et al., 2019; Cristofaro, 2020; Schunk and DiBenedetto, 2020). Cognitive theory suggests that human behavior is the product of the interaction between the self-system and the external environment (Wood and Bandura, 1989; Bandura, 1991). Executives play a decisive role in the organization of the firm. In fact, since the introduction of the concept of limited rationality (Simon, 1955), executive perception has been an important topic of academic debate. A rich body of literature has explored the crucial influence of corporate executives'

perceptions from the perspectives of firm performance, investment decisions, cash holdings, corporate social responsibility, and surplus management (Orens and Reheul, 2013; Chen et al., 2014; Li et al., 2020; Sarfraz et al., 2020; She et al., 2021; Zhang et al., 2021; Berthet, 2022). However, little work has focused on the economic consequences of executives' ESG perceptions.

ESG is gradually being taken seriously by the practical and academic communities as social responsibility issues such as climate risk, environmental pollution, and financial fraud are becoming increasingly serious. Especially after the inclusion of the MSCI index system, ESG is of great importance for Chinese enterprises, who can use it to enhance their competitive advantage (Albuquerque et al., 2019). As the standard bearers of social and economic development, enterprises are the subjects of ESG practice. According to cognitive theory, human behavior is influenced by the observation and interpretation of the environment during the learning process, and cognition, behavior, and environment are interdependent causal structures (Wood and Bandura, 1989). Therefore, changes in the external environment brought about by ESG and its related policies will also cause changes in the cognition of corporate executives, which in turn will affect micro-firm behavior. Green innovation, as a key way to promote green transformation, is highly dependent on the perceptions of corporate executives and their investment decisions. As green innovation is characterized by high investment, high risk, and long investment return cycles, it is often not prioritized in terms of resources and capabilities (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Huang and Li, 2017). The willingness of executives to use organizational resources for green innovation depends on their perceptions and interpretations of environmental protection. Huang et al. (2019) found that executives' environmental awareness had a positive impact on their firms' technological innovation, and executives with good environmental awareness would invest more in research and development (R&D), which would help firms achieve higher technological innovation efficiency. Therefore, the ESG awareness of executives can provide resources and technology to ensure the green innovation behavior of enterprises and thus improve their level of green innovation.

In view of this, we used cognitive theory and a sample of Chinese manufacturing listed companies to investigate the impact of executives' ESG cognition on corporate green innovation. First, we conducted a text analysis of data crawled from the personal microblogs of corporate executives and used the data to construct quantitative indicators of ESG cognition of corporate executives. Second, based on the indicators of executive ESG perceptions, we empirically examined the impact and mechanism of executive ESG perceptions on corporate green innovation.

This paper makes several contributions. First, using cognitive psychology theory, our research further enriches and extends the study of the economic consequences of cognitive theory on corporate innovation behavior by incorporating corporate executives' cognitive factors into the study of corporate green innovation. Previous studies have focused on

the impact of ESG ratings on corporate green innovation (Zheng et al., 2022) while also noting the important role of executive cognition (Mo et al., 2022; Tan and Zhu, 2022). In contrast to previous studies, this paper focuses on the influence and mechanisms of executive ESG cognition on corporate green innovation behavior based on a cognitive theoretical framework, which further enriches the research on executive cognition. Second, this paper explores the influence of executives' ESG cognition on corporate green innovation behavior, which further enriches the research on the factors influencing corporate green innovation. Previous studies on firms' green behavioral decisions have mainly focused on the influence of government environmental regulations, market demand, public pressure, and firms' profitability (Fernando and Wah, 2017; Chen et al., 2018; Chen and Liu, 2020; Wang et al., 2021; Gao et al., 2022; Xu et al., 2022), but these studies have neglected the subjective initiative of firm management. This paper, however, explores the motivation of corporate green innovation from the perspective of managers' cognition, further enhancing the research on the factors influencing corporate green innovation behavior.

Literature review

Executive cognition

Since the introduction of cognitive theory, a rich body of literature has explored the composition of executive cognition and its economic consequences for business organizations from different perspectives. Early on, scholars attempted to analyze the composition and characteristics of executive cognition, thus introducing several important concepts such as attention (Cho and Hambrick, 2006; Cristofaro, 2020; Schunk and DiBenedetto, 2020), selective perception (Sutcliffe and Huber, 1998), and blind spots (Zajac and Bazerman, 1991). In subsequent studies, using textual analysis, scholars have built on this to analyze the factors influencing the cognitive complexity of executives (Graf-Vlachy et al., 2020). One study by Eftekhar et al. (2014) analyzed the link between Facebook users' photo-related activities and the "big five" personality traits and found that neuroticism and extraversion, among other connections, predicted more photo uploads. Obschonka and Fisch (2018) analyzed Trump's personality traits by means of computer linguistic text analysis using content posted by him on Twitter. Scholars have also focused on the impact that company executives' perceptions have on corporate organizational behavior and found that executives' perceptions can significantly influence firm performance (Kim et al., 2016; Ou et al., 2018; Park et al., 2018). The economic consequences of specific executive cognitions have also been examined; for example, Liu and Xi (2021) found that CEO entrepreneurial cognitive orientation affects firm performance by triggering middle managers' confidence in organizational prospects or workplace anxiety.

Green innovation

Green innovation refers to activities such as developing new or improving existing product designs, processes, and organizational management in order to achieve the sustainable development goals of both economic and environmental benefits (Chen, 2008; Wang et al., 2021; Xu et al., 2022). Green innovation can be divided into two categories: Green product innovation and green process innovation (Gunasekaran and Spalanzani, 2012). The current research on green innovation focuses on its drivers and performance evaluation. Regarding the drivers of green innovation, there is a large body of literature using institutional and stakeholder theories to explore the impact of environmental regulatory pressure and stakeholder pressure on corporate green innovation from the perspective of the external environment (Delgado-Ceballos et al., 2012; Fernando and Wah, 2017; Chen et al., 2018; Chen and Liu, 2020). Based on the internal environment perspective, the driving role of organizational resources and capabilities and managers' perceptions is explored using resource-based theory (Lin and Chen, 2017; Qiu et al., 2020; Singh et al., 2020). There is also literature discussing the relationship between green innovation and firm performance. However, there is still academic disagreement on whether green innovation can improve firm performance. Green innovation can increase environmental investments, leading to additional costs for firms and consumption of their limited resources, which has a negative impact on firm performance (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Huang and Li, 2017). However, several studies have also argued that green innovation can improve a firm's green competitiveness and competitive advantage and enhance firm performance (Porter and Van der Linde, 1995; Hojnik and Ruzzier, 2016; Gao et al., 2022).

In general, although there is much discussion of executive cognition and corporate green innovation in the literature, there are still several shortcomings. First, existing studies on green innovation discuss more external factors, such as environmental regulation and stakeholder pressure, and largely ignore the influence of subjective factors of executive cognition. Second, previous studies on executives' environmental perceptions have mostly used cross-sectional data *via* questionnaires, while fewer have used medium- and long-term panel data from listed companies to verify their findings, limiting the relevance. Therefore, we used cognitive theory to examine the impact of executive ESG on green innovation.

Executive cognition and green innovation

The perceptions of corporate executives play an important role in influencing organizational behavioral decisions and economic performance and are a key element in explaining the different ways in which organizations respond to institutional pressures in the same environment (Hambrick, 2007).

As decision-makers in a firm's innovation strategy, the way executives identify and interpret opportunities and challenges in the external environment will be reflected in the firm's behavioral decisions, i.e., executives' perceptions intervene and determine the firm's behavioral choices.

Executive ESG cognition refers to the cognitive structure and cognitive process by which corporate executives pay attention to, interpret, and judge ESG policy information in the face of a complex internal and external environment and apply it to corporate decision-making. This paper argues that executive ESG cognition has an important driving role in corporate green innovation behavior. First, due to the huge costs associated with green manufacturing, companies are increasingly aware of the need to break the inherent production model through innovation. The stronger the ESG perception of corporate executives, the more likely they are to gain original and unique leadership through green technology innovation behaviors, achieving a win-win situation for both the economy and the environment. Liu et al. (2012) found that the environmental management practices of companies are closely related to the support of top management. Zhang et al. (2015) concluded that the commitment of managers to environmental sustainability has a significant impact on the environmental strategy activities of companies. Second, in the current situation of increasingly stringent government regulations, the ESG perceptions of corporate executives will prompt them to interpret external environmental regulations and stakeholders' green needs as opportunities for corporate development. They will also be encouraged to take the initiative to assume corporate environmental responsibility, seize the opportunity to transform green innovation into market value, actively allocate organizational resources to fit corporate environmental strategies, and shift corporate production and operations to a green mode of development. This will enable the company to shift its production and operations to a greener model in order to meet the green expectations of its stakeholders and gain a sustainable green competitive advantage. It is evident that corporate green behavior is directly driven by executives' ESG perceptions. Based on the above analysis, this study argues that the higher the level of ESG perceptions of executives, the more effectively green innovation can be carried out by enterprises. Therefore, we propose the following hypothesis:

Hypothesis 1: The level of ESG cognition among executives is positively related to the level of green innovation in companies.

Research design

Data

An initial sample was collected of listed companies in China's manufacturing sector from 2010 to 2019. Company-related data were obtained from the CSMAR database and the CNRDS database. The data related to executives' ESG perceptions were selected from

TABLE 1 Variable definition table.

Variables	Definition
<i>Green_Innovation</i>	Green invention and utility model patents granted in the year are added together, plus one for logarithmic value
<i>Green_Invention</i>	Green invention patents granted in the year, plus one for logarithmic value
<i>Green_Utility</i>	Green utility model patents granted in the current year, plus one to take the log value
<i>ESG_Ratio</i>	Disclosure ratio, as number of ESG-related tweets/non-related tweets
<i>ESG_LN</i>	Degree of disclosure, logarithmic value of the number of ESG-related tweets plus one
<i>SOE</i>	An indicator variable that equals one if a firm is a state-owned enterprise, and zero otherwise
<i>ROA</i>	Return on assets
<i>LEV</i>	Total liabilities divided by total assets
<i>Size</i>	The natural logarithm of the market capitalization of a firm
<i>AGE</i>	The natural logarithm of the age of a firm
<i>Board</i>	The number of directors sitting on the board
<i>TopShare</i>	Shareholding ratio of the largest shareholder (%)
<i>RD</i>	Proportion of R&D investment to operating income (%)
<i>Disclosure</i>	Stock exchange evaluation grade of information disclosure quality of listed companies

the microblogs of certified executives on Sina Weibo. The tweets of the executives were crawled by a Python crawler, and a textual analysis of the tweets was then carried out. The Latent Dirichlet Allocation (LDA) was used to analyze the topic distribution of the tweets, and a supervised machine learning algorithm was used to filter the tweets of the executives on the topic of social responsibility. The subsequent analyses in this paper were based on the social responsibility-related tweets posted by executives, and the number of tweets was used to investigate the influence between executives' perceptions and the level of corporate green innovation.

The initial sample was screened as follows: (1) financial companies were excluded; (2) companies labelled as "ST" and "*ST" were excluded; (3) companies with incomplete data and whose executives did not operate microblogs were excluded. A total of 2,640 observations were retained after the above screening.

Variables

This section introduces the dependent variable, explanatory variable, and control variables. The names and definitions of the main variables are shown in Table 1.

Dependent variable

The explained variable is the green innovation level of enterprises. In the process of modern innovation mechanisms, patents and technological innovation are interdependent and inseparable. As an object of state protection for enterprises' inventions and creations, patents to a certain extent reflect the level of innovation of enterprises, so this paper proposes that green patents can be used to effectively measure the level of green innovation of enterprises. Based on the above analysis, this paper adopts the sum of green invention and green utility model patents obtained by manufacturing enterprises in the same year as an indicator to measure the level of green innovation of enterprises. Considering the national classification of patents as invention

patents and utility model patents, among which invention patents have a higher level of technological innovation and utility model patents have a higher correlation with product shape and construction, this paper also explores the degree of influence of the explanatory variables on these two classifications, respectively.

Explanatory variable

The explanatory variable is ESG cognitive level of executives. Over the past decade, social media platforms such as Twitter and Weibo have grown in importance as interactive communication tools. Weibo, the largest domestic social media platform in China, is essentially a microblogging service and is very similar to Twitter in terms of its social service model. The two share many similarities, such as a large number of users, a huge amount of user-generated content, continuous and rapid growth, and the same content distribution model and core functions. The nature of social media data, which stores rich textual data about user interactions, can help us understand what users are thinking about a topic or event, enabling systematic analysis of the structure or patterns of activity among individuals or groups (Yang et al., 2021). Research in psychology has also found strong support for the usefulness and validity of integrative language analysis. For example, linguistic analysis has been widely used to study social relations, hierarchy, emotions, mindsets, and psychological traits (Pennebaker et al., 1997; Tausczik and Pennebaker, 2010). There are many microblog users in China, and many corporate executives have opened their own authenticated accounts. The tweets posted by users can reflect their perspectives and the extent to which they follow them. The number of ESG-related microblogs posted on Sina Weibo by executives who have opened microblogs was used as an explanatory variable to better measure the ESG awareness level of executives. To accurately measure executives' ESG perceptions, the following steps were strictly followed in the text analysis session: (1) Analyzing text collation: The microblogging data of executives from listed manufacturing companies were extracted, and the relevant format was converted for batch capturing of keywords. (2) Determining

keywords: We focused on the influence of executives' ESG cognition on corporate green innovation; therefore, words highly related to ESG were selected to build a thesaurus, such as "ESG," "corporate social responsibility," "green innovation," "environmental protection," etc. (3) Analysis: Python software was used to crawl the keywords and obtain the word frequency counts of the keywords. (4) Summary: To address the issue of text comparability, the ESG level of executives was measured in terms of two dimensions, including (a) the number of ESG-related tweets (ESG_LN) and (b) the ratio of the number of ESG-related tweets to the number of non-related tweets (ESG_Ratio).

Control variables

This paper selects property right nature (SOE), total assets net profit rate (ROA), asset-liability ratio (LEV), listed company size (SIZE), company age (AGE), board size (Board), the largest shareholder holding ratio (TopShare), R&D investment to operating income ratio (RD), and the performance of listed companies in each year made by Shanghai Stock Exchange and Shenzhen Stock Exchange (Disclosure) as the control variables of this paper. The nature of property rights divides listed companies into state-owned enterprises and private enterprises. If they are state-owned enterprises, they are assigned 1, and if they are private enterprises, they are assigned 0; Net profit margin of total assets refers to the profitability of the company; Asset-liability ratio indicates the ability of a company to repay its debts. In this paper, the size of listed companies, the age of the company and the size of the board of directors are treated by logarithm. In order to make the data better meet the normal distribution, the shareholding ratio of the largest shareholder is divided by 100.

Model

In order to verify the hypothesis of this paper, that is, the influence of executives' ESG cognition level on the green innovation level of enterprises, we construct a multiple linear regression model as follows:

$$\text{Green_Innovation}_{i,t} = \pm_0 + \pm_1 \text{ESG_Ratio}_{i,t} / \text{ESG_LN}_{i,t} + \text{Control}_{i,t} + \text{Year} + \text{Industry} + \mu \quad (1)$$

Where i represents an individual enterprise, t represents a year, \pm_0 represents an unpredictable random variable, and $\mu_{i,t}$ is an interference term that changes with time and individuals. The variables in the model are explained as mentioned above.

Results

Descriptive statistical analysis

Table 2 is the descriptive statistical results of the main variables in this paper. For the level of green innovation, the median level of

innovation of the sample companies was 0, indicating that more than half of the manufacturing companies have a poor level of green innovation. The mean value was 0.534, the standard deviation was 0.950, the maximum value was 6.111, and the minimum value was 0, implying that there are large differences in the level of innovation between different companies. For executives' ESG cognitive level, the mean values were 0.514 and 2.730 respectively, and the median values were 0.254 and 2.197 respectively, with the mean values being greater than the median; this shows that executives' ESG cognitive level is generally higher. Where the maximum values were 101.1 and 13.25 respectively, and the minimum values were both 0, with the standard deviation being 2.427 and 2.495, indicating that there are large differences in the cognition of executives in different enterprises. For the control variables, the large standard deviations of SIZE, AGE, Board, and RD imply that there are large differences in size, age, and R&D investment between the sample companies.

Baseline results

Table 3 show the regression results of the model (1). The results show that the coefficient of the proportion of ESG disclosure (ESG_Ratio) in column (1) was 0.0299 and was significant at the 1% statistical level (t -value of 4.4358). The regression coefficient of the degree of ESG disclosure by corporate executives (ESG_LN) in column (2) was 0.0259 and was significant at the 5% statistical level (t -value of 1.9852). This indicates that after considering the effects of control variables such as the firm's own characteristics, year, and industry, the higher the proportion of ESG-related disclosure (ESG_Ratio) and degree of disclosure (ESG_LN) in the tweets of corporate executives, the higher the level of corporate green innovation. This also indicates that executive ESG awareness enhances corporate green innovation.

Further analysis

Corporate green innovation patents can be specifically classified into green invention patents and green utility model patents. Table 4 reports the regression results of executive ESG perceptions on different types of green innovation patents. The results in columns (1) and (3) of Table 5 show that the regression coefficients for the proportion of executive tweets on ESG disclosure (ESG_Ratio) were 0.0178 and 0.0330 respectively, and both were significant at the 1% test level. The results from columns (2) and (4) show that the regression coefficients of the degree of disclosure of ESG on executive microblogs (ESG_LN) were 0.0205 and 0.0213 respectively, and both were significant at the 5% test level. This also indicates that after considering the effects of control variables such as firm characteristics, year, and industry, executive ESG awareness helps to increase the number of green invention patents and green utility model patents of firms. Further, by increasing the number of green invention and green utility model patents, executive ESG awareness in turn improves the level

TABLE 2 Descriptive statistics.

Variables	Obs	Mean	Std. dev.	Min	P25	Median	P75	Max	Skewness	Kurtosis
ESG Ratio	2,355	0.5142	2.4267	0.0000	0.0320	0.2537	0.5000	101.12	32.286	1276.1
ESG LN	2,355	2.7296	2.4950	0.0000	0.6931	2.1972	4.1589	13.251	1.2245	4.9086
Green invention	2,355	0.2843	0.7125	0.0000	0.0000	0.0000	0.0000	5.0689	3.2073	14.492
Green utility	2,355	0.3842	0.7896	0.0000	0.0000	0.0000	0.6931	5.7170	2.6001	10.888
Green innovation	2,355	0.5343	0.9502	0.0000	0.0000	0.0000	0.6931	6.1115	2.2061	8.3113
SOE	2,355	0.2790	0.4486	0.0000	0.0000	0.0000	1.0000	1.0000	0.9856	1.9714
ROA	2,355	0.0517	0.0417	-0.0044	0.0206	0.0414	0.0727	0.3721	1.5187	6.7983
LEV	2,355	0.3814	0.1867	0.0174	0.2320	0.3700	0.5173	0.9785	0.2849	2.4190
SIZE	2,355	9.5449	0.5318	7.6615	9.1567	9.4568	9.8282	11.555	0.8576	3.6896
AGE	2,355	2.6988	0.4105	0.6931	2.4849	2.7726	2.9957	3.9120	-0.9241	4.3429
Board	2,355	2.1415	0.1920	1.3863	1.9459	2.1972	2.1972	2.8904	-0.2175	4.2328
Top1	2,355	0.3413	0.1406	0.0431	0.2317	0.3190	0.4325	0.8649	0.6035	3.1369
RD	2,355	4.4836	3.5872	0.0000	2.6200	3.7300	5.4000	35.220	2.6110	14.601
Disclosure	2,355	0.9240	0.2651	0.0000	1.0000	1.0000	1.0000	1.0000	-3.1998	11.239

TABLE 3 Executives' ESG cognition and green innovation.

Variables	(1)	(2)
	Green_Innovation	Green_Innovation
ESG_Ratio	0.0299*** (4.4358)	
ESG_LN		0.0259** (1.9852)
SOE	-0.1282 (-1.4983)	-0.1298 (-1.4880)
ROA	1.5150** (2.3126)	1.5254** (2.3109)
LEV	0.5609*** (2.9636)	0.5543*** (2.9332)
SIZE	0.6564*** (5.2906)	0.6573*** (5.2347)
AGE	-0.0298 (-0.3036)	-0.0364 (-0.3685)
Board	-0.0042 (-0.0188)	-0.0069 (-0.0309)
TopShare	-0.2090 (-0.9079)	-0.1933 (-0.8337)
RD	0.0384*** (3.4597)	0.0387*** (3.5078)
Disclosure	0.1393* (1.9141)	0.1356* (1.8607)
Constant	-6.2085*** (-5.6840)	-6.2577*** (-5.6071)
Year	Control	Control
Industry	Control	Control
N	2,355	2,355
Adj_R ²	0.2189	0.2171

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

of green innovation of firms. In summary, the ESG awareness level of executives, i.e., the proportion of ESG disclosure (ESG_Ratio) and the degree of ESG disclosure (ESG_LN) in executive tweets, can, to a certain extent, increase the number of green patents represented by green inventions and green utility models, i.e., it can contribute to the level of green innovation of the company.

Robustness test

In order to further verify the reliability and robustness of the research results, the following robustness tests were conducted. First,

TABLE 4 Further analysis.

Variables	(1)	(2)	(3)	(4)
	Green_Invention	Green_Invention	Green utility	Green utility
ESG Ratio	0.0178*** (4.8153)		0.0330*** (4.7803)	
ESG_LN		0.0205** (1.9898)		0.0213** (2.0036)
SOE	-0.0961 (-1.5215)	-0.0964 (-1.5071)	-0.1052 (-1.4607)	-0.1079 (-1.4475)
ROA	0.4721 (1.0550)	0.4638 (1.0271)	1.1807** (2.0556)	1.2130** (2.0851)
LEV	0.3072** (2.2097)	0.2993** (2.1538)	0.4246*** (2.8742)	0.4228*** (2.8686)
SIZE	0.5480*** (4.9842)	0.5468*** (4.9988)	0.4680*** (4.3620)	0.4715*** (4.2538)
AGE	0.0362 (0.5435)	0.0310 (0.4650)	-0.0300 (-0.3666)	-0.0353 (-0.4290)
Board	-0.0371 (-0.1949)	-0.0387 (-0.2050)	-0.0127 (-0.0715)	-0.0155 (-0.0883)
Top1	-0.1771 (-1.0780)	-0.1647 (-0.9978)	-0.2281 (-1.1611)	-0.2152 (-1.0891)
RD	0.0320*** (4.0233)	0.0322*** (4.0772)	0.0250*** (3.0715)	0.0253*** (3.1230)
Disclosure	0.1137** (2.3796)	0.1100** (2.2949)	0.0754 (1.1921)	0.0736 (1.1610)
Constant	-5.2969*** (-5.6727)	-5.3198*** (-5.6915)	-4.2801*** (-4.5696)	-4.3436*** (-4.4330)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	2,355	2,355	2,355	2,355
Adj_R ²	0.1933	0.1941	0.1915	0.1852

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

TABLE 5 Exclude zero value of green innovation.

Variables	(1)	(2)
	Green_Innovation	Green_Innovation
<i>ESG_Ratio</i>	0.0287*** (6.6521)	
<i>ESG_LN</i>		0.0461** (2.3669)
<i>SOE</i>	-0.1286 (-0.9500)	-0.1309 (-0.9430)
<i>ROA</i>	0.2008 (0.1828)	0.0745 (0.0678)
<i>LEV</i>	0.7516** (2.4340)	0.6652** (2.1942)
<i>SIZE</i>	0.8046*** (4.5374)	0.8152*** (4.5184)
<i>AGE</i>	-0.0624 (-0.3607)	-0.0761 (-0.4344)
<i>Board</i>	-0.2278 (-0.6009)	-0.2338 (-0.6181)
<i>Top1</i>	-0.6378* (-1.7937)	-0.5973* (-1.6775)
<i>RD</i>	0.0435*** (3.3149)	0.0443*** (3.3412)
<i>Disclosure</i>	0.2026 (1.4109)	0.1918 (1.2654)
<i>Constant</i>	-6.1681*** (-4.3424)	-6.3636*** (-4.3558)
<i>Year</i>	<i>Control</i>	<i>Control</i>
<i>Industry</i>	<i>Control</i>	<i>Control</i>
<i>N</i>	803	803
<i>Adj_R²</i>	0.2470	0.2469

The *T* value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

we conducted a small sample test. According to the descriptive statistics in Table 2, we found that there were more cases of zero green innovation patents in enterprises. In order to eliminate the biased estimation brought by this part of the sample, we removed the observations with zero green innovation patents in the robustness test and re-ran the regression. In addition, in testing the impact of executives' ESG perceptions on different types of green innovation, we also removed observations where the number of green inventions obtained by the firm in the year or the number of green utility models obtained in the year was 0 and re-checked the regression results. Second, a negative binomial regression was used, and since the number of green innovation patents also fit the counting model, the test was switched to a negative binomial regression.

Small sample

Table 5 demonstrates executive ESG perceptions, represented by the percentage of ESG disclosure (*ESG_Ratio*) and the degree of disclosure (*ESG_LN*) of executive tweets after removing the observation that the number of green innovation inventions obtained by the firm in the year was zero. Results show that they were significant at the 1% level and the 5% level, indicating that an increase in executive ESG perceptions can enhance the level of green innovation of the firm.

Table 6 reports the regression results after removing the observations that the number of green inventions and the number of green novelties obtained by the firm in the year were zero, respectively. In columns (1) and (3), the regression coefficients of the proportion of executive twitter ESG disclosure (*ESG_Ratio*) were 0.010 and

0.029, respectively, and passed the 5 and 1% test levels. This indicates that after removing the sample 0 value, the proportion of ESG disclosure by executive microblogging (*ESG_Ratio*) is more able to enhance the level of green innovation of the company by increasing the number of green inventions obtained by the company. In column (2), the regression coefficient of the degree of ESG disclosure by executives on Twitter (*ESG_LN*) was 0.060, which passed the 1% test level, while the result in column (4) was positive despite a slight decrease in significance, a result that also supports the findings above.

Negative binomial regression

The data on patent applications without the natural logarithm were discrete variables, and there were a large number of zero values in their distribution, which may not conform to the assumption of normal distribution, and the expectation of the variables was not equal to the variance. Given this, we adopted negative binomial regression to deal with the problem of non-normal distribution of the explained variables.

Table 7 shows that after switching to the regression treatment, the results were still robust, the significance improved, and the regression coefficient was still positive. The results in column (1) show that the regression coefficient of the proportion of ESG disclosure by executives on Weibo (*ESG_Ratio*) was 0.0058 and was significant at the 5% test level. The results in column (2) show that the regression coefficient of the degree of ESG disclosure by executives on Weibo (*ESG_LN*) was 0.0408 and was significant at the 5% test level. This result is generally consistent with the results of the previous regression using OLS method and supports the conclusion in the previous paper that the degree of ESG disclosure by executives (*ESG_LN*) can enhance the level of corporate green innovation.

The results in Table 8 show that after switching to the regression treatment, the results were still robust, the significance improved, and the regression coefficients were still positive. The results in columns (2) and (4) show that an increase in the degree of ESG disclosure (*ESG_LN*) on executives' microblogs can significantly increase the number of green inventions and green utility models obtained by companies in the same year. This further indicates that an increase in the degree of ESG disclosure (*ESG_LN*) on executives' microblogs can significantly increase the level of companies' green innovation. The results in column (1) did not improve in significance, but the overall regression coefficient was still positive. The results in column (3) also passed the 1% level test on top of the positive coefficient. The above empirical results strongly support the hypothesis proposed in this paper, and the conclusions drawn are reliable and robust.

Heterogeneity analysis

Industry heterogeneity analysis

Table 9 reports the results of the regressions distinguishing between heavily polluting firms and non-polluting firms. In columns

TABLE 6 Exclude zero value of green inventions.

Variables	(1)	(2)	(3)	(4)
	Green_Invention	Green_Invention	Green utility	Green utility
ESG_Ratio	0.0095** (2.1346)		0.0291*** (7.9432)	
ESG_LN		0.0602*** (3.5452)		0.0297 (1.6049)
SOE	-0.1792 (-1.2507)	-0.1604 (-1.1427)	-0.1912 (-1.4392)	-0.2042 (-1.4558)
ROA	-0.2479 (-0.1929)	-0.5512 (-0.4283)	0.6804 (0.6151)	0.6851 (0.6202)
LEV	0.6094* (1.8180)	0.4329 (1.3105)	0.5134* (1.7473)	0.4526 (1.5954)
SIZE	0.8812*** (5.2232)	0.8766*** (5.2052)	0.6495*** (3.6867)	0.6677*** (3.6075)
AGE	-0.1757 (-0.9291)	-0.2012 (-1.0370)	0.0615 (0.3651)	0.0570 (0.3340)
Board	-0.2949 (-0.7305)	-0.3267 (-0.8107)	-0.1760 (-0.5053)	-0.1746 (-0.4982)
Top1	-0.4547 (-1.2863)	-0.4169 (-1.2020)	-0.4859 (-1.4227)	-0.4492 (-1.3065)
RD	0.0379*** (2.7477)	0.0373*** (2.7454)	0.0151 (1.2522)	0.0165 (1.3443)
Disclosure	0.2575** (2.4274)	0.2066* (1.8500)	0.1727 (1.1199)	0.1668 (1.0387)
Constant	-6.7475*** (-5.1790)	-6.8110*** (-5.5826)	-5.0680*** (-3.5465)	-5.3189*** (-3.4187)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	465	465	629	629
Adj_R ²	0.2757	0.2955	0.2394	0.2273

The *T* value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

(2) and (4), the regression coefficients of the proportion of ESG disclosure (ESG_Ratio) and the degree of disclosure (ESG_LN) on executives' microblogs were 0.0286 and 0.0359 respectively, both of which were significantly positive at the 1% level. The regression coefficients of the proportion of ESG disclosure (ESG_Ratio) and the degree of disclosure (ESG_LN) on executives' microblogs in columns (1) and (3) were not significant. This indicates that non-heavily polluting firms are more efficient in green innovation compared to heavily polluting firms. Further, an increase in the proportion of ESG disclosure (ESG_Ratio) and the degree of disclosure (ESG_LN) on executives' microblogs is also more likely to improve the level of firms' green innovation.

Financing constraints

Corporate green innovation activities are influenced by financing constraints. To test the mechanism of the influence of executive ESG

TABLE 7 Executives' ESG cognition and green innovation.

Variables	(1)	(2)
	Green_Innovation	Green_Innovation
ESG_Ratio	0.0058** (2.4406)	
ESG_LN		0.0408** (2.1859)
SOE	-0.1407 (-1.0543)	-0.1366 (-1.0279)
ROA	3.8987*** (3.4436)	3.7868*** (3.3660)
LEV	1.3762*** (3.7504)	1.3246*** (3.6518)
SIZE	0.8413*** (7.4715)	0.8350*** (7.6571)
AGE	-0.1615 (-0.7556)	-0.1844 (-0.8491)
Board	-0.0382 (-0.1185)	-0.0584 (-0.1818)
Top1	-0.2213 (-0.5733)	-0.2025 (-0.5233)
RD	0.0621*** (3.8240)	0.0624*** (3.8720)
Disclosure	0.2976* (1.7692)	0.2864* (1.6819)
Constant	-10.1353*** (-9.2979)	-10.0843*** (-9.5599)
Year	Control	Control
Industry	Control	Control
Observations	2,355	2,355
Pseudo R ²	0.1159	0.1178

The *T* value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

perceptions on corporate green innovation, we used the SA index to measure the level of financing constraints of firms and re-tested the sample by grouping them at the median of the SA index. Table 10 reports the regression results after grouping by the mean value of financing constraints. The results in columns (2) and (4) show that the regression coefficients for the proportion of ESG disclosure by executive microblogs (ESG_Ratio) and the degree of disclosure (ESG_LN) were 0.030 and 0.022 and significant at the 1 and 5% test levels, respectively. Thus, the findings in Table 10 suggest that the impact of executive ESG perceptions on corporate green innovation is mainly found in firms with low financing constraints.

Regional marketization process

When companies engage in green innovation, it is difficult to keep the pace and level of development of different companies synchronized, and there can be priorities or lags depending on various factors. There are differences in the level of social responsibility and technological innovation between firms in different marketization regions. Studies have shown that the degree of marketization has an impact on the level of social responsibility and innovation commitment of firms. Following Fang (2011), we used the regional marketization index score to measure the regional marketization process and used the median of the sample as the basis for grouping the regional marketization process.

Table 11 reports the results of regressions that grouped the means of the regional marketization process. A high marketization process was conducive to firm innovation in those regions. Our results from this grouped regression also mirror the above findings. The results in

TABLE 8 Executives' ESG cognition and green inventions.

Variables	(1)	(2)	(3)	(4)
	Green_Invention	Green_Invention	Green utility	Green utility
ESG Ratio	0.0038 (1.1737)		0.0096*** (3.4524)	
ESG_LN		0.0533** (2.0978)		0.0481** (2.4260)
SOE	-0.1624 (-0.9205)	-0.1513 (-0.8635)	-0.1546 (-1.0314)	-0.1551 (-1.0336)
ROA	3.8589*** (2.7202)	3.6627** (2.5643)	3.9749*** (2.9416)	3.8875*** (2.9065)
LEV	1.7717*** (3.4398)	1.6822*** (3.2921)	1.4218*** (3.6634)	1.3723*** (3.6063)
SIZE	1.2073*** (8.2668)	1.1930*** (8.4546)	0.8058*** (6.0498)	0.8049*** (6.1347)
AGE	0.0066 (0.0213)	-0.0306 (-0.0979)	-0.1775 (-0.7416)	-0.2084 (-0.8463)
Board	-0.2080 (-0.4730)	-0.2516 (-0.5791)	-0.0415 (-0.1272)	-0.0621 (-0.1896)
Top1	-0.3205 (-0.6618)	-0.2890 (-0.5922)	-0.3908 (-0.8543)	-0.3733 (-0.8216)
RD	0.0980*** (4.6677)	0.0972*** (4.6847)	0.0540*** (3.3550)	0.0550*** (3.4282)
Disclosure	0.4400* (1.9114)	0.4243* (1.8130)	0.2175 (1.1304)	0.2064 (1.0545)
Constant	-15.6772*** (-9.7139)	-15.4972*** (-9.9338)	-9.7628*** (-8.1247)	-9.7687*** (-8.3240)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	2,355	2,355	2,355	2,355
Pseudo R ²	0.1392	0.1419	0.1290	0.1313

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

columns (1) and (3) show that the regression coefficients for the proportion of ESG disclosure by executive microbloggers (ESG_Ratio) and the degree of disclosure (ESG_LN) were 0.026 and 0.022 respectively, both significant at the 1% test level. This suggests that in regions with a higher marketization process, an increase in ESG awareness among executives would be more conducive to an increase in the level of corporate innovation.

Conclusion and discussion

According to cognitive theory, the behavior of corporate executives is governed and influenced by their cognition. On this basis, executive ESG cognition has a guiding effect on corporate green innovation behavior. Based on data from personal microblogs of executives of Chinese listed companies, we used text analysis to construct quantitative indicators of ESG perceptions of

TABLE 9 Industry heterogeneity analysis.

Variables	(1)	(2)	(3)	(4)
	Heavy pollution	Nonheavy pollution	Heavy pollution	Nonheavy pollution
ESG Ratio	-0.0050 (-0.4130)	0.0286*** (3.2027)		
ESG_LN			-0.0039 (-0.5082)	0.0359*** (3.1981)
SOE	-0.0013 (-0.0296)	-0.1954*** (-2.9374)	-0.0007 (-0.0156)	-0.1935*** (-2.9065)
ROA	1.5859*** (3.6976)	1.4240* (1.8616)	1.5755*** (3.6785)	1.3104* (1.7085)
LEV	0.3456*** (2.7920)	0.6724*** (3.5593)	0.3466*** (2.7991)	0.6536*** (3.4568)
SIZE	0.2162*** (4.8676)	0.9918*** (14.4688)	0.2175*** (4.8901)	0.9929*** (14.4901)
AGE	-0.2081*** (-3.6003)	0.0926 (1.2502)	-0.2080*** (-3.5985)	0.0771 (1.0385)
Board	0.1695* (1.7722)	-0.0833 (-0.5479)	0.1711* (1.7891)	-0.0775 (-0.5097)
Top1	0.2474* (1.9141)	-0.4180** (-2.1391)	0.2438* (1.8836)	-0.4124** (-2.1105)
RD	0.0057 (0.6773)	0.0406*** (5.7517)	0.0060 (0.7129)	0.0421*** (5.9572)
Disclosure	0.0160 (0.2387)	0.2383** (2.3641)	0.0168 (0.2503)	0.2346** (2.3270)
Constant	-2.2570*** (-5.0634)	-9.0604*** (-13.2073)	-2.2637*** (-5.0786)	-9.1377*** (-13.3505)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	1,018	1,337	1,018	1,337
Adj_R ²	0.1047	0.2544	0.1047	0.2544
p value		0.0014		0.0428

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

company executives. Further, using data from Chinese listed manufacturing companies, we empirically investigated the impact of executive ESG perceptions on corporate green innovation. The findings show that executive ESG perceptions significantly improve the level of corporate green innovation. Moreover, the findings of this paper still held after the endogeneity issue was addressed through a series of robustness tests. Further research found that the enhancing effect of executive ESG perception on the level of corporate green innovation was mainly found in the sample without heavy pollution and with lower financing constraints and a higher marketization process.

The research in this paper incorporates the cognitive factors of corporate executives into the study of corporate green innovation, further enriching and extending the study of the economic consequences of cognitive theory on corporate

TABLE 10 Financing constraints heterogeneity analysis.

Variables	(1)	(2)	(3)	(4)
	Higher financing constraint	Lower financing constraint	Higher financing constraint	Lower financing constraint
ESG Ratio	0.0051 (0.2338)	0.0296*** (3.8050)		
ESG_LN			0.0313*** (2.7757)	0.0215** (2.1840)
SOE	0.0309 (0.5632)	-0.3165*** (-4.3781)	0.0384 (0.7019)	-0.3330*** (-4.5967)
ROA	0.8465 (1.3353)	2.3177*** (3.4721)	0.8366 (1.3243)	2.3620*** (3.5209)
LEV	0.5801*** (3.4307)	0.5502*** (3.0708)	0.5554*** (3.2967)	0.5432*** (3.0177)
SIZE	0.4211*** (6.2529)	0.7988*** (13.1642)	0.4058*** (6.0276)	0.8095*** (13.3111)
AGE	0.2236* (1.8390)	0.0922 (1.1745)	0.2132* (1.7618)	0.0918 (1.1621)
Board	-0.0293 (-0.2064)	0.0294 (0.2203)	-0.0459 (-0.3251)	0.0415 (0.3102)
Top1	-0.1409 (-0.7634)	-0.2342 (-1.3375)	-0.1208 (-0.6567)	-0.2243 (-1.2751)
RD	0.0387*** (4.7646)	0.0393*** (5.3600)	0.0383*** (4.7416)	0.0403*** (5.4759)
Disclosure	0.1951** (2.3148)	0.0283 (0.2697)	0.1873** (2.2293)	0.0240 (0.2278)
Constant	-5.4081*** (-5.2405)	-7.7835*** (-13.1648)	-5.2384*** (-5.0861)	-7.9484*** (-13.4307)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	1,106	1,249	1,106	1,249
Adj_R ²	0.1589	0.2827	0.1648	0.2771
p value		0.4795		0.6947

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

TABLE 11 Group regression analysis of regional marketization process.

Variables	(1)	(2)	(3)	(4)
	High marketization process	Low marketization process	High marketization process	Low marketization process
ESG Ratio	0.0261*** (3.4609)	-0.0196 (-0.5159)		
ESG_LN			0.0218*** (2.5857)	0.0010 (0.0767)
SOE	-0.0625 (-1.1575)	-0.0950* (-1.6603)	-0.0684 (-1.2645)	-0.0959* (-1.6754)
ROA	1.6124*** (2.9181)	0.9139 (1.4646)	1.5970*** (2.8804)	0.9473 (1.5115)
LEV	0.5148*** (3.5100)	0.3475** (2.0726)	0.5055*** (3.4380)	0.3445** (2.0548)
SIZE	0.8342*** (15.5100)	0.1922*** (3.4221)	0.8367*** (15.5259)	0.1944*** (3.4684)
AGE	0.0276 (0.4628)	-0.2368*** (-2.7751)	0.0232 (0.3877)	-0.2364*** (-2.7682)
Board	-0.1086 (-0.9347)	0.2709** (2.0561)	-0.1080 (-0.9276)	0.2753** (2.0930)
Top1	-0.3549** (-2.3913)	0.2156 (1.1103)	-0.3511** (-2.3623)	0.2014 (1.0462)
RD	0.0465*** (7.1102)	-0.0022 (-0.3177)	0.0466*** (7.1052)	-0.0022 (-0.3122)
Disclosure	0.1181 (1.4627)	0.1001 (1.2016)	0.1174 (1.4525)	0.0974 (1.1674)
Constant	-7.6800*** (-14.5916)	-2.1682*** (-3.3951)	-7.7367*** (-14.6945)	-2.2062*** (-3.4582)
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
N	1,877	478	1,877	478
Adj_R ²	0.2591	0.1347	0.2570	0.1342
p value		0.1324		0.3369

The T value calculated after misadjustment of clustering standard at company level is in brackets; *, ** and *** are significant at the significance level of 10, 5 and 1%, respectively. The following table is the same.

innovation behavior. It also further enriches the study of the influencing factors of corporate green innovation behavior from the perspective of managers' cognition. In addition to this, the findings of this paper have important practical implications for improving corporate green innovation. At the enterprise level, enterprises should follow the general trend of green development, continuously enhance their own green awareness, and actively implement various green behaviors to achieve the development goal of a win-win situation for both the economy and the environment. On the one hand, enterprises should strengthen their ability to perceive resource and environmental issues, enrich their resource and environmental knowledge, raise their awareness of resource conservation and environmental protection responsibilities, and cultivate senior management's awareness of green competitive advantages. ESG awareness is the spiritual source of green development and plays a vital role in enterprises' acquisition of green performance. Enterprises should focus on the implementation of green behaviors, actively engage in green technological innovation, green production and other environmentally friendly behaviors, actively seek green development resources, and plan and allocate them appropriately. Enterprises should also accurately grasp policy dividends and maximize government funding support to broaden the resource base for green behaviors. At the government level, various incentive policies should continue to be used to drive the green performance of enterprises. Governments should continue to strengthen environmental regulations through strict environmental regulatory instruments, promote the establishment of ESG concepts among corporate executives, enhance ESG awareness, raise corporate awareness of green development, and implement green innovation strategies. However, the excessive costs and risks of green production, governance, and innovation have led to a lack of incentive for companies to acquire green performance. The government therefore needs to further improve various incentive policies by providing innovation subsidies and tax breaks for companies, which in turn will enhance their incentive to produce and innovate in a green way. The government should continue to strengthen market supervision, promote green consumption behavior, and boost the market's awareness of the green development of enterprises, forming a mutual push between the green development of enterprises and the market.

This paper had some limitations that must be acknowledged. First, as this paper only selected companies in the manufacturing industry, where environmental pollution is a prominent issue and where executives have personal microblogs, the sample size was relatively small. Second, although this paper draws on existing research to define executive ESG perceptions, due to the subjective

nature of the textual analysis and the extent of information disclosure on Weibo, the measurement of executive ESG perceptions may have inevitably been biased, and a more scientific measurement method should be adopted in the future in order to improve the reliability of research findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

DW, YL, SH, and QY have made important contributions. DW, YL, and SH involved in the idea construction of the paper, the data analysis and the first draft. QY involved in the data collected, the data analysis and the first draft. All authors contributed to the article and approved the submitted version.

Funding

YL acknowledges financial support from the National Natural Science Foundation of China (grant number: 72002043). Shiyang Hu acknowledges financial support from the National Natural Science Foundation of China (grant numbers: 72272018 and 71802029) and the Fundamental Research Funds for the Central Universities (grant number: 2022CDJSKJC13).

Conflict of interest

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 28 September 2022

ACCEPTED 15 November 2022

PUBLISHED 06 December 2022

CITATION

Jin H, Yang J and Chen Y (2022) Energy
saving and emission reduction fiscal policy
and corporate green technology
innovation.
Front. Psychol. 13:1056038.
doi: 10.3389/fpsyg.2022.1056038

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Energy saving and emission reduction fiscal policy and corporate green technology innovation

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With the increasing prominence of resource and environmental issues, countries around the world are paying more and more attention to the concept of sustainable development. Under this concept, China started to implement a pilot project of “National Comprehensive Demonstration City of Energy Saving and Emission Reduction Fiscal Policy” in 2011 to protect resources and environment through green and low-carbon development. This paper aims to investigate whether and how the pilot policy induces corporate green technology innovation. Based on the data on Chinese listed firms from 2008 to 2019 and the relevant theories of economics, management and organizational psychology, we find that the pilot policy can promote corporate green technology innovation. This indicates that the pilot policy, as an external force, will encourage firms to improve their adaptability through green technology innovation which is one type of organizational change, thus improving their organizational effectiveness. The heterogeneity analyses reveal that the promotion effect of the pilot policy on green innovation is stronger among firms in high-carbon industries, firms in the mature stage and firms that are not state-owned. The mechanism tests find that the credit allocation effect and innovation compensation effect generated by the pilot policy are the key channels to promote green technology innovation. In addition to enriching the research on the evaluation of the effects of the pilot policy, our paper also expands the literature on organizational psychology and organizational change from the perspective of corporate green innovation, offers practical implications for the low-carbon transition of manufacturing industries under the emission peak and carbon neutrality targets, and provides insights for other emerging economies to achieve better resource and environmental protection through the energy saving and emission reduction fiscal policy.

KEYWORDS

energy saving and emission reduction fiscal policy, green technology innovation, organizational change, organizational effectiveness, sustainable development

Introduction

Nowadays, resource and environmental problems are becoming increasingly serious, posing a critical challenge to the sustainable development of mankind. In 1987, the World Commission on Environment and Development (WCED) first raised the concept of sustainable development, emphasizing the importance of reconciling economic development with resource conservation and environmental protection. Since then, countries around the world have gradually incorporated the concept of sustainable development into their plans. As latecomers of economic development, emerging economies find it difficult to balance the protection of resources and the environment while pursuing economic development. In order to save resources and protect the environment, governments usually implement environmental policies to solve the problems of resources and the environment. Enterprises are modern forms of organizations that aim at profitability, and they constantly exchange materials, energy and information with the external environment in order to constantly reform and develop (Schein, 2011). On the one hand, strict environmental regulations increase the cost of pollution control for enterprises, which may become an external pressure for organizational change and is not conducive to enterprise competitiveness; on the other hand, it may also force enterprises to carry out organizational innovation and management innovation, which becomes an external incentive for organizational change and enhances enterprise competitiveness. Therefore, it is of theoretical and practical significance to study how emerging economies can achieve sustainable development through environmental policies.

The traditional neoclassical view is that while environmental regulations can solve pollution problems, it can also increase firms' production costs and reduce profitability, leading to a decline in firm productivity and economic performance (Barbera and McConnell, 1990; Jorgenson and Wilcoxon, 1990). In the 1990s, Porter and Linde (1995) argued that from a dynamic point of view, environmental regulations can stimulate technological and organizational innovation and promote rational allocation of production resources, thus generating an "innovation compensation effect" that can compensate for the cost of regulations, which is known as the "Porter hypothesis." Since then, scholars have developed a rich verification around the Porter hypothesis (Gray and Shadbegian, 2003; Wagner, 2005; Hamamoto, 2006; Kneller and Manderson, 2012; Bergek and Berggren, 2014; Wang and Liu, 2014). Currently, a growing literature supports the Porter hypothesis and suggests that technological innovation is the key to improving energy efficiency, environmental protection and green development (Chakraborty and Chatterjee, 2017; Xu and Cui, 2020; Xu et al., 2022). However, financial bottlenecks are a major obstacle to green technology innovation in enterprises. Organizational psychology argues that companies need to overcome psychological inertia, improve psychological tolerance and psychological adaptability when undertaking organizational changes like innovation (Christensen

and Bower, 1996; Rindova et al., 2010). Innovation is characterized by high cost, high risk, and uncertain payback period. Given the high risk and investments in green technology innovation projects, whether a company chooses to invest in green technology innovation depends on the management's motivation and willingness to innovate. If the management is in a good frame of mind regarding expected future returns but lacks financial support, then it is likely that the management will not choose green technology innovation activities. Therefore, financial bottlenecks are a major impediment to corporate green technology innovation, which makes compensation mechanisms for green technology innovation by financial institutions and capital markets increasingly important (Bento and Fontes, 2015). Expanding capital markets and broadening financing channels are necessary guarantees for green cycles and sustainable development in emerging economies (Zeng et al., 2017).

Since the implementation of the Reform and Opening up Policy, China has achieved rapid development and become the world's second largest economy and one of the typical representatives of emerging economies. In order to promote its own enterprises to establish a green, recycling, low-carbon development concept and to give full play to the green fiscal funds to guide the role of energy saving and emission reduction, in 2011, the National Development and Reform Commission of the People's Republic of China issued the Notice on Comprehensive Demonstration of Energy Saving and Emission Reduction Fiscal Policy, setting six objectives which include the achievement of industrial low-carbonization, reduction of major pollutants, and scaling up of renewable energy use, and subsequently further expanding the scope of the pilot project. However, there are a very few existing studies evaluating the effects of this policy. At present, only Lin and Zhu (2019) and Xu et al. (2022), from the macro perspective of urban eco-efficiency and carbon emissions, have evaluated the carbon emission reduction effects and sustainable development effects of the energy saving and emission reduction fiscal policy. However, the existing research lacks empirical evidence from micro enterprises level. Therefore, based on the perspective of green technology innovation of enterprises, this paper adopts the difference-in-differences (DID) method to systematically evaluate the energy saving and emission reduction fiscal policy and tries to answer the following questions: First, can the policy promote corporate green technology innovation? Second, is there a Porter effect? If there is, what is the mechanism by which the pilot policy promotes green technology innovation in enterprises? Lastly, are there any variations in policy effects in different regions, industries and for different types of enterprises? The answers to the above questions can not only enrich and complement the research in areas related to the Porter hypothesis, but also provide empirical support for emerging economies to guide the green and low-carbon transition of enterprises through green fiscal policies.

Therefore, our paper takes the pilot construction of National Comprehensive Demonstration City of Energy Saving and Emission Reduction Fiscal Policy implemented and gradually

promoted in China since 2011 as the entry point, manually screens out green patent data of Chinese A-share listed companies from 2008 to 2019 based on the Green List of International Patent Classification launched by WIPO and the international patent classification numbers. Based on this data and the relevant theories of economics, management and organizational psychology, we systematically explore the green technology innovation effect of China's energy saving and emission reduction fiscal policy. We find that the pilot policy can induce corporate green technology innovation. This suggests that as the government and other stakeholders pay more attention to environmental protection, the pilot policy, as an external force, will promote firms to improve their adaptability through green technology innovation which is one type of organizational change, thus improving their organizational effectiveness. Furthermore, the green technology innovation effect of the policy starts to appear in the fourth year after the construction of the demonstration city and gradually increases year by year. The mechanism analyses show that the pilot policy promotes corporate green technology innovation mainly through the funding allocation effect and innovation compensation effect. Moreover, the green technology innovation effect of the policy has obvious industry and enterprise heterogeneity, and the induced effect of green technology innovation is more pronounced when the enterprises are within high-carbon industries, when the enterprises are in mature stage, and when the enterprises are not state-owned.

Compared to previous studies, our paper makes several contributions. First, based on the relevant theories of economics, management and organizational psychology, our paper examines the implementation effects of the energy saving and emission reduction fiscal policy from the perspective of corporate green technology innovation for the first time, providing empirical evidence at the micro-firm level for the research in this area, thus enriching the study of the economic consequences of the energy saving and emission reduction fiscal policy. Second, our study documents that the energy saving and emission reduction fiscal policy can alleviate the psychological barriers faced by the management in making organizational change (i.e., corporate green innovation) through the funding allocation effect, which extends the literature on organizational psychology and organizational change from the perspective of corporate green innovation. Third, the in-depth research on the differential impacts of enterprise ownership, enterprise life cycle and industrial characteristics on inducing green technology innovation will provide directions for the orderly promotion and precise implementation of the pilot policy in the future. Fourth, our paper provides empirical evidence from emerging economies for the studies related to the Porter hypothesis, which provides a useful addition to this field. At last, this study could also provide useful insights for other emerging economies to guide the green and low-carbon transition of enterprises through green fiscal policies.

The rest of our paper is arranged as follows: the second part introduces the policy background, the third part presents the related literature and hypothesis development, the fourth part

introduces the research design of our study, the fifth part shows the empirical results of the benchmark analysis, the sixth part further examines the mechanism and heterogeneity of the pilot policy inducing green technology innovation, and the last part contains conclusions and policy implications.

Policy background

In order to establish the concept of green, recycling and low-carbon development, accelerate the construction of energy saving and emission reduction work led by the government, dominated by enterprises, effectively driven by the market and participated by the whole society, in June 2011, the Ministry of Finance and the Development and Reform Commission jointly issued the Notice on the Comprehensive Demonstration of Energy Saving and Emission Reduction Fiscal Policy, which identifies eight cities (e.g., Beijing, Hangzhou, Shenzhen, Chongqing, etc.) to take the lead in launching comprehensive pilot for the energy saving and emission reduction fiscal policy.

In October 2013, the second batch of comprehensive demonstration cities were added, including Shijiazhuang, Tangshan City, Qiqihaer City, Tongling City, and so on; in 2014, 12 new cities (e.g., Urumqi City, Tianjin, Linfen City, Xuzhou City, Liaocheng City, etc.) were added as the third batch of comprehensive demonstration cities. These three batches of cities cover 27 provinces in China, and each city has its own characteristics in terms of economic development, industrial structure, resource endowment and environmental carrying capacity, which can reflect the differentiation and representativeness of the demonstration cities.

The policy explicitly states that the construction of demonstration city needs to complete six tasks, the main one of which is to achieve industrial low-carbonization. It also requires to ① Eliminate backward production capacity and equipment, support key enterprises to implement energy-saving technology transformation, and vigorously promote the application of advanced energy-saving and environmental protection technologies and equipment; ② Improve the threshold of access to high-energy-consuming and high-emission industries and the level of energy consumption limits for major energy-consuming products; ③ Accelerate the development of strategic emerging industries and advanced service industries, and optimize the industrial structure. In specific practice, the demonstration city construction promotes the low-carbon transformation of the city by means of financial funding guidance. During the demonstration period, the central government will give financial incentives to the typical demonstration projects declared and filed by the demonstration cities, from which the municipalities directly under the central government, provincial capitals and other cities will be awarded 600, 500, and 400 million yuan of green financial funds per year, respectively. The demonstration cities decide how to use the comprehensive incentive funds, and the central

government will only be responsible for the record management of the relevant projects.

Literature review and research hypothesis

Literature review

The relationship between environmental regulations and technological innovation has always been a research hotspot in the field of environmental economics. This paper presents a literature review from two aspects: the impact of environmental regulations on green technology innovation and the research related to energy saving and emission reduction policies.

The research on green innovation originated in the 1990s, most of which mainly refers to green technology innovation. The definition of green technology innovation usually varies according to the research topic. [Rennings \(2000\)](#) defines green technology innovation as a series of value creation activities that can generate new products or new processes, and contributes to reducing environmental burdens and achieving ecological sustainability purposes. The green technology innovation defined by the World Intellectual Property Organization (WIPO) covers the widest range, including environmentally relevant pollutant disposal and technologies related to climate change mitigation, and contains the patent classification numbers of all related technologies. Regarding the impact of environmental policies on green technology innovation, the existing research mainly focuses on the Porter hypothesis. Based on theoretical analyses and case studies, [Porter and Linde \(1995\)](#) believe that designing reasonable environmental regulations can help promote corporate technological innovation and organizational innovation, which will not only improve environmental performance, but also partially, sometimes even completely offset the additional regulatory costs. [Jaffe and Palmer \(1997\)](#) first distinguish between the strong Porter hypothesis and the weak Porter hypothesis.

Currently, most studies support the weak Porter hypothesis. Using the cost of pollution control as a measure of the intensity of environmental regulations, [Hamamoto \(2006\)](#) empirically tests the impact of environmental regulations on technological innovation in manufacturing, and finds that the Porter effect does exist: the stronger the environmental regulation, the higher the level of innovation characterized by R&D expenditure. [Bergek and Berggren \(2014\)](#) argue that well-designed environmental regulations can force energy-intensive firms to engage in environmentally friendly green technology innovation activities. Some scholars also put forward the opposite view, arguing that the pressure of environmental regulations can adversely affect enterprises' production and operation, and thus inhibit their R&D innovation. For example, [Kneller and Manderson \(2012\)](#), using a sample of enterprises in United Kingdom manufacturing industry, find that environmental regulations lead to higher compliance costs for enterprises, which forces resources to shift from

traditional production to pollution control, resulting in some crowding-out effect on corporate investment in innovation. The cost of regulations is particularly pronounced in resource-intensive industries ([Gray and Shadbegian, 2003](#)).

The research on energy saving and emission reduction policies mainly includes two directions. Early literature uses the total emissions of pollutants and the rate of compliance with emission standards as measures of energy saving and emission reduction by local governments to examine the impact of environmental regulations on efficiency gains or productivity growth of enterprises ([Domazlicky and Weber, 2004](#)). Such indicators equate the results of pollution control with environmental regulation itself, which leads to a serious endogeneity between environmental regulations and pollution control. Therefore, it cannot be simply assumed that the intensity of environmental regulations is high if the pollutant emissions are low or the compliance rate is high. [Johnstone et al. \(2010\)](#) and [Chakraborty and Chatterjee \(2017\)](#) examine the impact of renewable energy policies on firms' patent applications and R&D investment from a patent perspective, but they fail to strictly distinguish between green technology innovation and other non-environmental technology innovation. In recent years, most of the literature adopts demonstration policies to examine the environmental and economic effects of energy saving and carbon reduction policy with the help of causal inference methods. Using the establishment of a national comprehensive demonstration city for energy saving and emission reduction fiscal policy as a quasi-experiment, [Lin and Zhu \(2019\)](#) construct a DID model to examine the impact of the policy on urban sustainable development. The results show that the eco-efficiency of Chinese cities has been effectively improved during the implementation period of the policy, but there is a time lag of at least 3 years for the policy effects. In the context of China's emission peak and carbon neutrality targets, [Xu et al. \(2022\)](#) construct a DID model using the energy saving and emission reduction fiscal policy to examine the impact of the policy on carbon emission reduction in 284 cities in China. They find that the policy significantly reduces urban CO₂ emissions. [Xu and Cui \(2020\)](#) shift their research perspective from the mid-macro level to the firm level and investigate the impact of China's low-carbon city pilot policy on corporate green technology innovation using a DID method. The results show that China's low-carbon city pilot policy can induce corporate green technology innovation to a certain extent, especially for high carbon emission industries and non-state enterprises.

Research hypothesis

According to organizational psychology theory ([Schein, 2011](#)), as an important organization, a company consists of many interacting, interdependent and mutually influencing subsystems. Therefore, when making organizational change in a company (e.g., green technology innovation), it is essential to take the individual changes of key members as the starting point and the important

intermediary (Schein, 2011), especially to overcome the psychological barriers of the management which includes changing its attitudes and values (Gioia and Chittipeddi, 1991), eliminating potential threats, overcoming psychological inertia, and improving psychological tolerance and psychological adaptability (Christensen and Bower, 1996; Rindova et al., 2010). Unlike conventional production operations and general investment, corporate green technology innovation is a change characterized by high investment, high cost and high risk, which constitutes a major psychological barrier to the management in carrying out corporate green technology innovation and thus affects managers' motivation for conducting corporate green technology innovation. Without sufficient motivations, organizational change will not happen (Schein, 2011). Therefore, how to overcome the psychological barriers of the management and motivate the management to carry out corporate green technology innovation becomes the core issue for the green technology innovation of companies.

Energy saving and emission reduction fiscal policy can alleviate the psychological barriers faced by the management in making corporate green technology innovation through the funding allocation effect which includes credit support and government subsidies, and thus promotes firms' green technology innovation. On the one hand, the central government will give comprehensive financial incentives to the demonstration cities included in the assessment of energy saving and emission reduction through financial allocation. Moreover, the central government also provides an extra 20% incentives for the cities that have achieved their energy saving and emission reduction targets and gained excellent assessment results. This provides sufficient incentives for the enterprises in the demonstration cities to conduct green technology innovation.

On the other hand, the financial funds like credit support and government subsidies can alleviate corporate financial constraints, which will greatly mitigate the management's concerns about decisions of green technology innovation and overcome the psychological barriers of the management when conducting green technology innovation. Under the guidance of green financial funds, the firms in the demonstration cities can obtain finance support more easily and thus may have a stronger motivation to conduct green technology innovation. Therefore, we expect that the energy saving and emission reduction fiscal policy will provide a new financing channel for firms in the demonstration cities, and thus have a positive impact on the firms' green technology innovation. We hence propose our first hypothesis as follows:

Hypothesis 1: Energy saving and emission reduction fiscal policy will promote firms' green technology innovation.

Whether a firm carries out innovation after obtaining financial funds depends on two considerations. On the one hand, well-designed environmental policies can generate a Porter effect, which helps to motivate enterprises to increase their R&D investment (Porter and Linde, 1995). In the process of building

demonstration cities, local governments use both financial incentives and target constraints to jointly promote energy saving and emission reduction within the demonstration cities. If the policy is well designed, this combination of policy tools will encourage enterprises to increase their R&D investment. In addition, the demonstration cities also set up special funds for energy saving and emission reduction to encourage enterprises to carry out low-carbon technology research and development through direct incentives and other means.

On the other hand, if enterprises only choose to purchase large-scale emission reduction equipment rather than independent research and development after obtaining fiscal support, such inefficient investment will lead to a failure of the fiscal policy. Jin et al. (2022) empirically evaluate the policy effect of China Green Finance Reform and Innovation Pilot Zone and find that although the establishment of the pilot zone increases the credit funds of non-heavily polluting enterprises, it fails to promote their green technology innovation, because enterprises would choose policy arbitrage in order to obtain more green credit. Similarly, if the assessment and supervision mechanisms in the demonstration cities are not in place, the green funds of enterprises may shift from productive areas to non-productive activities, thus crowding out their R&D investment. Therefore, it is uncertain whether enterprises invest in R&D activities after obtaining fiscal support. We hence propose that:

Hypothesis 2a: Energy saving and emission reduction fiscal policy promotes firms' green technology innovation through R&D innovation compensation effect.

Hypothesis 2b: Energy saving and emission reduction fiscal policy fails to produce innovation compensation effect, which is detrimental to firms' green technology innovation.

Research design

Sample and data

The initial sample in our paper includes all the listed companies in manufacturing industry from 2008 to 2019. Firms with missing data and firms receiving a Special Treatment status are excluded. The data used in our paper include three categories. First, the financial data at the enterprise level are obtained from the China Securities Market and Accounting Research database (CSMAR). Second, the city-level data are from the China City Statistical Yearbook and the Economy Prediction System (EPS) database. Third, we manually collect corporate green patents based on the Green List of International Patent Classification issued by the World Intellectual Property Organization (WIPO) and the names of listed companies. Moreover, in order to further reflect the types and value of green patents, we divide green patents into green

invention patents and green utility patents. At last, all continuous variables are winsorized at the first and 99th percentiles.

Indicator construction

The purpose of our research is to examine the effect of the energy saving and emission reduction fiscal policy on firms' green technology innovation. Using the International Patent Classification (IPC) numbers in the Green List of International Patent Classification issued by the WIPO and the names of listed firms as keywords, we manually collect firms' green patents from the official website of the State Intellectual Property Office. The number of green patent applications is used as a proxy for corporate green technology innovation. We use firms' green patent applications as the dependent variable for the following two reasons: Firstly, compared to R&D inputs, patents may more naturally reflect the outputs of firms' green technology innovation activities, and they have a clear technical categorization which can reflect the value and contributions of innovation activities; Secondly, considering the long time taken from patent application to grant, using patent application data may assess the impact of the energy saving and emission reduction fiscal policy on green technology innovation in a more effective way. Following Xu and Cui (2020), we exclude the missing values (*Null*) of green patent data, and only keep the green patent data of enterprises with application records in the current year. We use three indicators, total green patents (*EnvirPat*), green invention patents (*EnvirInvPat*) and green utility patents (*EnvirUtyPat*), to measure green patent applications and take logarithms of them.¹ In the robustness test, we also use the number of green patents granted (*PatGrant*), the number of green invention patents granted (*InvPatGrant*) and the number of green utility patents granted (*UtyPatGrant*) as alternative measures to ensure the reliability of the regression results.

In addition, we control for other factors that may influence firms' green technology innovation. ① The scale of the firm (*scale*), which is an important factor influencing firm innovation (Bu et al., 2020). The larger the firm, the more likely it is to have sufficient funds to conduct green technology innovation activities. We use the logarithm of total assets at the end of the year to measure *scale*. ② Leverage ratio (*lev*). The more leveraged the firm is, the greater its debt risk tends to be, which is not conducive to green technology innovation. Therefore, we use the ratio of a firm's total liabilities to total assets at the end of the year to measure *lev*. ③ The older the firm, the more mature and conservative the firm might be, which may lead the firm to make only minor modifications to their original technologies and products rather than invest more in green technology innovation (Kueng et al., 2014). Hence,

1 Note: In order to avoid the influence of zero value, the number of the three kinds of patent applications are processed by adding one and then taking the logarithm.

we control for *age* in our model. The indicator *age* is computed as the natural logarithm of the firm's age. ④ The ratio of fixed assets (*fixasset*) is measured as the ratio of net fixed assets to total assets. The higher the ratio, the more difficult it may be for companies to transform and innovate green. ⑤ Management shareholding ratio (*share*) is computed as the ratio of management shareholding to total shareholding. ⑥ Tobin's Q (*tobinQ*). We use the sum of the market value of shareholders' equity and the book value of liabilities divided by the book value of total assets at year-end and then take the logarithm to measure *tobinQ*. ⑦ Two positions in one (*one*). The indicator *one* takes the value of 1 if the chairman and the Chief Executive Officer (CEO) are the same person, and 0 otherwise. Table 1 shows the descriptive statistics of the main variables.

Empirical model

In order to examine the impact of the energy saving and emission reduction fiscal policy on corporate green technology innovation, we use the establishment of National Comprehensive Demonstration City of Energy Saving and Emission Reduction Fiscal Policy as a quasi-experiment and construct an asymptotic difference-in-differences (DID) model for causal identification. The specific model is as follows:

$$EnvirPat_{ict} = \alpha_0 + \alpha_1 DID_{ct} + X_{ict}'\theta + p_i + q_t + s_{pt} + \varepsilon_{ict} \quad (1)$$

where *i*, *c*, *p*, and *t* represents the firm, city, province and year, respectively. *EnvirPat_{ict}* denotes the number of green patents filed in year *t* by a listed company *i* within city *c*. *DID_{ct}* equals one if city *c* is selected as a comprehensive demonstration city for the energy saving and emission reduction fiscal policy in year *t*, and zero

TABLE 1 Descriptive statistics.

Variables	N	Mean	S.D.	Min	Max
<i>EnvirPat</i>	16,873	0.320	0.760	0.000	6.440
<i>EnvirInvPat</i>	16,873	0.220	0.610	0.000	6.110
<i>EnvirUtyPat</i>	16,873	0.190	0.540	0.000	5.350
<i>PatGrant</i>	14,893	0.270	0.660	0.000	5.600
<i>InvPatGrant</i>	14,893	0.120	0.420	0.000	4.680
<i>UtyPatGrant</i>	14,893	0.200	0.560	0.000	5.140
<i>DID</i>	16,873	0.210	0.400	0.000	0.937
<i>scale</i>	16,873	21.85	1.200	19.32	26.06
<i>lev</i>	16,873	0.400	0.200	0.050	0.970
<i>age</i>	16,868	2.760	0.340	1.790	3.500
<i>fixasset</i>	16,873	0.240	0.140	0.001	0.730
<i>share</i>	16,424	0.160	0.220	0.000	0.690
<i>tobinQ</i>	16,301	0.600	0.460	-0.120	2.100
<i>one</i>	16,715	0.300	0.460	0.000	1.000

N indicates the number of the sample observations. Mean, Min, and Max denote variables' mean value, minimum, and maximum, respectively. S.D. indicates the standard deviation of variables.

otherwise. X_{ict} denotes a set of control variables. p_i represents individual fixed effects. q_t indicates time fixed effects. s_{pt} represents joint fixed effects of provinces over time, and ε_{ict} denotes error term.

In the baseline analysis, we focus on the coefficient of DID_{ct} (α_1), which reflects the impact of the energy saving and emission reduction fiscal policy on the green patent applications of firms within the experimental group of cities. If α_1 is significantly positive, it means that the pilot policy helps to promote the green technology innovation of enterprises in the pilot area.

Results and analyses

Baseline regression results

Table 2 reports the regression results of the impact of the energy saving and emission reduction fiscal policy on corporate green technology innovation. We measure corporate green technology innovation using three indicators: the total number of green patent applications (*EnvirPat*), the number of green invention patent applications (*EnvirInvPat*), and the number of green utility model patent applications (*EnvirUtyPat*). In columns (1), (3), and (5), the results show that for *EnvirPat*, *EnvirInvPat*, and *EnvirUtyPat*, the coefficients of *DID* are all positive and significant at 1% level,

indicating that the pilot policy promotes corporate green technology innovation. The models in columns (2), (4), and (6) further incorporate corporate control variables as well as province fixed effects over time. The results show that the coefficient of *DID* is significantly positive only when the dependent variable is *EnvirPat*. This indicates that additional regional factors do affect corporate green technology innovation, so it is necessary to control for all three fixed effects simultaneously in the baseline model, which can more accurately capture the impact of the pilot policy. After excluding possible confounding factors, the pilot policy results in a significant increase in the number of green patent applications. However, the impact of the pilot policy on green invention patents and green utility patents is not significant. The possible reason is that the primary task of the pilot policy is to reduce carbon in industries, thus the induced effect of the pilot policy on corporate green technology innovation is limited at the overall level without differentiating the carbon attributes of industries. This will be verified in the subsequent heterogeneity analyses in our paper.

Parallel trend test

The premise of using the DID method for policy evaluation is that the experimental and control groups need to satisfy parallel

TABLE 2 The impact of the energy saving and emission reduction fiscal policy on corporate green technology innovation.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>EnvirPat</i>	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>	<i>EnvirUtyPat</i>
<i>DID</i>	0.0705*** (0.0144)	0.0386** (0.0192)	0.0563*** (0.0119)	0.0222 (0.0159)	0.0321*** (0.0103)	0.0056 (0.0140)
<i>scale</i>		0.2346*** (0.0066)		0.1943*** (0.0055)		0.1443*** (0.0048)
<i>lev</i>		0.0070 (0.0340)		-0.0037 (0.0280)		0.0151 (0.0247)
<i>age</i>		-0.1114*** (0.0199)		-0.0637*** (0.0164)		-0.1034*** (0.0145)
<i>fixasset</i>		-0.2343*** (0.0463)		-0.2679*** (0.0382)		-0.0611* (0.0337)
<i>share</i>		0.0163 (0.0309)		-0.0026 (0.0255)		0.0255 (0.0225)
<i>tobinQ</i>		0.0802*** (0.0164)		0.0764*** (0.0136)		0.0460*** (0.0120)
<i>one</i>		0.0368*** (0.0128)		0.0335*** (0.0106)		0.0291*** (0.0093)
<i>Constant</i>	0.3044*** (0.0063)	-4.5139*** (0.1562)	0.2088*** (0.0052)	-3.8440*** (0.1288)	0.1795*** (0.0045)	-2.7143*** (0.1138)
Individual	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Province × year	No	Yes	No	Yes	No	Yes
<i>R</i> ²	0.0965	0.2104	0.0741	0.1902	0.0898	0.1801
<i>N</i>	16,873	15,716	16,873	15,716	16,873	15,716

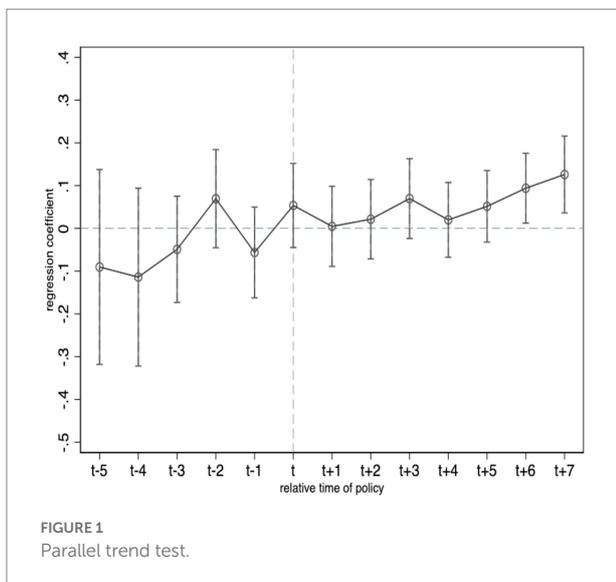
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

trends, which means that when the policy is not implemented, the trends of the green technology innovation of firms in the experimental cities and the control cities should remain parallel. To conduct a parallel trend test, we draw on Beck et al. (2010) and set up the following model:

$$EnvirPat_{ict} = \gamma + \sum_{k=-5}^{k=7} \beta_k \times D_{c,t+k} + X_{it}'\eta + p_i + q_t + s_{pt} + \varepsilon_{ict} \tag{2}$$

In Equation (2), $D_{c,t+k}$ refers to a set of dummy variables that denote the k th year of policy implementation starting in city c . Since the pilot cities were implemented in three batches in 2011, 2013, and 2014, respectively, the sample interval covers the 5 years before and 7 years after implementation. β_k in the model is the coefficient we focus on and indicates the difference between the experimental and control groups at the k th year of the policy start. If none of the coefficient of β_k is significant in the period of $k < 0$, it demonstrates that the experimental and control groups satisfy the parallel trend assumption. If the coefficient of β_k in the period of $k < 0$ are partially significant, it indicates that the experimental and control groups were significantly different before the policy was implemented and do not satisfy the common trend assumption.

Figure 1 illustrates the parallel trend test depicted with the total number of green patent applications as the dependent variable. We can see that, in the interval of $k < 0$, all estimated coefficients of β_k are not significant at the 95% confidence interval. And the values of the coefficients oscillate around 0, indicating that, prior to the implementation of the energy saving and emission reduction fiscal policy, there was no significant difference between the levels of the green technology innovation of firms in the experimental cities and the control cities. Starting from the fourth year after the policy's implementation, firms



within the experimental cities show an increase in green technology innovation year over year, indicating that there is at least a 3-year lag in the green technology innovation effect of the fiscal policy on energy conservation and emission reduction.

Placebo test

Another concern regarding the identification assumption of the DID method is the interference of other unobservable city characteristics that change over time on the estimation results. There are differences across cities in terms of resource endowment, institutional environment, customs and culture, etc. Although the identification in the preceding section has taken province fixed effects over time into account, it is not possible to control for some time-varying, unobservable characteristics at the city level. To address this problem, we conduct an indirect placebo test which has been widely used in the relevant literature (Chetty et al., 2009). First, the expression of the coefficient can be derived from the following equation:

$$\hat{\alpha}_1 = \alpha_1 + \delta \times \frac{\text{cov}(DID_{ct}, \varepsilon_{ict} | W)}{\text{var}(DID_{ct} | W)} \tag{3}$$

where W includes all other control variables and fixed effects, and δ is the effect of unobservable factors on the dependent variable. If $\delta = 0$, then unobservable factors do not affect the estimation results. It means that $\hat{\alpha}_1$ is proved to be unbiased, but this cannot be directly verified. Therefore, we perform an indirect placebo test, the logic of which is to find an error variable that would theoretically have no effect on the outcome variable to take the place of DID_{ct} . This variable is randomly generated. If this variable would actually have no effect on the results, then $\hat{\alpha}_1 = 0$. Conversely, then $\hat{\alpha}_1 \neq 0$.

Specifically, a “pseudo-policy dummy” is constructed by randomly selecting 27 cities out of 230 cities as the experimental group and the other cities as the control group, thereby generating a false coefficient of estimation. Since the “pseudo-experimental group” is randomly generated, the simulated policy dummy does not affect the dependent variable, and its wrong estimation coefficient should be close to 0. In our paper, 500 random samples are conducted. Figure 2 shows the significance and distribution of the estimated coefficients for the 500 random samples. The results show that the distribution of the “pseudo-policy dummy variables” is mostly concentrated around the zero point, and the corresponding p -values are higher than 0.1, consistent with the expectations of the placebo test.

Other robustness tests

Firstly, we choose the number of green patents granted ($PatGrant$), the number of green invention patents granted

(*InvPatGrant*) and the number of green utility patents granted (*UtyPatGrant*) as new dependent variables. The results in columns (1)–(3) in Table 3 show that, compared with the control group, the pilot policy leads to a significant increase in the number of green patents granted to the treatment group, among which, the impact on the number of green invention patents granted is significant, and the impact on the number of green utility patents granted is not significant.

Secondly, as the time of setting up the second batch of comprehensive demonstration cities for the energy saving and emission reduction fiscal policy was October 2013 and there may be a certain time lag from the introduction of the national policy to the implementation by local governments, the robustness test takes 2014 as the policy shock node for the second batch of pilot cities. The results in columns (4)–(6) in Table 3 show that the pilot policy still promotes corporate green patent applications at the 5% significance level and promotes corporate green invention patent applications at the 10% significance level, but the effect on green utility patent applications is insignificant.

Thirdly, in order to avoid potential sample self-selection problems, we further adopt the PSM-DID method for robustness testing. Since our sample size is sufficient, we choose a more stringent

caliper radius (0.0001) for matching in order to minimize the impact of “selectivity bias.” The results in columns (1)–(3) in Table 4 show that the energy conservation and emission reduction fiscal policy still promotes firms’ green patent applications at the 5% significance level, which remains consistent with the baseline results. In addition, due to the fact that the PSM method is highly dependent on the formal setting of the first-stage logistic model, Hainmueller (2012) proposes an Entropy Balancing method that does not depend on the setting of the first-stage logistic model. Therefore, we also use the Entropy Balancing method to conduct our robustness test. Columns (4)–(6) in Table 4 report the difference-in-differences estimates after matching through the Entropy Balancing method. The results show that the pilot policy can still significantly promote corporate green technology innovation, which further strengthens the robustness of the baseline results.

Finally, during the period of model city construction, some pilot cities may also be stimulated by other innovative policies, such as the low-carbon city pilot policy initiated by the National Development and Reform Commission (NDRC) in 2010. It has been shown that the low-carbon city pilot policy can significantly induce green technology innovation among high-carbon emitting firms (Xu and Cui, 2020). In addition, in October 2011, the NDRC issued the Notice on Piloting Carbon Emissions Trading, which formally approved seven provinces and cities to carry out pilot carbon trading. Such policies may also promote green technology innovation among enterprises. In order to exclude the interference of other confounding policies at the city level, we control for the above two types of policies separately. The results in Table 5 show that after controlling for the interference of other policies in the same period, the energy saving and emission reduction fiscal policy still significantly promotes the green patent applications of enterprises.

Additional analyses

Mechanism analyses

The above analyses show that the fiscal policy for energy efficiency and emission reduction can promote corporate green

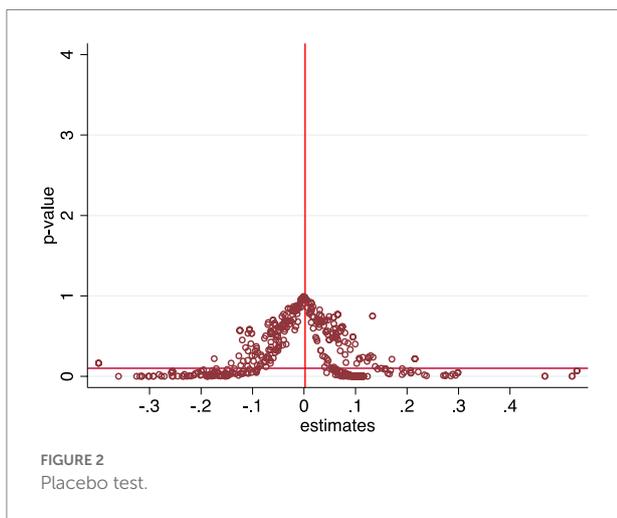


TABLE 3 Robustness tests: replacing core variables.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>PatGrant</i>	<i>InvPatGrant</i>	<i>UtyPatGrant</i>	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>
<i>DID</i>	0.0453** (0.0184)	0.0324*** (0.0122)	0.0040 (0.0158)	0.0419** (0.0194)	0.0264* (0.0160)	0.0070 (0.0141)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Individual</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Province × year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>R²</i>	0.2032	0.1430	0.1835	0.2104	0.1903	0.1801
<i>N</i>	13,794	13,794	13,794	15,716	15,716	15,716

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

TABLE 4 Robustness tests: Reducing selection bias.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>
<i>DID</i>	0.0396** (0.0192)	0.0227 (0.0159)	0.0063 (0.0140)	0.0386** (0.0192)	0.0222 (0.0159)	0.0056 (0.0140)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Individual	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Province × year	Yes	Yes	Yes	Yes	Yes	Yes
<i>R</i> ²	0.2108	0.1906	0.1803	0.2104	0.1902	0.1801
<i>N</i>	15,707	15,707	15,707	15,716	15,716	15,716

***, ** and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

TABLE 5 Robustness tests: excluding confounding policies.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>
<i>DID</i>	0.0386** (0.0192)	0.0222 (0.0159)	0.0056 (0.0140)	0.0370* (0.0195)	0.0200 (0.0161)	0.0061 (0.0142)
Carbon emissions trading	Yes	Yes	Yes	Yes	Yes	Yes
Low carbon city pilot				Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Individual	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Province × year	Yes	Yes	Yes	Yes	Yes	Yes
<i>R</i> ²	0.2104	0.1902	0.1801	0.2104	0.1902	0.1801
<i>N</i>	15,716	15,716	15,716	15,716	15,716	15,716

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

technology innovation, so what is the inherent transmission mechanism? In order to financially assist the transformation of the pilot cities to low-carbon cities, green fiscal policies have been implemented in these cities. For enterprises facing financial constraints within pilot cities, the relevant financial departments will provide them with incentive funds like credit support and government subsidies to ease their financial pressure during the process of technological transformation. We construct a difference-in-differences-in-differences (DDD) model based on equation (1) to examine the credit mechanism and the government subsidy mechanism generated by the pilot policy. The specific models are as follows:

$$\begin{aligned}
 \text{EnvirPat}_{ict} = & \gamma_0 + \gamma_1 \text{treat}_{ct} \times \text{time}_{ct} \times \text{loan}_{ct} \\
 & + \gamma_2 \text{treat}_{ct} \times \text{loan}_{ct} + \gamma_3 \text{time}_{ct} \times \text{loan}_{ct} \\
 & + \gamma_4 \text{treat}_{ct} \times \text{time}_{ct} + X_{ict}'\theta + p_i + q_t + s_{pt} + \varepsilon_{ict} \quad (4)
 \end{aligned}$$

$$\begin{aligned}
 \text{EnvirPat}_{ict} = & \gamma_0 + \gamma_1 \text{treat}_{ct} \times \text{time}_{ct} \times \text{sub}_{it} + \gamma_2 \text{treat}_{ct} \\
 & \times \text{sub}_{it} + \gamma_3 \text{time}_{ct} \times \text{sub}_{it} + \gamma_4 \text{treat}_{ct} \times \text{time}_{ct} \\
 & + X_{ict}'\zeta + p_i + q_t + s_{pt} + \varepsilon_{ict} \quad (5)
 \end{aligned}$$

In equation (4), (5), *treat_{ct}* denotes the policy grouping dummy variable, *time_{ct}* denotes the policy time dummy variable, *loan_{ct}* denotes the logarithm of the balance of all loans from financial institutions in the city *c* at the end of year *t*, and *sub_{it}* denotes the government subsidies received by firm *i* in year *t*. *sub_{it}* is computed as the natural logarithm of one plus the government subsidies received by enterprises. The results are shown in Table 6.

Columns (1)–(3) of Table 6 show the results of the credit mechanism test. It can be found that the coefficients of the interaction (*treat* × *time* × *loan*) are significantly positive, which indicates that the energy saving and emission reduction fiscal policy can promote corporate green technology innovation by increasing the overall loan balance at the city level. Columns (4)–(6) of Table 6 report the results of the government subsidy mechanism. The results show that the coefficients of the interaction (*treat* × *time* × *sub*) are all significantly positive at the 1% level, indicating that the pilot policy can promote enterprises' green technology innovation through the government subsidy mechanism. The results together suggest that the pilot policy does alleviate the psychological barriers faced by the management in making organizational change (i.e., corporate green innovation) through the credit mechanism and the government subsidy

mechanism, which enriches the literature on organizational psychology and organizational change from the perspective of corporate green innovation.

Another issue is whether enterprises in the demonstration cities decide to increase their R&D expenditures after getting credit support and government subsidies. It has been pointed out that after receiving credit support or government subsidies, firms are likely to use the funds either to increase R&D investment or to expand fixed asset investment (Qian et al., 2021). Therefore, we further test the innovation input mechanism generated by the pilot policy, which is modeled as follows:

$$\ln rd_{ict} = d_0 + d_1 DID_{ct} + X_{ict}' \rho + p_i + q_t + s_{pt} + \varepsilon_{ict} \quad (6)$$

$$tensity_{ict} = f_0 + f_1 DID_{ct} + X_{ict}' \varphi + p_i + q_t + s_{pt} + \varepsilon_{ict} \quad (7)$$

In Equations (6), (7), $\ln rd_{ict}$ denotes the logarithm of the R&D expenditure of firm i in year t , and $tensity_{ict}$ denotes the R&D intensity of firm i in year t . Here we use the ratio of the R&D expenditure of firm i to sales revenue to measure $tensity_{ict}$. Table 7 reports the results of the innovation input mechanism of the pilot policy. It can be found that the pilot policy increases the R&D intensity of firms, indicating that the energy saving and emission reduction fiscal policy promotes firms' green technology innovation through innovation compensation effect. Thus, hypothesis 2a is verified.

Heterogeneity analyses

Heterogeneity of enterprise

Different ownership types usually have different impacts on firms' R&D investment and technological innovation. To test whether ownership type will influence the effect of the pilot policy on corporate green technology innovation, we split the whole sample into two subsamples based on firms' ownership type, and re-estimate model (1) separately.

The results in Table 8 show that the pilot policy significantly promotes the green technology innovation of non-SOEs. The possible reason is that non-SOEs usually face credit discrimination in the capital market, and the energy conservation and emission reduction fiscal policy makes non-SOEs have stronger incentives to choose green technology innovation through the support of green special funds. On the contrary, SOEs are invested or controlled by the central government or local governments and have a great advantage in resource allocation, especially in obtaining financial support (Allen et al., 2005). With their political power, SOEs can not only acquire more financial funds, but also reduce the environmental pressure from regulations. Therefore, when faced with environmental constraints, SOEs are more likely to develop "innovation inertia."

Further, we also examine the impact of enterprise life cycle on the association between the pilot policy and corporate green technology innovation. We refer to the cash flow model of Dickinson (2011) and Liu et al. (2020) to classify the enterprise life cycle. The positive and negative combinations of three cash flow types (i.e., net cash flow from operating activities, net cash flow from investing activities, and net cash flow from financing

TABLE 6 Credit and Government Subsidy Mechanism Inspection.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>	<i>EnvirPat</i>	<i>EnvirInvPat</i>	<i>EnvirUtyPat</i>
<i>treat</i> × <i>time</i>	−0.7320*** (0.2620)	−0.6306*** (0.2161)	−0.2898 (0.1909)	−0.7964*** (0.1175)	−0.7525*** (0.0966)	−0.4403*** (0.0859)
<i>treat</i> × <i>loan</i>	−0.0013 (0.0022)	−0.0017 (0.0018)	−0.0012 (0.0016)			
<i>treat</i> × <i>time</i> × <i>loan</i>	0.0425*** (0.0141)	0.0366*** (0.0117)	0.0170* (0.0103)			
<i>treat</i> × <i>sub</i>				−0.0012 (0.0023)	−0.0017 (0.0019)	−0.0012 (0.0017)
<i>treat</i> × <i>time</i> × <i>sub</i>				0.0524*** (0.0075)	0.0491*** (0.0061)	0.0284*** (0.0055)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Individual	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Province × year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.2112	0.1911	0.1804	0.2115	0.1924	0.1810
N	15,698	15,698	15,698	15,129	15,129	15,129

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

activities) are used to reflect the business risk, profitability, and growth rate of enterprises in different life cycles.

The findings in Table 9 demonstrate that after controlling for all three fixed effects simultaneously, the pilot policy has a significant effect on the green technology innovation of mature firms, regardless of whether green patent applications or green invention patent applications are used as the dependent variable. The pilot policy also plays a role in promoting the green patent applications of growth firms, while it does not have any significant effect on the green technology innovation of declining firms. The reason may be as follows. On the one hand, growth firms are full of innovative energy but have insufficient R&D experience, so they are less likely to make successful green invention innovation which has higher technical difficulty. On the other hand, mature firms are becoming more sophisticated in their production model, constantly updating their organizational structure, and having a wide range of partners and interest groups in the market, so they have sufficient funds to purchase advanced emission equipment and carbon reduction facilities, and tend to invest in green innovation, especially in green invention innovation with greater innovation breakthrough and higher future income. However, declining firms are more likely to suffer from institutional rigidity, section redundancy and worsening financial conditions, which leads them to become more conservative and unwilling to invest in green innovation which is characterized by high investment, high cost and high risk (Kueng et al., 2014).

Heterogeneity of industry

The tasks of the energy saving and emission reduction fiscal policy include six aspects, the main one of which is to achieve industrial low-carbonization. The policy may be more beneficial for high-carbon industries because it places great emphasis on the low-carbonization of industrial structures. To examine whether the impact of the pilot policy on corporate green technology innovation differs between high-carbon and low-carbon

industries, we identify six industries as high-carbon industries² according to the Report on China's Carbon Emission Trading Report (2017). Table 10 reports the test results of the group regressions.

The results in Table 10 show that after controlling for the three fixed effects simultaneously, the pilot policy significantly promotes the green patent applications as well as green invention patent applications of firms in high-carbon industries, but it has no significant effect on the green technology innovation of firms in low-carbon industries. From the above analyses, it can be seen that there is significant industrial heterogeneity in the impact of the energy saving and emission reduction fiscal policy on corporate green technology innovation, and that the positive effect of the pilot policy on enterprises' green technology innovation in high-carbon industries is more significant than that in low-carbon industries.

Conclusions and policy Implications

Conclusions

Green technology innovation is an important force to promote the low-carbon development of industries. Using data from Chinese A-share listed firms in manufacturing industry from 2008 to 2019, we examine whether and how the energy saving and emission reduction fiscal policy affects firms' green technology innovation. Our paper finds that, firstly, the pilot policy significantly promotes corporate green technology innovation. This finding remains after we conduct a series of robustness checks, including placebo tests, using alternative measures of green technology innovation, and excluding confounding policies. Secondly, the effect of the pilot policy on corporate green technology innovation is heterogeneous at firm-level and industry-level. At the firm level, the positive effect of the pilot policy on green technology innovation is more pronounced in non-state-owned enterprises and mature enterprises. At the industry level, the pilot policy is more helpful to promote the green technology innovation of firms in high-carbon industries. Thirdly, credit support, government subsidies and enhanced innovation inputs are the key channels through which the pilot policy promotes corporate green technology innovation.

TABLE 7 Innovation input mechanism test.

	(1)	(2)
	<i>lnrd</i>	<i>tensity</i>
<i>DID</i>	0.1313 (0.2184)	0.0053*** (0.0016)
<i>Control variables</i>	Yes	Yes
<i>Individual</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>Province × year</i>	Yes	Yes
<i>R²</i>	0.4928	0.1742
<i>N</i>	10,122	10,122

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

2 Note: The specific high carbon emission industries in the text include: paper and paper products industry (C22), petroleum processing, coking and nuclear fuel processing industry (C25), chemical raw materials and chemical products manufacturing industry (C26), non-metallic mineral products industry (C30), ferrous metal smelting and rolling processing industry (C31), non-ferrous metal smelting and rolling processing industry (C32).

TABLE 8 The heterogeneity of enterprise ownership.

	<i>EnvirPat</i>		<i>EnvirInvPat</i>		<i>EnvirUtyPat</i>	
	<i>SOEs</i>	<i>Non-SOEs</i>	<i>SOEs</i>	<i>Non-SOEs</i>	<i>SOEs</i>	<i>Non-SOEs</i>
<i>DID</i>	-0.1138** (0.0505)	0.0837*** (0.0216)	-0.1235*** (0.0429)	0.0689*** (0.0174)	-0.0681* (0.0363)	0.0250 (0.0160)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Individual</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Province × year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>R²</i>	0.2751	0.2002	0.2544	0.1776	0.2531	0.1752
<i>N</i>	4,868	10,159	4,868	10,159	4,868	10,159

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

TABLE 9 The heterogeneity of enterprise life cycle.

	<i>EnvirPat</i>			<i>EnvirInvPat</i>			<i>EnvirUtyPat</i>		
	<i>Growth</i>	<i>Maturity</i>	<i>Decline</i>	<i>Growth</i>	<i>Maturity</i>	<i>Decline</i>	<i>Growth</i>	<i>Maturity</i>	<i>Decline</i>
<i>DID</i>	0.0636** (0.0293)	0.0961** (0.0439)	-0.0325 (0.0328)	0.0345 (0.0240)	0.0830** (0.0357)	-0.0361 (0.0275)	0.0313 (0.0214)	-0.0379 (0.0239)	0.0193 (0.0312)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Individual</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Province × year</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>R²</i>	0.2119	0.2748	0.2654	0.1978	0.2468	0.2466	0.1861	0.2389	0.2496
<i>N</i>	7,547	5,537	2,547	7,547	5,537	2,547	7,547	5,537	2,547

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

TABLE 10 The heterogeneity of industry.

	<i>EnvirPat</i>		<i>EnvirInvPat</i>		<i>EnvirUtyPat</i>	
	<i>High carbon industries</i>	<i>Low carbon industries</i>	<i>High carbon industries</i>	<i>Low carbon industries</i>	<i>High carbon industries</i>	<i>Low carbon industries</i>
<i>DID</i>	0.1153*** (0.0407)	0.0192 (0.0221)	0.1124*** (0.0350)	0.0021 (0.0181)	-0.0131 (0.0253)	0.0069 (0.0165)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Individual</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Province × year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>R²</i>	0.2043	0.2321	0.1686	0.2165	0.2406	0.1920
<i>N</i>	3,531	12,152	3,531	12,152	3,531	12,152

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. T-statistics are based on robust standard errors and are presented in parentheses.

Policy implications

Our findings provide the following policy implications for effectively promoting the construction of comprehensive demonstration cities for energy saving and emission reduction fiscal policy and encouraging corporate green technology innovation.

Firstly, the scope and areas of demonstration work on the energy saving and emission reduction fiscal policy should be further expanded to promote the green and low-carbon transformation of enterprises in the pilot cities. Our research demonstrates that the energy saving and emission reduction fiscal policy do have a positive impact on the green technological

innovation of firms. Therefore, local governments need to summarize and refine the pilot experience in a timely manner, form experience models, and thus provide experience and reference for the achievement of China's emission peak and carbon neutrality targets from the city level. At the same time, in the process of using financial funds to guide corporate green technology innovation, pilot cities should be effectively supervised and guided in order to fully induce corporate green technology progress and thus achieve a win-win situation of low-carbon emission reduction and economic development.

Secondly, the transition of high-carbon industries to low-carbon direction is an important source of corporate green technology innovation. A clearer technology transition guidance program should be developed for high-carbon industries to further induce more innovative green invention innovation. The industry heterogeneity test shows that the pilot policy promotes green technology innovation more significantly in high-carbon industries than in low-carbon industries, and that the green technology innovation in high-carbon industries is mainly manifested in green invention patents. This indicates that the transformation of high-carbon industries plays an important role in promoting the low-carbonization of industries in the pilot cities, and that the higher-value green invention patents are the key to promote the transformation of high-carbon industries to low-carbonization. Therefore, to improve the effectiveness of the pilot program, local governments should continue to use the policy to encourage high-carbon industries to conduct more green technology innovation and achieve low-carbon transformation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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YC: integrated arrangement, writing of the first draft, theoretical analysis, revision checking, and funding support. HJ: data processing, theoretical analysis, writing of the first draft, and revision checking. JY: literature search and organization, data collection and organization, and data processing. All authors contributed to the article and approved the submitted version.

Funding

YC acknowledges financial support from the National Natural Science Foundation of China (grant no. 72102024), China Postdoctoral Science Foundation (grant no. 2021M700575), and the Fundamental Research Funds for the Central Universities (project no. 2021CDSKXYJG007).

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 20 September 2022

ACCEPTED 12 December 2022

PUBLISHED 06 January 2023

CITATION

Yao Z, Zhang Z and Ma J (2023) Party
branches, policy perception and corporate
social responsibility: Evidence from
Chinese private enterprises.
Front. Psychol. 13:1048060.
doi: 10.3389/fpsyg.2022.1048060

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Party branches, policy perception and corporate social responsibility: Evidence from Chinese private enterprises

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Introduction: Party branches embedded in private enterprises are a unique phenomenon in the Chinese economy, but few studies have focused on the economic consequences. We hope to explore the impact of party branches on small and medium-sized private enterprises' corporate social responsibility (CSR) in China in order to fill the gaps in current research.

Methods: Data were used from the 11th Chinese Private Enterprise Survey (CPES) in 2014. The study uses the methodology of fixed effect model, mediation analysis and moderation analysis. Moreover, propensity score matching and Heckman two-step method deal with the endogeneity problem and check the robustness of the results.

Results: We find that, first, the embedding of party branches will improve the CSR performance of private enterprises in various dimensions by enhancing the perception of private enterprises in policy; second, in various influence pathways, the party branches will enhance the perceptions of policy related to economic interests, which has a more significant impact on enhancing the performance of philanthropic CSR. Further research reveals that business owners' first-given and later-generated political connections support the party branches' perception of policies related to economic and social interests, respectively.

Discussion: The findings suggest that political intervention by China's ruling party in private firms promotes CSR performance, but this is influenced by the political connections of the firm owners. In addition to providing empirical support for the study of corporate behavior in the Chinese context, this paper identifies the impact and development trajectory of the party branches of China's ruling party on CSR. However, this paper does not discuss the implicit costs required for party branches to promote CSR, and we hope that future research will make further explorations.

KEYWORDS

party branches, private enterprises, corporate social responsibility, policy perception, China

1. Introduction

In a policy statement for private businesses published in September 2020, the Central Committee of the Communist Party of China emphasized the necessity of “consolidating and broadening political consensus, further strengthening the party building work of private enterprises, and effectively playing the role of the party organization as a fighting fortress and the vanguard and exemplary role of party members.” Party branches embedded in private businesses are now a very widespread political and economic phenomena in China since they are a legal institutional structure that is explicitly outlined in the *Articles of the Communist Party of China* and the *Company Law of the People’s Republic of China*. According to the “Intra-Party Statistical Bulletin of the Communist Party of China” issued by the Central Committee of the Communist Party of China, as of June 5, 2021, 1.513 million grass-roots party organizations have been established in firms in mainland China, and the embeddedness of party branches and corporate governance have been deeply integrated. Has the Communist Party’s widespread and broad engagement in businesses have the anticipated political and economic effects?

The effect of party branches operating inside of businesses has been studied by several academics. Enhanced party building may greatly increase corporate governance in Chinese SOEs, according to Bi (2021) and Yu et al. (2021), on the other hand, find that acquisitions with their own party committees create significantly higher market value for acquiring firms. Additionally, Li and Cheng (2021) discover that from the standpoint of R&D and innovation, the engagement of Communist Party branches in the activities of Chinese listed enterprises decreases innovative inputs but enhances firms’ innovation performance. As is evident, the majority of past studies have employed state-owned businesses as their study sample. But the different nature and lifecycle of enterprises can lead them to behave differently (Durana et al., 2021). While for private enterprises, political ties to the Communist Party have been discovered to aid enterprises access external resources, as seen in the case of the Chinese private firm’s debt financing and business performance (Haveman et al., 2017; Valaskova et al., 2021). Additionally, this relationship is related to regional institutional environment and industrial policy (Zhang et al., 2022).

Chinese firms are exposed to political influence from three primary sources: state shareholding, government and ministries, and party committees. Political influence from government and state-owned shareholders affects corporate behavior primarily by influencing the allocation of external resources. However, the party branch is directly embedded in the internal organization and governance structure of the company and intervenes in a more direct way. Although China’s political system is based on “party-government unity,” from the perspective of the “administrative-political” dichotomy, due to the principal-agent relationship and institutional inertia, the government and state-owned shareholders may also produce strategic administrative phenomena like

“political tournaments” at the local grassroots level and at the individual enterprise level, deviating from the wishes of political parties (Feldman et al., 2021). Additionally, due to the special institutional environment in China, companies sometimes give up some economic benefits in order to obtain other resources. Thus, rather of concentrating simply on commercial concerns, political engagement from the corporate party branch might affect the enterprise’s non-profit activities. Zhang et al. (2021) found that corporate party committee governance enhanced corporate willingness to donate in a study of Chinese listed firms in the heavy-pollution industry. Studies have also found that Communist Party interventions, such as corporate party branches and inculcation of CEO ideology, promote environmental corporate social responsibility (ECSR) among Chinese firms (Zhou et al., 2021; Su and Zhang, 2022). As noted above, research that have hitherto been conducted on the impact of corporate party branches on nonprofit activity have mostly emphasized corporate social responsibility in a wide sense.

Corporate social responsibility (CSR) is a broad concept that can take many forms. Businesses can benefit society while boosting their brands through CSR programs such as philanthropy and volunteer efforts. Therefore, exploring the factors affecting CSR has long been an important topic of interest for scholars. Previous studies have analyzed the factors affecting CSR from several perspectives, such as tournament incentives (Khan et al., 2022) and non-financial disclosure (Jackson et al., 2020), but few studies have focused on the impact of political intervention of the ruling party on CSR. In particular, there was a lack of discussion of the mechanisms of influence. According to the social embeddedness theory, social interactions and social network structure have an impact on economic behavior through affecting a number of mediating elements, including resource availability, emotional support, and knowledge sharing (Granovetter, 2018). Party branches that are embedded in the firm also play a “supervisory” and “leadership” function, affecting the way the business acts. Private firms in China are typically less perceptive of policy than state-owned firms with links to the institution. According to signaling theory, in order to reduce of information asymmetry, information must be sent across organizations *via* certain signals. By embedding into the governing structure of private enterprises, the party branch transmits the CCP Central Committee’s will, enhances the perception of policies among private enterprises, and influences their behavior by integrating them into the party organization network across China. This article aims to investigate whether party branches impact CSR performance through improving the private enterprises’ policy perception.

This study investigates the impact of the party branch as a kind of formal institutional structure on the social responsibility of private firms based on the 11th Chinese Private Enterprise Survey (CPES). This article also aims to investigate the mediation effect of policy perception ability in order to more precisely identify its effect path. We found that, first, the embedding of party branches will improve the CSR of private

enterprises in different dimensions, by enhancing the policy perception of private enterprises. Second, in various influence pathways, the party branches will enhance the perceptions of policy related to economic interests, which has a more significant impact on enhancing the performance of philanthropic CSR. Finally, by examining the effects of moderation, it can be shown that business owners' first-given and later-generated political connections support the party branches' perception of policies related to economic and social interests, respectively. After adjusting for endogeneity using propensity score matching, and Heckman two-step method, these results remain valid.

The theoretical contributions of this study in comparison to earlier research are as follows. First, by using Chinese private firms as the research subject, this work broadens the research viewpoint on the impact of Communist Party branches on corporate conduct and enhances the pertinent research literature. Second, the majority of current research on CSR is undertaken from a single perspective, and only a small number of empirical evaluations are done from a multidimensional perspective. It is inevitable that managers' initial motivations would differ, which will result in different CSR performance. The varied influences of party branches on various forms of CSR are thoroughly examined in this work, which also advances the body of knowledge about the effects of party branches on corporate governance. Third, this research focuses on the mediating effect of policy perceptions based on social embeddedness theory and signaling theory. The influence paths of party branches in private businesses are explained by the empirical evidence presented in this paper.

2. Literature review and hypotheses

2.1. Concepts and dimensionality of corporate social responsibility

The term "corporate social responsibility" (CSR) refers to what society expects from a business organization. It calls for businesses to look beyond conventional corporate objectives like "profit first" and place an emphasis on contributions to all stakeholders, such as the employees, clients, and society. According to the stakeholder theory, an organization's business risks are shared by all of its stakeholders, hence it should adopt social responsibility as a risk mitigation strategy (Dmytriiev et al., 2021). Because it provides a more comprehensive response to the question of "to whom should corporations be accountable," it has emerged as the dominant theory in the field of CSR research. The classic CSR pyramid model treats CSR as a structural component, incorporating economic, legal, ethical, and philanthropic duties from the bottom up. Environmental, Social and Governance (ESG) has received a great deal of attention in recent years and has influenced the way researchers view CSR, with an increasing focus on the environmental dimension of CSR (Gillan et al., 2021).

However, most of studies still categorize CSR as ranging from economic to philanthropic.

The existing research reveals that there are several motivations for businesses to fulfill CSR, including the four main points listed below. First, there is the altruistic motivation for altruism, which views CSR as a physical manifestation of ethical behavior (Miller et al., 2022). Second, the strategic motivation, which uses CSR to support the company's growth strategy (Nave and Ferreira, 2019). By carrying out its social obligation, the business may demonstrate to the outside world that it works responsibly, earning the respect of external stakeholders and enhancing its reputation and legitimacy. Third, the managerial self-interested motivation to achieve other specific goals, which is essentially a self-interested behavior, such as the enterprise hopes that through good social responsibility performance as a crisis and impression management tool, thus improving the company's reputation and public image (Du, 2015). Fourth, political incentive, businesses must do well in CSR to satisfy political demands (Xu and Liu, 2020). Chinese businesses are driven more by political and self-interest to fulfill their social obligation. Many businesses desire to leverage their strong CSR performance to further economic and political objectives, such as reducing the risk of litigation's erosion of credibility and legitimacy (Du, 2015). Therefore, its performance in many dimensions may depending on the different motivations. We contend that a multifaceted analysis of the specific performance of CSR is required.

2.2. Social embeddedness, signaling and mediation effects

Chinese private businesses are integrated into the Communist Party of China's organizational network *via* party branches located inside such businesses. According to Granovetter (2018), organizations must construct information channels with the strength of weak ties if they wish to retain effective ties. Party branches serve as an important channel of communication and contact with Chinese authorities, despite the fact that they are typically not directly involved in the management of private enterprises. Yan and Xu (2022) found that the Chinese Communist Party branch as a crucial communication bridge between the government and firms, which transfers public governance goals to private enterprises, and promotes employment protection. They also integrate private businesses into the organizational network of the CCP by acting as a kind of interorganizational social contact. He and Liu (2022) found that Chinese authorities exert political pressure on private enterprises to set up party branches within the firm intending to regain political influence, and this pressure forces family firms to comply with the requirement to set up party branches and thus build an organizational network of the party.

According to signaling theory, sending signals across organizations helps reduce information asymmetry. Chinese private businesses frequently lack connections to the system, in

contrast to state-owned companies' inherent political links (Wang et al., 2022). As a result, when the CCP communicates private businesses of its policy intentions, there are frequently weak channels and poor execution. By arranging actions for party building, the party branches embedded in private businesses objectively perform the function of sending signals (He and Liu, 2022). Party branches act as "supervision" and "leadership" entities by promptly communicating the most recent policy intent to businesses, so reducing the problem of information asymmetry. However, very few research have been done to investigate the mechanisms behind the influence of the party branch. Party branches often do not participate directly in the administration of private businesses; instead, they influence and control businesses through indirect channels such as political propaganda (Mittelstaedt, 2021). Because of this, it is important to take into account the relevant mediating effects in order to understand the function and impact mechanism of the party branch embedded in private enterprises.

2.3. Institutional context and research hypothesis

The economic system in mainland China has changed a lot in recent years. Prior to the "reform and opening up," private capital was rarely allowed to engage in economic activity during the planned economy era. As a result, economic development had to be handled by state-owned enterprises. Prior to the reform and opening up, state-owned firms in China engaged into implicit long-term labor contracts in the form of unit ownership with their employees and assumed various public benefits, such as employment, health care, pensions, housing, and education. And they carried out their production under the coordination of a command planning economy. At this stage, however, businesses are offering more social benefits than they can reasonably afford, which has had detrimental effects including low productivity and free-riding (Cai, 2019).

The 11th Central Committee of the Communist Party of China's Third Plenary Session brought about a fundamental change in the country's economic system. China's economic system underwent a phase of transition from a planned economy to "socialist market economy," in which private firms were permitted to function and state-owned enterprises progressively withdrew from the majority of economic sectors. China's economic reform, however, has led to "big layoffs" and the serious loss of state-owned assets as a result of poor management. The rights of the environment, employees, and customers have also been violated by the brutal expansion of many private enterprises. Even some people have expressed the opinion that these private enterprises may have original sin (Shi et al., 2022). In general, Chinese private businesses at this time did not take corporate social responsibility very seriously, which had major negative externalities. Enterprises are regulated and compelled to pay attention to and take responsibility for CSR as China's market

opens up and its legal system steadily improves. Private companies in China are also fulfilling CSR by enhancing working conditions and making charity donations (Lau et al., 2016).

Private businesses in China are required to create party branch committees. Do party branches that are embedded in businesses, which are a crucial source of knowledge about policy for company owners, have an impact on how well CSR is carried out in private enterprises? The Constitution of the Communist Party of China defines the "supervision" and "leadership" roles that party branches play in private businesses. Party branches influence private enterprises to respond to the Party's political views through semi-obligatory propaganda, so enhancing the enterprises' feeling of social responsibility (Dong et al., 2016). According to Gupta et al. (2017), ideologies that come from organizations are more likely to support CSR than ideologies that come from individuals. The private enterprises embedded in the party branch are connected to the organizational network of the Communist Party and develop a unified organizational perspective under the "supervision" and "leadership" of the party branch (Yan and Xu, 2022). As a result, they may be affected by the party's wishes and invest heavily in CSR than other businesses. Therefore, we propose the following research hypothesis.

H1: The Party Branch will promote the fulfillment of CSR in Chinese private enterprises.

Party branches often do not participate directly in the business administration of Chinese private firms, in contrast to state-owned ones. Instead, they have an indirect impact on corporate behavior by altering the internal informational environment, and this effect alters how business owners view the external political environment (Yan and Xu, 2022). According to the social cognitive theory of triadic reciprocal causation, the environment can impact conduct *via* altering perception (Bergman et al., 2019). Different perceptions of business owners can lead to different decisions. For a long time, Chinese private enterprises have had poor policy perception abilities, and created significant governance challenges (Dai and Si, 2018). However, as China's economic reform moves forward, this circumstance is progressively getting better. According to Article 19 of The People's Republic of China's Company Law: "In companies, the organization of the Communist Party of China shall be established and its activities shall be carried out in accordance with the provisions of the Constitution of the Communist Party of China. The company shall provide the necessary conditions for the activities of the Party organization." The embedding of party branches in private enterprises is formally institutionalized under the legislation. The Communist Party of China's Constitution stipulates that the party branch of private enterprises is responsible for monitoring business operations through propaganda. Through events like party congresses, it transfers the Party Central Committee's policy spirit to the internal workings of the company, enhancing private enterprises' capacity for policy perception. The capacity to perceive policy better will alter private enterprise goals through mediating effect, forcing enterprises to invest significant

resources in CSR for cater to the Party values. As a result, we propose the following research hypothesis.

H2: The Party Branch will promote policy perception in Chinese private enterprises.

H3: Policy perception mediates the relationship between party branch and CSR performance.

3. Methodology

3.1. Sample and data selection

This study is devoted to mapping party branches, policy perceptions and CSR, and uses Chinese small and medium-sized private enterprises as a research sample. This requires important business data about the firms, as well as information about the entrepreneurs' political identities. In China, it is difficult for academic institutions to obtain this information through independent investigation, which requires the assistance of official institutions. The 11th China Private Enterprise Survey (CPES) in 2014 provided the sample data used in this study. The survey was carried out under the auspices of a committee that was jointly established by the State Administration for Industry and Commerce of China, the Federation of Industry and Commerce, the United Front Work Department of the CCP Central Committee, and other authority departments. A sample of private enterprises with excellent representativeness and reliability is created by using a multi-stage sampling procedure. It includes company information and indicators of the personal characteristics of business owners, covers a total of 6,144 private firms across 31 provincial-level units and 19 industry categories in mainland China, and has good data quality and sample representativeness. Samples that lacked important factors were eliminated from this study before the analysis began. Additionally, all continuous variables were winsorized at the 1% level in order to remove the impact of outliers. Finally, 5,005 valid cross-sectional data samples were acquired.

The establishment of party branches in private enterprises is a unique political and economic phenomenon in China. Because this nation has maintained a one-party dictatorship despite implementing market-oriented reforms, and only a small number of nations fit this requirement. Although most multi-party democracies lack the necessary conditions to establish party branches in private enterprises, it is nevertheless possible to replicate the research in different conditions. In terms of methodological steps, we suggest that researchers in other countries first consider how to gather trustworthy data on firms' business and political connections and then focus on concretely defining the vague concept of policy perception. For instance, researchers can use corporate political donations to gauge the effect that party affiliation has on them. The impact of this on the entrepreneur's perception of the party's policies is next examined,

followed by a look at whether it has an impact on the business's strategy.

3.2. Measurement

3.2.1. Dependent variables

Corporate Social Responsibility (CSR_i). The concept of the pyramid model of CSR is used in this study to quantify the social responsibility of businesses in several dimensions by focusing on the performance of three private firm areas: labor protection, environmental protection, and charity giving. Among them, CSR of labor (CSR_1) and CSR of environmental (CSR_2) are economic and strategic, while CSR of charitable (CSR_3) is more altruistic and philanthropic. We use the amount of employee training and social insurance paid by the company to measure CSR_1 ; the amount of environmental protection paid by the company to measure CSR_2 ; and the amount of donation to charity to measure CSR_3 . For each of the aforementioned variables, a logarithm is applied.

3.2.2. Independent variables

Party branch (*CCP*). To identify if the party branch was embedded into the firm, we generated dummy variables and utilized the CCP organization's establishment in a private firm as a proxy variable. If a party organization was established in the sample firms, *CCP* was given the value 1, otherwise it was given the value 0.

3.2.3. Control variables

Firm characteristics (*Firm*) and owner characteristics (*Owner*) were chosen as control variables in relation to the dependent variable. The following variables serve as controls with regard to firm characteristics: firm age (*Coage*), operational income (*Income*), net profit (*Profit*), firm size (*Size*), and board of directors (*Board*). The following variables serve as controls with regard to owner characteristics: Gender (*Gender*), Age (*Age*), Education (*Education*), and Political Identity (*PI*). In our research, we also control for the fixed effects of industry and province. The definitions of the variables are displayed in [Table 1](#).

3.3. Statistical method

In this study, we used ordinary least squares (OLS) regression to serve as the baseline regression, and a fixed effects model is used in the baseline regression so as to address endogeneity. The following econometric model was developed to investigate whether party branches improve CSR in Chinese private enterprises.

$$CSR_i = \alpha_0 + \beta_i CCP + \gamma_1 Firm + \gamma_2 Owner + \eta_j + \lambda_k + \varepsilon_i \quad (1)$$

where CSR_i is three dimensions of CSR ($i=1,2,3$), *Firm* and *Owner* are control variables for firm characteristics and owner

TABLE 1 Variable definitions.

Variable type		Variable name	Symbol	Definition
Dependent variables		CSR of labor	CSR_1	Employer-paid social insurance premiums and employee training costs, totaled and take the logarithm
		CSR of environmental	CSR_2	The environmental pollution control costs by enterprises, take the logarithm
		CSR of charitable	CSR_3	The amount of corporate donations to charitable causes, take the logarithm
Independent variables		Party branch	CCP	Whether the enterprise established a party branch (Yes = 1, No = 0)
Intermediate variables		Policy perception	<i>Perception</i>	Business owners' perception of and participation in the six policies and activities ("better understand, participated in" is assigned a value of 2; "heard, some understanding" is assigned a value of 1; "do not know" is assigned a value of 0, the same below)
		Policy perception for profit	<i>Tool</i>	Business owners' perception of and participation in three policies and activities that are closely linked to the economic interests of the business
		Nonprofit policy perception	<i>Value</i>	Business owners' perception of and participation in three policies and activities that are closely linked to social interests
Control variables	Firm characteristics (<i>Firm</i>)	Firm age	<i>Coage</i>	Statistical year – year of business registration
		Operational income	<i>Income</i>	Total operating income, normalized
		Net profit	<i>Profit</i>	The amount of net profit, normalized
		Firm size	<i>Size</i>	Total number of employees, take the logarithm
		Board of directors	<i>Board</i>	Whether or not the company has a board of directors (Yes = 1, No = 0)
	Owner characteristics (<i>Owner</i>)	Gender	<i>Gender</i>	Gender of business owner (male = 1, female = 0)
		Age	<i>Age</i>	Statistical year - year of birth of the business owner
		Education	<i>Education</i>	Whether or not the business owner has university study experience (Yes = 1, No = 0)
		Political identity	<i>PI</i>	Whether or not the business owner is serving as a delegate to the People's Congress (PC) or a member of the Political Consultative Conference (PCC) (Yes = 1, No = 0)

characteristics, respectively. η_j and λ_k denote province and industry fixed effects, and ε_i is a random error term. This paper will also use a variety of models to test for fixed effects, such as the causal steps approach, the Sobel test, and the Bootstrap structural equation model (SEM) to make the results more credible. On this basis, moderating effects of political connections will also be considered. To sum up, the conceptual model is displayed in [Figure 1](#).

4. Analysis and results

4.1. Descriptive analysis

[Table 2](#) presents descriptive statistics for the primary variables. The findings show that the mean value of CCP is 0.370, meaning that 37% of the sample firms had a party branch in place. In terms of firm characteristics, the mean value of $Coage$ is 10.832, indicating that Chinese private businesses are

often new. This may be due to the late opening up of China and the short average lifespan of private enterprises. And the operating circumstances of Chinese private enterprises are severely polarized, as evidenced by the mean value of the normalized operational income being negative. In particular, the average of the raw data on corporate net profits is also negative, showing that Chinese private enterprises have a typically bad chance of surviving in business.

As for the characteristics of business owners, the mean value of $Gender$ is 0.851, and the proportion of male business owners is much higher than that of female. The average age was 45.431, with the youngest being 25 years old and the oldest being 64 years old. The mean value of PI is 0.366 shows that 36.6% of business owners are now NPC deputies or CPPCC members, indicating that Chinese private business owners are more engaged in politics. We tested the variance inflation factor before the regression analysis. With a maximum VIF value of 1.77, serious multicollinearity was not seen.

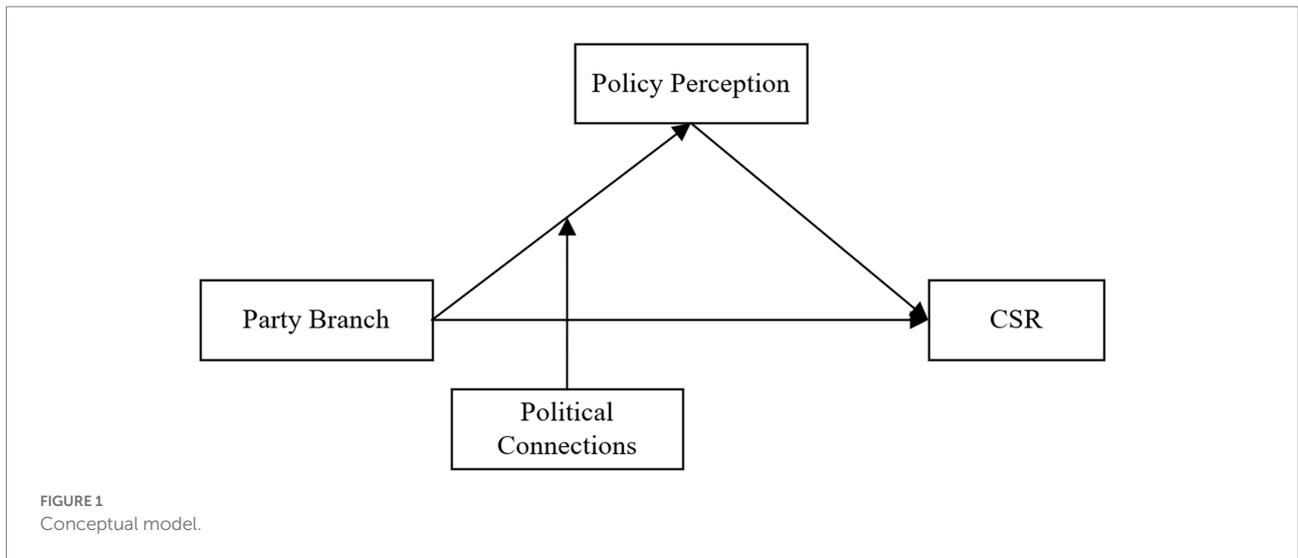


TABLE 2 Descriptive statistics of the variables.

	Number	Average	Standard deviation	Minimum	Maximum
CCP	5,005	0.370	0.483	0.000	1.000
CSR ₁	5,005	9.840	5.349	0.000	16.831
CSR ₂	5,005	4.865	5.973	0.000	16.524
CSR ₃	5,005	7.298	5.542	0.000	15.568
Coage	5,005	10.832	6.033	1.000	27.000
Income	5,005	-0.032	0.109	-0.067	0.768
Profit	5,005	0.012	0.032	-0.009	0.231
Size	5,005	4.119	1.594	1.099	8.033
Board	5,005	0.575	0.494	0.000	1.000
Gender	5,005	0.851	0.357	0.000	1.000
Age	5,005	45.431	8.450	25.000	64.000
Education	5,005	0.369	0.483	0.000	1.000
PI	5,005	0.366	0.482	0.000	1.000

4.2. Regression analysis and results

Table 3 shows the model's OLS regression findings, where columns (1)–(3) control for firm characteristics only, while columns (4)–(6) control for business owner characteristics additionally. The regression findings demonstrate that, whether in the areas of labor protection, environmental protection, or charity giving, the Party branch greatly enhances the CSR performance of Chinese private enterprises. When business owner characteristics were not taken into account, the estimated party branch coefficients on CSR were 0.918, 1.376, and 1.574, all of which were significant at the 1% level. The coefficients are 0.799, 1.338, and 1.261, respectively, after taking account for the business owner characteristics, and they are also significant at the 1% level. H1 is therefore proved.

Our main worry is the sample's bias due to selection, which makes it difficult to determine whether party branches influence the CSR performance of Chinese private enterprises. That is, rather than being randomly selected, party branches embedded in private enterprises are more likely to be found in larger companies. Large companies may perform better in CSR than smaller ones, which introduces systematic bias and makes it challenging to identify causal relationships. As a result, extra tests are carried out in this research based on model (1), where CSR expenditures are adjusted for the number of employees. The results are broadly in line with Table 3, and the coefficients that we are interested in are all positively significant at the 1% level, suggesting that the influence of sample bias may not be as significant as it may first estimate.

TABLE 3 Party branches and CSR in Chinese private enterprises: OLS regression.

	(1)	(2)	(3)	(4)	(5)	(6)
	CSR ₁	CSR ₂	CSR ₃	CSR ₁	CSR ₂	CSR ₃
<i>CCP</i>	0.918*** (0.160)	1.376*** (0.178)	1.574*** (0.167)	0.799*** (0.162)	1.338*** (0.180)	1.261*** (0.167)
<i>Coage</i>	0.036*** (0.012)	0.007 (0.013)	0.125*** (0.013)	0.029* (0.013)	0.005 (0.014)	0.107*** (0.013)
<i>Income</i>	-0.454 (0.867)	2.036** (0.962)	-0.125 (0.902)	-0.726 (0.866)	2.134** (0.963)	-0.348 (0.890)
<i>Profit</i>	1.237 (2.906)	-0.234 (3.223)	7.651** (3.022)	0.960 (2.898)	-0.123 (3.221)	7.414** (2.977)
<i>Size</i>	1.275*** (0.057)	1.092*** (0.063)	1.071*** (0.059)	1.207*** (0.058)	1.086*** (0.065)	0.933*** (0.060)
<i>Board</i>	0.004 (0.136)	0.011 (0.151)	-0.355** (0.141)	-0.034 (0.136)	0.042 (0.151)	-0.349** (0.140)
<i>Gender</i>				-0.073 (0.190)	0.176 (0.211)	0.040 (0.195)
<i>Age</i>				0.016* (0.009)	-0.009 (0.010)	0.002 (0.009)
<i>Education</i>				0.736*** (0.149)	-0.489*** (0.165)	0.042 (0.153)
<i>PI</i>				0.399*** (0.152)	0.444*** (0.169)	1.949*** (0.156)
<i>Industry</i>	Yes					
<i>Province</i>	Yes					
<i>Constant</i>	0.429 (0.534)	-1.878*** (0.592)	-1.607*** (0.555)	-0.137 (0.639)	-1.625** (0.709)	-1.642** (0.656)
<i>N</i>	5,005	5,005	5,005	5,005	5,005	5,005
<i>R-squared</i>	0.252	0.262	0.246	0.257	0.264	0.270

***p<0.01, **p<0.05, *p<0.1; standard errors in parentheses, same as in the following tables.

4.3. Mediating effects of policy perception

The previous regression results show that the party branch significantly enhances the CSR performance of Chinese private enterprises. What thus is the party branch’s mechanism for promoting CSR in private enterprises? We will examine the mediating role that private firms’ policy perceptions play in order to address this problem. Specifically, we assigned values to enterprises’ perceptions of and engaged in the six policies and activities: “*Opinions on Further Supporting the Healthy Development of Small and Micro Enterprises*” (Article 29 for small and micro enterprises), “*Several Opinions of the State Council on Encouraging and Guiding the Healthy Development of Private Investment*” (Article 36 for private investment), “*Guiding Opinions on Financial Support for Economic Restructuring and Transformation and Upgrading*,” “For the

People, Pragmatic and Clean” Party’s Mass Line Education and Practice Activities, the Guangcai Project, and “Private Entrepreneurs and the Chinese Dream” education and practice for people in the non-public sector. The policy perception variable is assigned a value of 2 for “know, attended,” 1 for “heard, know,” and 0 for “do not know.” Use *Perception* as a proxy variable with a maximum value of 12 and a minimum value of 0 to determine how private enterprises are perceived in terms of policy.

We initially carry out a mediating effects test utilizing the causal steps approach. The model is setup as shown below.

$$CSR_i = \alpha_0 + \beta_i CCP + \gamma_1 Controls + \eta_j + \lambda_k + \varepsilon_i \quad (2)$$

$$Perception = \alpha_0 + \beta_i CCP + \gamma_1 Controls + \eta_j + \lambda_k + \varepsilon_i \quad (3)$$

$$CSR_i = \alpha_0 + \beta_i CCP + \delta_i Perception + \gamma_1 Controls + \eta_j + \lambda_k + \varepsilon_i \quad (4)$$

TABLE 4 Party branches and CSR in Chinese private enterprises: Mediating effects of policy perception.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>Perception</i>	CSR ₁	CSR ₁	CSR ₂	CSR ₂	CSR ₃	CSR ₃
<i>CCP</i>	0.901*** (0.087)	0.799*** (0.162)	0.718*** (0.164)	1.338*** (0.180)	1.153*** (0.181)	1.261*** (0.167)	0.909*** (0.165)
<i>Perception</i>			0.089*** (0.026)		0.206*** (0.029)		0.391*** (0.027)
<i>Coage</i>	0.050*** (0.007)	0.029** (0.013)	0.024* (0.013)	0.005 (0.014)	-0.006 (0.014)	0.107*** (0.013)	0.087*** (0.013)
<i>Income</i>	0.272 (0.465)	-0.726 (0.866)	-0.751 (0.866)	2.134** (0.963)	2.078** (0.958)	-0.348 (0.890)	-0.455 (0.871)
<i>Profit</i>	2.501 (1.554)	0.960 (2.898)	0.736 (2.896)	-0.123 (3.221)	-0.638 (3.206)	7.414** (2.977)	6.436** (2.916)
<i>Size</i>	0.313*** (0.031)	1.207*** (0.058)	1.179*** (0.059)	1.086*** (0.065)	1.022*** (0.065)	0.933*** (0.060)	0.810*** (0.059)
<i>Board</i>	-0.126* (0.073)	-0.034 (0.136)	-0.022 (0.136)	0.042 (0.151)	0.068 (0.150)	-0.349** (0.140)	-0.300** (0.137)
<i>Gender</i>	-0.112 (0.102)	-0.073 (0.190)	-0.063 (0.190)	0.176 (0.211)	0.199 (0.210)	0.040 (0.195)	0.084 (0.191)
<i>Age</i>	0.014*** (0.005)	0.016* (0.009)	0.015 (0.009)	-0.009 (0.010)	-0.012 (0.010)	0.002 (0.009)	-0.003 (0.009)
<i>Education</i>	0.228*** (0.080)	0.736*** (0.149)	0.716*** (0.149)	-0.489*** (0.165)	-0.536*** (0.165)	0.042 (0.153)	-0.047 (0.150)
<i>PI</i>	1.117*** (0.081)	0.399*** (0.152)	0.299* (0.155)	0.444*** (0.169)	0.214 (0.171)	1.949*** (0.156)	1.512*** (0.156)
<i>Industry</i>	Yes						
<i>Province</i>	Yes						
<i>Constant</i>	3.147*** (0.342)	-0.137 (0.639)	-0.419 (0.643)	-1.625** (0.709)	-2.273*** (0.712)	-1.642** (0.656)	-2.873*** (0.648)
<i>N</i>	5,005	5,005	5,005	5,005	5,005	5,005	5,005
<i>R-squared</i>	0.255	0.257	0.259	0.264	0.272	0.270	0.300

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The coefficients β_i and δ_i in Equations 3, 4 should both be positively significant if policy perception mediates the relationship between the party branch and CSR. Additionally, after controlling for *Perception*, the coefficient β_i 's value in Equation 4 should drop or lose significance in comparison to the value in Equation 2. The findings of the mediating effects test are presented in Table 4. According to the results in column (1), the coefficient β_i in Equation 3s has an estimated value of 0.901, which is positively significant at the 1% level. The regression coefficients of *Perception* on CSR_{*i*} in columns (3), (5) and (7) are 0.089, 0.206 and 0.391, respectively, all of which are positively significant at the 1% level. The results in columns (2)–(7) show that the coefficients of CSR_{*i*} all decrease after controlling for policy perception (CSR₁ decreases from 0.799 to 0.718; CSR₂ decreases from 1.338 to 1.153; CSR₃ decreases from 1.261 to 0.909). The aforementioned results

suggest that the party branch may improve CSR performance by improving the policy perception of the owner of private enterprises. Thus, H2 and H3 are verified.

However, there is a query as to what is the purpose of Chinese private enterprises to perceive policies? According to institutional theory, on the one hand, private enterprises can enhance their awareness of the institutional environment in order to better understand changes in policies, adjust their business plans, and enhance their economic performance. On the other hand, institutional pressure can improve CSR performance through community isomorphism (Roszkowska-Menkes et al., 2017). Strategic choice theory suggests that a manager's perception of the external environment is the primary element determining a company's strategic decisions. Varied ways that business owners perceive political climate will ultimately result in different

TABLE 5 Heterogeneity policy perceptions: the Sobel & KHB test.

Independent variable	Intermediate variables	Dependent variable	Sobel test				KHB test	
			Direct effect	Indirect effects	Total effect	Share of intermediary effect	Intermediary Effect	Share of intermediary effect
CCP	Tool	CSR ₁	0.912***	0.032**	0.944***	3.42%	0.019	2.03%
		CSR ₂	1.531***	0.077***	1.608***	4.77%	0.047**	2.93%
		CSR ₃	1.119***	0.133***	1.252***	10.64%	0.045**	3.56%
	Value	CSR ₁	0.875***	0.069***	0.944***	7.30%	0.057**	6.08%
		CSR ₂	1.449***	0.158***	1.608***	9.85%	0.130***	8.08%
		CSR ₃	0.837***	0.415***	1.252***	33.16%	0.388***	31.01%

*** $p < 0.01$, ** $p < 0.05$.

strategies that businesses behave. We thus think it is necessary to investigate if there are differences in the impact effects of party branches on different policy perceptions, and then on the CSR performance of private enterprises.

We subsequently investigated enterprises' perceptions of policy related to economic interests (*Tool*) and those related to social interests (*Value*) based on the analyses mentioned above. We categorize the problems that make up *Perception* in detail. The same as previously, we assign values to three policies that are directly connected to economic interests: "Article 29 for small and micro enterprises," "Article 36 for private investment," and "Guidance Opinions." Then, the variable *Tool*, with a maximum value of 6 and a minimum value of 0, is used as a proxy variable to measure the degree of private enterprises' perceptions of policy related to economic interests. At the same time, the enterprises' participation in the "Party's Mass Line Education and Practice Activity," "Guangcai Project," and "Education and Practice of Non-public Economic Personnel" was assigned a value, and the same is treated as a variable *Value* with a maximum value of 6 and a minimum value of 0 as a proxy variable for the degree of private enterprises' perceptions of policy related to social interests.

We use the Sobel test instead of the causal steps approach in the next analysis to quantify the mediating effect. In addition, we also used the KHB test, which loosens the linear model's presumptions. Both approaches enable the estimation of the proportion of mediating effects. The results of Sobel test and KHB test are reported in Table 5. According to the results, *Tool* and *Value* are significantly important mediating factors in each path. In particular, the mediating effect that Party Branch enhance CSR of charitable (*CSR*₃) by enhancing the perceptions of policy related to social interests (*Value*) of Chinese private enterprises is more obvious. The proportion of party branches increasing *CSR*₃ through this effect achieved 33.16% and 31.01%, respectively, according to the results of the Sobel test and the KHB test. In general, party branches have a more important role in boosting corporate social responsibility of charitable by improving the perception of policies related to social interests.

According to Wooldridge (2010), the normality assumption must be met by the sampling distribution of the mediating variables in order for the Sobel test to be valid. Therefore, as an alternative, we use the Bootstrap structural equation model, which does not depend for such assumption of normality. The mediating effect test of SEM, which is depicted in Figure 2, confirms the plausibility of the findings and is consistent with the previous findings.

4.4. Moderating effects of political connections

According to Tijani et al. (2021), a strategic alliance and partnership is an important tool for small private enterprises' survival. But in post-communist countries such as China, political connections are also important for the survival of enterprises. Chinese private enterprises are more interested in developing political relationships to obtain government resource support as contrasted to the inherent political advantages that state-owned enterprises enjoy (Zhang et al., 2022). In addition to the political connections that private enterprises establish for the purpose of business interests, Chinese authorities also want to use their political connections to influence private enterprises. It is possible to distinguish between "first-given political connections" and "later-generated political connections" based on the time of business owners' acquisition of these relationships. The distinction between the two is whether the political connections were made before or after the business owner founded the enterprise. The government positions held by the business owner before to founding the business can be used to gauge the "first-given political connections." With access to this institutional resource, business owners may develop a cognitive imprint and improves their capacity to recognize policy possibilities. "Later-generated political connections" often refer to the political status that a business owner has attained after founding their business, such as current membership in the National People's Congress, or the Chinese People's Political Consultative Conference (Fan et al.,

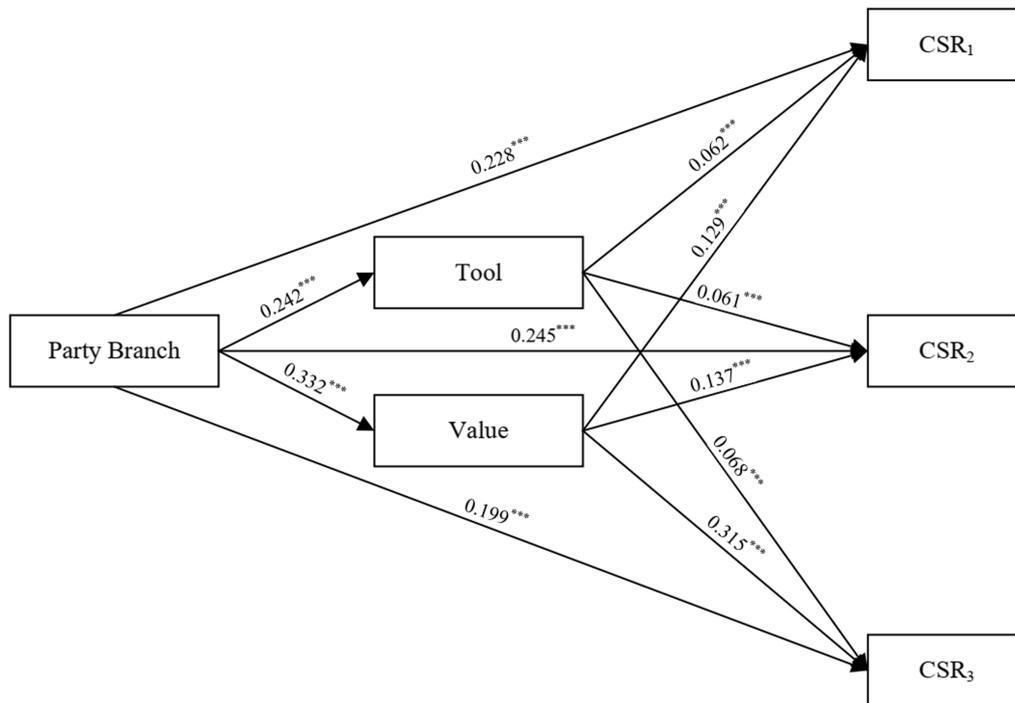


FIGURE 2 Structural equation model path analysis. *** $p < 0.01$.

TABLE 6 Party branches and CSR in Chinese private enterprises: moderating effects of political connections.

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Tool</i>	<i>Tool</i>	<i>Tool</i>	<i>Value</i>	<i>Value</i>	<i>Value</i>
CCP	0.347*** (0.054)	0.304*** (0.061)	0.346*** (0.062)	0.554*** (0.051)	0.539*** (0.057)	0.498*** (0.058)
CCP × IC		0.135** (0.066)			0.042 (0.072)	
CCP × PO			0.003 (0.075)			0.144** (0.070)
Controls	Yes					
Industry	Yes					
Province	Yes					
Constant	1.832*** (0.207)	1.871*** (0.208)	1.834*** (0.208)	1.261*** (0.195)	1.274*** (0.196)	1.297*** (0.196)
N	5,005	5,005	5,005	5,005	5,005	5,005
R-squared	0.133	0.134	0.133	0.267	0.267	0.268

*** $p < 0.01$, ** $p < 0.05$.

2007; Zhang et al., 2016). In addition, Chinese private enterprises also develop political connections by hiring former government officials (Cheng, 2018).

Therefore, we investigate the moderating effects of both the “first-given” and “later-generated” political connections on the perceptions of policy held by private enterprises. Denote

“first-given political connections” by institutional capital (IC, if the business owner held a government leadership position before establishing the firm) and “later-generated political connections” by party official (PO, if the business owner held a position in the Communist Party). The results of the test for moderating effects are shown in Table 6. The exact test results of the control variables

TABLE 7 Propensity score matching.

	1:1 matching		radius matching		kernel matching		local linear regression matching		N
	ATT	Value of t	ATT	Value of t	ATT	Value of t	ATT	Value of t	
CSR ₁	1.309***	5.32	1.034***	5.10	1.074***	5.41	1.060***	4.31	5,005
CSR ₂	2.069***	7.01	1.696***	7.59	1.756***	7.98	1.743***	5.90	5,005
CSR ₃	1.137***	4.27	1.152***	5.54	1.219***	5.98	1.197***	4.49	5,005

****p* < 0.01.

are not reported later due to space constraints. In columns (2), (3), (5), and (6), the estimated coefficients of the interaction terms *CCP* × *IC* and *CCP* × *PO* are all positive. Additionally, there are significant effects for both the influence of *PO* on *Value* and the effect of *IC* on *Tool*. This result is generally consistent with the findings of [Chen and Cao \(2016\)](#). It's possible that this is the case because business owners who formerly held leadership positions in bureaucracy are better versed with the Chinese government's political subterfuges and have a broader network of contacts. This group of business owners left their influential government jobs to pursue their businesses, placing a greater focus on using political ties for financial advantage. Rich Chinese private business owners, however, do not yet have the commensurate social standing; as a result, they choose to utilize their economic might to forge political relationships and rise in social standing.

5. Endogeneity and robustness test

5.1. Endogeneity test

The article's most concerning endogeneity is selection bias, where larger firms may perform better in terms of CSR but larger firms are more likely to embed party branches. When the sample exhibits selection bias brought on by quantifiable factors, Propensity Score Matching (PSM) can be utilized to reduce the bias. It selects a firm from the sample that matches other traits with the party branch-containing company's other traits. The CSR performance of these two companies is then contrasted to determine the real influence of the party branch on CSR.

We used local linear regression, 1:1 matching, radius matching, kernel matching, and propensity score matching to match all of the control variables. We also estimated the treatment effects for propensity score matching. After the balance test, the bias of each variable was also greatly decreased. The largest bias after matching is 3.6%, which is less than 5%. The detailed results of the balance test are not reported in this study due to space constraints.

Table 7 shows that regardless of the matching rule selected, the ATT of the party branch on the CSR performance of private enterprises is significant at the 1% level. The aforementioned findings somewhat reduce the endogeneity brought on by

TABLE 8 Instrumental variable test: Heckman two-step model.

	(1)	(2)	(3)
	CSR ₁	CSR ₂	CSR ₃
<i>CCP</i> – <i>IV</i>	0.882*** (0.162)	1.313*** (0.181)	1.276*** (0.166)
<i>IMR</i> ₁	-14.378*** (1.451)		
<i>IMR</i> ₂		5.906*** (1.661)	
<i>IMR</i> ₃			-9.728*** (1.253)
<i>Controls</i>	Yes		
<i>Industry</i>	Yes		
<i>Province</i>	Yes		
<i>N</i>	5,005	5,005	5,005

****p* < 0.01.

selection bias. It demonstrates the causal link between the party branch and CSR in private enterprises.

Additionally, we reduced endogeneity brought on by self-selection using the Heckman two-step method. As the instrumental variable for party branches, we select the coverage rate of party branches in the industry where the company is located (*CCP* – *IV*). This is because, whereas a company's decision to build a party branch is impacted by the industry's overall situation, a company's CSR performance is unaffected by the industry's party branch coverage. By using Probit estimation, we are able to calculate the Inverse Mills Ratio (*IMR*_{*i*}) in the first step of the Heckman two-step test. The second step of the regression model then includes *IMR*_{*i*} as control variables for testing, which reduces endogeneity. The regression coefficients are still positively significant according to the results of the Heckman two-step test, which are shown in Table 8. Additionally, the coefficients significance of *CCP* – *IV* are consistent with the results of the above, demonstrating the validity of the study's findings.

5.2. Robustness test

We carried out the subsequent robustness tests to confirm the results' dependability. First, the sample of financial, energy and

mining sectors were excluded before analysis. Second, we create a dummy variable CSR_i_Dum for CSR_i and assign a value of 1 to samples with above-average CSR performance and a value of 0 to samples with below-average CSR performance. Then use CSR_i_Dum instead of CSR_i for the test. The results of all these robustness tests are consistent with the above. The robustness tests' details are not reported due to space restrictions, but the results are maintained for reference.

6. Conclusion and discussion

6.1. Conclusion

The embedding of the party branch in private enterprises is a unique feature of the Chinese economic system. This article explores the effect of party branches on the CSR performance of private enterprises in China and makes an effort to explain the mechanisms based on data from the 11th Chinese Private Enterprise Survey (CPES). We found that, first, the embedding of party branches will alleviate information asymmetry, improve the CSR performance of private enterprises in multiple dimensions by enhancing the perception of private enterprises in policy. Second, in various influence pathways, the party branches will enhance the perceptions of policy related to economic interests, which has a more significant impact on enhancing the performance of philanthropic CSR. Further research reveals that business owners' first-given and later-generated political connections support the party branches' perception of policies related to economic and social interests, respectively. After endogeneity and robustness are taken into account using propensity score matching and Heckman's two-step model, the aforementioned conclusions remain valid. This demonstrates that the party branch embedded into private enterprises effectively performs the anticipated "supervisory" and "leadership" roles, which influences the policy perception and enhances CSR performance.

In summary, the findings in this article demonstrate significant role that the Party branch plays in Chinese private enterprises and reveal how the Party branch will encourage private businesses to actively engage in CSR by improving their perceptions of the Party's policies. With the aid of these findings, we are able to comprehend the effects brought about by the Party branch's integration with private businesses inside China's distinctive political and economic systems. And they complement the findings of political economics research on post-communism and emerging economies and provide theoretical references.

6.2. Managerial implications

First, for businesses, building political connections is frequently advantageous for corporate growth, especially in emerging economies. Private businesses can increase their perception of policies and improve their performance by forming connections

with the government. Even while party branches cannot be established by corporations in the majority of countries, company owners can nonetheless overcome this obstacle by, for instance, developing personal relationships with government officials.

Second, although it appears to be impossible to do in most states, we found that it is feasible for the ruling party to boost the effectiveness of policies by forming party organization in firms. However, the ruling party can still influence businesses by, for example, strengthening their cooperation with them in order to increase their perception of the political party's policy proposals.

Finally, the public should encourage companies to engage in CSR activities. There is no doubt that CSR has benefited stakeholders, despite some studies showing that it is not driven entirely by altruism. The public can reward companies that demonstrate strong CSR performance to encourage such sustainable business, such as purchasing more of their products and services.

6.3. Limitations and future research directions

This study also has some limitations. For businesses, improving CSR performance comes at a high cost. If it goes beyond what is reasonable, it may have a negative impact on the operations and financial condition of the business. This study only reveals the effects and mechanisms of party branch promotion of CSR, but does not provide a comprehensive analysis of the overall impact of this behavior on the company. Despite the social externalities of CSR activities, it is undoubtedly detrimental if firms cater to bureaucracies at the expense of long-term growth under political intervention. For example, party branches may make mandatory donation requests to improve CSR performance, but this does not represent the true will of the companies. Entrepreneurs may also hope to structure political-business relations by conducting good CSR activities, thereby obtaining rent-seeking gains for the firm or seeking higher political status for themselves. In addition, there may also be multiple mechanisms for party branches to promote CSR. However, due to data limitations, this study was not able to analyze other possible mechanisms in detail. We ask these questions in the hope that future research will address them.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

This article was funded by the following projects: 1. National Natural Science Foundation of China Youth Project (Project No. 72102088); 2. Outstanding Doctoral Dissertation Publishing Project of National Social Science Fund (Project No. 2021FYB062); 3. Central Socialist University United Front High-end Think Tank Project (Project No.: ZK20210151).

Acknowledgments

Thanks to the experts in forums such as Camphor Economics Seminar for their comments on the revision of this article.

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OPEN ACCESS

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SPECIALTY SECTION

This article was submitted to
Organizational Psychology,
a section of the journal
Frontiers in Psychology

RECEIVED 05 October 2022

ACCEPTED 14 February 2023

PUBLISHED 02 March 2023

CITATION

Li H, Li Y and Sun Q (2023) The influence
mechanism of interlocking director network on
corporate risk-taking from the perspective of
network embeddedness: Evidence from China.
Front. Psychol. 14:1062073.
doi: 10.3389/fpsyg.2023.1062073

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The influence mechanism of interlocking director network on corporate risk-taking from the perspective of network embeddedness: Evidence from China

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The interlocking director network can not only help achieve low-cost information sharing and exchange learning among enterprises, but also provide essential resource support for corporate risk-taking behavior. This study aims to empirically analyze the impact, mechanism of action, and boundary of influence of interlocking director network (NET) on corporate risk-taking (RISK) using data of Chinese A-share listed companies from 2007 to 2020. The results show: (1) There is a significant positive correlation between NET and RISK, and the above results are still established after a series of robustness tests. (2) Mechanistic tests show that the NET can promote RISK through two channels: alleviating financing constraints and increasing R&D investment. (3) Further analysis reveals the promotion of NET on RISK is more significant in non-state-owned enterprises and enterprises with higher industry competition intensity. These findings have positive implications for the construction of an inter-enterprise interlocking director network and the enhancement of the risk-taking level.

KEYWORDS

interlocking director network, corporate risk-taking, financing constraints, R&D investment, industry competition intensity

1. Introduction

The outbreak of COVID-19 and the increasingly fierce global competition have brought unprecedented risks and challenges to the development of Chinese enterprises. In such an economic situation, enterprises must appropriately improve their level of risk-taking if they want to maintain competitive advantage and achieve long-term sustainable economic growth (Tran, 2019). Corporate risk-taking indicates the preference of enterprises for high-risk and high-return projects in the investment process, reflecting the analysis and selection of investment projects that can generate expected returns and cash flows but are fraught with uncertainty factors by enterprise managers (Min et al., 2015). The higher the level of corporate risk-taking, the more the enterprise tends to invest in high-risk, high net present value projects (Chong et al., 2018). As high-risk projects tend to generate higher expected returns than low-risk projects, a reasonable level of corporate risk-taking is an important reference for maintaining long-term competitiveness and increasing the long-term value of enterprises. A considerable amount of research has shown that the level of corporate risk-taking is one of the fundamental forces that

drive long-term and high-quality economic growth (Boubakri et al., 2013; Faccio et al., 2016). From the microcosmic view, higher risk-taking helps enterprises obtain more profits and wealth, maintain long-term competitive advantage, and improve the value and capital allocation efficiency of enterprises (Li et al., 2021). From the macroscopic view, corporate risk-taking is conducive to promoting technological progress, accelerating social capital accumulation, upgrading industrial structure and improving social productivity (Habib and Hasan, 2017). However, some scholars have attributed the root causes of the United States financial crisis to excessive risk-taking, arguing that excessive risk-taking can lead to more serious economic consequences (Xiaorong and Ruijun, 2014).

As an important informal institutional arrangement, the network relationships embedded in social networks have built a channel for enterprises to share scarce resources and exchange heterogeneous information. In recent years, research on social networks has received increasing attention in the field of organizational psychology. Traditional organizational psychology research has focused on the attributes of actors in organizations in isolation, i.e., the capabilities and characteristics of actors. In contrast, contemporary scholars focus on the relationships among actors in organizations, i.e., how actors use relational network opportunities to gain appropriate social capital, which in turn ultimately influences the organization's own behavior and decisions (Brass, 2012). Corporate risk-taking has a strong resource dependence, which is not only influenced by the subjective willingness of decision-makers to take risks, but also by the objective limitations on the enterprise's ability to access resources (Ferris et al., 2019). In addition, high-risk projects often require more start-up capital, and the ability of enterprises to access external resources and the level of financing constraints they face can affect the attitude of their managers toward risk. Relevant psychological studies point out that social capital plays an important role in influencing the behavior and decisions of firms (Lazarova and Taylor, 2009). Given that social capital embedded in social networks can provide the necessary resources to support corporate risk-taking, this paper focuses on the impact of social networks in the form of interlocking directors on corporate risk-taking by studying the following questions: (i) Can NET significantly improve RISK? (ii) Through what channels does NET play a role in RISK? (iii) Is there any difference in the impact of NET on RISK for enterprises with different ownership nature and industry competition intensity?

In order to answer the above questions, based on the network embeddedness perspective and using the data of Chinese A-share listed firms from 2007 to 2020 as a sample to construct the interlocking director network of listed companies, in this study, we systematically examine the influence of network centrality indicators and structural hole richness of NET on RISK. It is found that NET can indeed significantly enhance RISK, and the higher the network centrality and the richer the structural holes, the higher the level of RISK. Financing constraints and R&D investment play a mediating role in the process of NET influencing RISK. The NET can enhance RISK: by alleviating financing constraints and increasing R&D investment. Further subdividing the nature of corporate ownership and the intensity of industry competition, it is found that the promotion effect of NET on RISK is more significant in non-state-owned firms and firms with higher industry competition intensity.

Compared with the existing literature, the main innovations and contributions of this paper mainly lie in three aspects. First, it expands

the research perspective on the economic consequences of interlocking director network and the influencing factors of corporate risk-taking. Current research has focused on the influence of interlocking director network on enterprise innovation (Chuluun et al., 2017; Jiang et al., 2020), enterprise strategic decision-making (Deutsch et al., 2011; Zou et al., 2019), enterprise value (Larcker et al., 2013; Zona et al., 2018) and corporate social responsibility (Xiaoqing et al., 2020), and less attention has been paid to the important role played by interlocking director network, an informal social network relationship, in corporate risk-taking. In addition, most of the literature on the influencing factors of corporate risk-taking is based on the principal-agent theory framework, and scholars have studied the impact of enterprise characteristics (Peltomäki et al., 2021), corporate governance (Nakano and Nguyen, 2012; Sila et al., 2016; Gopalan et al., 2021), managers' characteristics (Zhu and Chen, 2015; Ferris et al., 2019) and relevant systems and policies (Li et al., 2013; Langenmayr and Lester, 2018) on corporate risk-taking from the micro-level and external macro-environment. This paper, however, takes a new perspective of social network embeddedness and uses network centrality and structural hole richness indicators to study the impact of NET on RISK, extending the research perspective on the influencing factors of corporate risk-taking. Second, compared with Su and Liu's study, this paper further analyses and tests the influence mechanism of NET on RISK by introducing two mediating variables, namely financing constraints and R&D investment, which makes the influence channel of NET on RISK clearer and more complete, and provides some theoretical reference and empirical basis for promoting the improvement of corporate risk-taking under the background of economic transformation (Su and Liu, 2019). Third, the ability of enterprises to access resources varies across different nature and competitive environments. Therefore, based on Su and Liu's research, this paper further reveals the boundary conditions of the influence of NET on RISK from the perspective of the nature of the ownership and the intensity of industry competition, which is helpful for enterprises to take appropriate risk investment behavior in the face of the complex and changeable market competition environment.

2. Theory and hypothesis

2.1. Interlocking director network and corporate risk-taking

According to resource dependency theory, an important element of corporate risk-taking is access to abundant scarce resources and critical information (Zona et al., 2018). Previous studies have shown that the social network of enterprises is beneficial for enterprises to obtain relevant knowledge, experience and information resources required for risk-taking behavior (Dbouk et al., 2020). As an important social network relationship, the interlocking director network is a direct or indirect inter-enterprise network established by directors who serve on the boards of two or more enterprises at the same time through cross-servicing (Bianchi et al., 2020). At present, most scholars describe the position of enterprises in the network from two aspects: centrality and structural holes. "Centrality" mainly describes whether an enterprise is near the center or the edge of the network. The "structural hole" is a bridge for two enterprises that have no direct connection. Because the position of enterprises in the network is an

important factor determining their ability to obtain resources, this study mainly uses centrality and structural holes to explain the impact of NET on RISK. Interlocking directors establish a connection between the internal organization and the external market environment by serving on the boards of multiple corporations, which provides enterprises with rich heterogeneous resources and an important channel for information sharing (Deren and Yunsen, 2012). Based on the existing literature, the influence of NET on RISK is mainly reflected in the governance effect and resource effect.

In terms of governance effect, the existence of agency problems will reduce the level of RISK. For the sake of self-interest, managers are more likely to adopt a relatively stable investment strategy to avoid personal wealth loss, dismissal risk and professional reputation loss caused by investment failure (John et al., 2008). The interlocking director network can influence the ability of corporate risk-taking through the function of the board of directors. On the one hand, interlocking directors can use their central position in the network to gain more information, resources and knowledge of governance behavior, which can enhance their decision-making influence on the board of directors and accumulate more personal reputation capital for them (Larcker et al., 2013). This reputation capital will strengthen their supervision effect and make them more motivated and stricter to restrain and supervise the self-interest and rent-seeking behavior of managers, which further eases the agency conflict of enterprises. When the agency conflict is alleviated, enterprise managers are more willing to invest in venture capital projects that contribute to corporate growth and have a positive net present value to enhance the level of RISK. On the other hand, interlocking directors at the center of the network and occupying the position of structural holes can provide enterprises with more abundant and diversified information resources. These heterogeneous information resources are conducive to enhancing directors' right to advise on company management decisions, and help managers make more informed risk investment decisions (Chao and Jianjun, 2018). Relevant psychological research shows that enterprises can gain social capital such as knowledge and experience by observing and emulating the superior strategic behavior of partners in the network, which helps them make better decisions (Xie et al., 2020; Tian et al., 2021).

In terms of resource effect, risk-taking is a resource-consuming activity (Ferris et al., 2019). The social capital and information channels brought by the interlocking director network can alleviate the dependence of corporate risk-taking behavior on external resources and help improve the level of risk-taking. First, as an informal institutional arrangement, the interlocking director network has the advantages of low connection cost, stable connection and effective connection, which can help companies obtain more resources at a lower cost (Larcker et al., 2013). Specifically, the higher the centrality of the interlocking director network of a company, the more relationships it establishes with other companies, the shorter the transmission path of information and resources, and the faster the company has access to core resources and effective information. In addition, enterprises occupying structural holes function as information dissemination "bridges" in the network, which can connect enterprises that are not directly connected to access heterogeneous resources and key information needed for risk-taking behavior (Tortoriello, 2015). Second, the root of the resource constraint problem faced by enterprises lies in the information asymmetry among enterprises. Enterprise relationship network

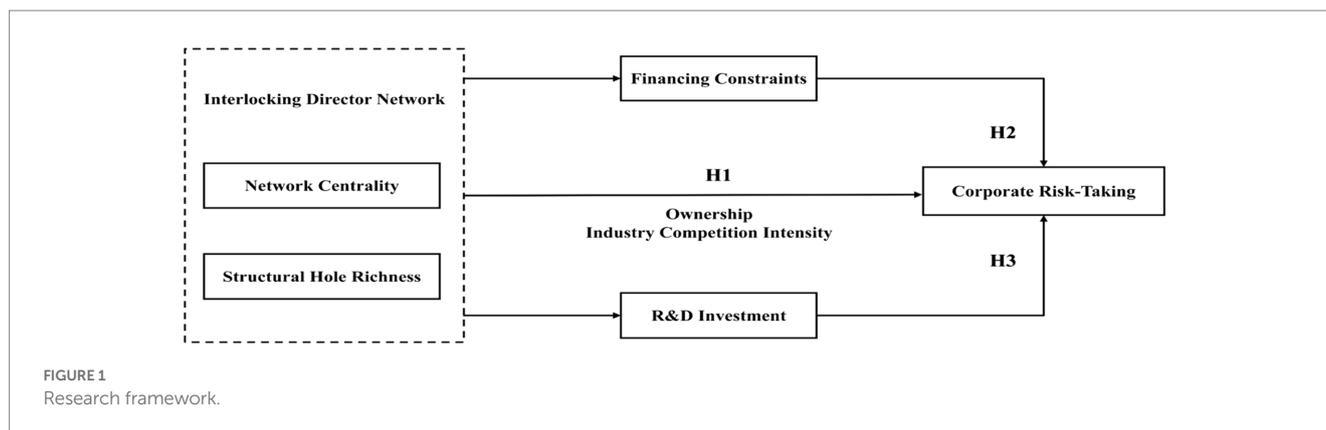
embedding can accelerate the rapid transmission and flow of information among enterprises, increase the frequency of information communication and resource-sharing opportunities, reduce the information asymmetry in the investment process and create more venture capital projects and strategic implementation platforms for enterprises. Accordingly, Hypothesis 1 is proposed:

H1: Interlocking director network is positively related to corporate risk-taking. The higher the centrality or the richer the structural holes, the higher the level of risk-taking.

2.2. The mediating effect of financing constraints

As an important factor restricting the development of enterprises, financing constraints have been the focus of academic research. Studies have shown that the interlocking director network can alleviate the financing constraints of enterprises through the advantage of network location (Xiaoqing et al., 2020). For one thing, the embedding of the interlocking director network relationship provides information channels for enterprises to communicate with the outside world, which can alleviate the information asymmetry between enterprises and fund providers, help enterprises obtain more external funds and financing channels at a lower cost, and reduce the difficulty of external financing. Wang et al. (Ying and Tingqiu, 2014) found the embedding of the director network is beneficial to increase the ability of enterprises to obtain debt financing. The higher the network centrality of the enterprise, the more access to debt resources and information, and the lower the cost of debt financing. The work of Chuluun et al. (2014) suggested that the information transmission function of the director network is beneficial in reducing the financing constraints arising from information asymmetry between the enterprise and external creditors. For another, the interlocking director network can also affect the efficiency of corporate governance. Gertler (1989) pointed out that agency problems will affect the level of corporate financing constraints. The social capital and reputation capital brought by the interlocking director network to the enterprise can reduce management's agency problems, improve corporate governance efficiency and alleviate the financing constraints of the enterprise.

The venture capital projects of enterprises are characterized by long investment cycles, large capital investments and many uncertainties, which means that enterprises need sufficient resources to support the investment process. However, the financing constraints faced by enterprises in the investment process will restrict the ability of enterprises to obtain resources and reduce the level of corporate risk-taking. Yan et al. (Ruosen et al., 2020) found that enterprises with higher financing constraints will tend to avoid high-risk investment projects in order to increase the success rate of loans, which will reduce corporate risk-taking. However, enterprises can use their location advantage in the social network to access resources and alleviate financing constraints. Enterprises with higher network centrality and richer structural holes will have a stronger ability to access information and resources (Xiaoqing et al., 2020). Therefore, the interlocking director network of enterprises can help enterprises obtain the resources required for venture capital investment at a lower



financing cost and improve the level of corporate risk-taking. On this basis, Hypothesis 2 is proposed:

H2: Financing constraints play a mediating role in the relationship between NET and RISK. The NET can improve RISK by reducing financing constraints.

2.3. The mediating effect of R&D investment

Corporate R&D activities are a high-risk, high-return strategic behavior with high requirements for innovative resources and information. Resource allocation and R&D decisions of enterprises are often decided by the board of directors, in which interlocking directors play an important role in this process. Interlocking directors are a reliable and low-cost network of inter-enterprise relationships where enterprises can exchange resources and share information to obtain the resources and information flow needed for R&D activities (Jiang et al., 2020). Network centrality and structural holes are key indicators to measure the network position of interlocking directors. Compared with enterprises at the edge of the network, enterprises occupying the central position of the network are more likely to obtain new information and new resources related to R&D activities (Ying and Guangli, 2018). These new information and resources help to promote technology exchange among enterprises, reduce the cost of trial-and-error and investment risks of enterprise innovation and R&D, and increase the motivation of enterprise R&D investment. Generally speaking, enterprises in the structural hole position possess a large amount of heterogeneous information and resources, which can be integrated and utilized to increase the motivation for enterprises to invest in R&D.

The R&D investment of enterprises is strongly related to the level of risk-taking (Dewett, 2007). In general, enterprises with more R & D investment have a stronger risk appetite. Banerjee and Gupta (2019) found that the R&D investment of enterprises will significantly promote the level of risk-taking. Therefore, it is important for enterprises to appropriately increase their risk-taking level once they are involved in investment decisions related to R&D projects. However, the R&D investment of enterprises is an investment with high risk, long cycle, and uncertain return. Only when enterprises obtain new resources and information from the outside for a long time

can they ensure the smooth progress of R&D projects (Ying and Guangli, 2018). The key technical resources and rich technical experience brought by the interlocking director network are conducive to prompting managers to increase the R&D investment intensity of enterprise innovation activities and enhance the level of risk-taking. Therefore, hypothesis 3 is proposed:

H3: R&D investment plays a mediating role in the relationship between NET and RISK. The NET can improve RISK by increasing corporate R&D investment.

In summary, the overall research framework of this paper is shown in Figure 1.

3. Data and research method

3.1. Sample and data

Considering that the China Securities Regulatory Commission regulated the R&D expenditure of listed companies in 2007, we selected the data of Chinese A-listed companies from 2007 to 2020 as the research sample. In order to prevent the interference of heterogeneous factors, the sample data were processed as follows: (1) excluding the sample of companies in the financial and insurance industries; (2) excluding ST, PT and delisted samples; (3) excluding the sample with missing data concerning financial or governance; and (4) considering the influence of abnormal values, the main continuous variables were tailed (winsorize) at the upper and lower 1% levels. Finally, a total of 19,689 annual-firm data were obtained. The data of corporate risk-taking and R&D investment in this study were obtained from the WIND database, the data of the interlocking director network and other listed companies' finance and governance were obtained from the CSMAR database, and the data of GDP growth rate was from China Statistical Yearbook. In order to ensure the accuracy and completeness of the data to the greatest extent, the CSMAR database was used to check and supplement the R&D investment data.

Regarding the data related to the NET, this study first obtained the employment data of directors of listed companies from the personal characteristic files in the CSMAR database, and excluded the samples of non-directors who held positions in other listed companies. Next, we used the programming function of PYTHON software to convert the "2-mode" matrix of "director-company" into the "1-mode" matrix

of “company-company.” If two companies have the same director, the elements of the matrix are recorded as 1, or else 0. Then, the matrix of each year was imported into UCINET and converted into a net file that could be recognized by PAJEK. Finally, we used PAJEK software to calculate the network centrality and structural hole indicators by year.

3.2. Variable definition

3.2.1. Dependent variable

Based on the studies of Faccio et al. (2016) and Li et al. (Wenggui and Minggui, 2012), we used the volatility of corporate surplus to measure the level of RISK. Since executive tenure in Chinese listed companies is typically 3 years, this study used every 3 years ($t-2, t$) as an observation period. To eliminate the effects of industry and economic cycles, we calculated the standard deviation (RISK1) and extreme deviation (RISK2) of return on assets adjusted by the industry and annual average to measure RISK, respectively. In addition, because of the large number of manufacturing companies in China, we refined the industry categorization of manufacturing companies to secondary codes and removed the sample of only one company in the industry. The specific calculation process of corporate risk-taking can be seen in the following equation:

$$Adj_Roa_{i,t} = \frac{EBIT_{i,t}}{ASSET_{i,t}} - \frac{1}{X} \sum_{k=1}^X \frac{EBIT_{k,t}}{ASSET_{k,t}} \tag{1}$$

$$RISK1_{i,t} = \sqrt{\frac{1}{T-1} \sum_{t=1}^T \left(Adj_Roa_{i,t} - \frac{1}{T} \sum_{t=1}^T Adj_Roa_{i,t} \right)^2} \Big| T=3 \tag{2}$$

$$RISK2_{i,t} = \max(Adj_Roa_{i,t}) - \min(Adj_Roa_{i,t}) \tag{3}$$

where $Adj_Roa_{i,t}$ represents the return on assets adjusted by the industry and annual average; EBIT is the profit before interest and tax; ASSET is the total assets at the end of the year; the subscripts i indicates the company and t indicates the year; X and k respectively represent the total number of enterprises in a certain industry and the k -th enterprise in the industry; $T = 3$ represents a 3-year observation period.

3.2.2. Independent variables

The independent variables in this study are the centrality and structural holes of NET. Network centrality focuses on the self-directed connected nature of a company, and to some extent reflects the importance and influence of that company in the overall network. Previous studies mostly used three indicators: degree centrality, closeness centrality and betweenness centrality. However, the closeness centrality has higher requirements on the network, and it can only be done when the network is completely connected, so this indicator is rarely used. Therefore, drawing on the methods of Xie and Chen (Deren and Yunsen, 2012), we adopted two indicators, degree centrality (Degree) and betweenness centrality (Betweenness), to

measure the centrality of interlocking directors of listed companies in the overall network. The calculation formula is shown below:

$$Degree_i = \frac{\sum_{j \neq i} X_{ij}}{g-1} \tag{4}$$

where i is the focal company and j is other companies other than i in that year; X_{ij} is a network connection, if company i and j have at least one interlocking director, the $X_{ij} = 1$, or else $X_{ij} = 0$; g is the total number of companies in the network, and due to the year difference, $(g-1)$ is used in this paper to eliminate the effect of the network size difference.

$$Betweenness_i = \frac{\sum_{j < k} g_{jk(n)} / g_{jk}}{(g-1)(g-2)/2} \tag{5}$$

where g_{jk} is the number of shortest paths between company j and k ; $g_{jk(n)}$ is the number of shortest paths between company j and k , and through company i ; g is the number of companies in the interlocking director network, and $(g-1)(g-2)/2$ is used to eliminate the effect of the network size difference of listed companies.

Different from network centrality, structural holes focus more on the non-redundant connections between two actors. As shown in Figure 2A, four independent individual actors A, B, C, and O have direct connections (represented by solid lines) between them, and each actor has the same positional advantage in the network and the same access to resources and information, so there is no structural hole in this network. However, in contrast, see Figure 2B, there is no direct connection between the three actors A, B, and C (indicated by dashed lines), but there is a direct connection between actor O and A, B, and C. At this time, O becomes the only channel for communication among A, B, and C. The flow direction of information and resources in the network is controlled by O, and O occupies the structural hole position in the whole network.

The calculation methods of the structural hole index include effective size, efficiency, constraint and hierarchy, among which the constraint index is more widely used. Following the study of Tortoriello (2015), this paper measured the richness of the structural holes (SH) of the interlocking director network by the difference between 1 and Constraint. SH is calculated as follows:

$$SH_i = 1 - \left(P_{ij} + \sum_q P_{iq} P_{qj} \right)^2, q \neq i, j \tag{6}$$

where P_{ij} represents the direct connection strength between company i and company j ; $\sum_q P_{iq} P_{qj}$ is the sum of the strength of the indirect connection between company i and company j where passing through company q is the only way; $\left(P_{ij} + \sum_q P_{iq} P_{qj} \right)^2$ represents the degree to which company i is constrained by company j . The larger the SH, the richer the structure holes of the interlocking director network.

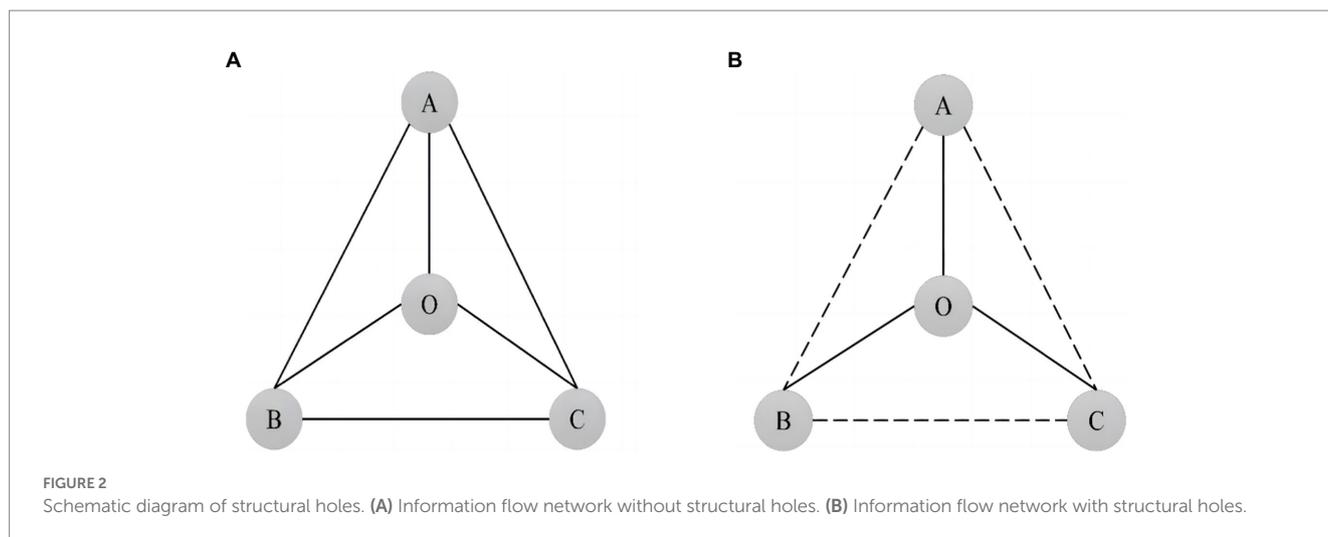


TABLE 1 Definition and description of main variables.

Type	Name	Code	Definition
Dependent variable	Corporate risk-taking	RISK1	Standard deviation calculated from Equation (2)
		RISK2	The extreme deviation calculated from Equation (3)
Independent variables	Degree centrality	Degree	See Equation (4), calculated by PAJEK software
	Betweenness centrality	Betweenness	See Equation (5), calculated by PAJEK software
	Structural hole richness	SH	See Equation (6), calculated by PAJEK software
Control variables	Firm size	Size	Natural logarithm of total assets at the end of the year
	Leverage level	Lev	Total liabilities/total assets
	Firm Age	Age	Natural logarithmic of listing age plus one
	Ownership concentration	Top1	Shareholding proportion of the largest shareholder at the end of the year
	Profitability	ROA	Net profit/total assets
	Firm growth	Growth	Sales revenue growth rate
	Capital expenditure level	Cap	Capital expenditure/total assets
	GDP growth rate	Gdp	GDP growth rate, data from China Statistical Yearbook

3.2.3. Control variables

Based on the studies of Zhang et al. (Min et al., 2015) and Boubakri et al. (2013), this study selected firm size (Size), leverage level (Lev), firm age (Age), shareholding proportion of the largest shareholder (Top1), profitability (ROA), firm growth (Growth), capital expenditure level (Cap) and GDP growth rate (Gdp) as control variables. The details are reported in Table 1.

3.3. Model setting

In order to test the effect of NET on RISK, the following regression model was constructed to test hypothesis H1:

$$RISK_{i,t} = \alpha_0 + \alpha_1 NET_{i,t} + \alpha_2 Controls_{i,t} + \sum Company_i + \sum Year_t + \epsilon_{i,t} \quad (7)$$

where i and t represent company and year respectively; NET denotes the relevant measurement indicators of interlocking director network, specifically including Degree, Betweenness and SH; Controls represents all control variables in Table 1; $Company$ and $Year$ respectively represents individual and year fixed effects; ϵ is the error term that is assumed to be normally distributed with zero mean value and constant variance (Elahi et al., 2021). This paper used the two-way fixed effects model of panel data to estimate, and further conducted clustering processing at the company level.

In order to further explore the influence mechanism of NET on RISK, this paper introduces two mediating variables, financing constraint and R&D investment, and drawing on the application of the mediating effect test by Wen et al. (Zhonglin et al., 2004), the following mediating effect model is constructed on the basis of Equation (7) to test hypothesis 2 and hypothesis 3:

$$SA / R \& D_{i,t} = \gamma_0 + \gamma_1 NET_{i,t} + \gamma_2 Controls_{i,t} + \sum Company_i + \sum Year_t + \epsilon_{i,t} \quad (8)$$

TABLE 2 Descriptive statistics of main variables.

Name	Code	N	Mean	SD	Median	Min	Max
Corporate risk-taking	RISK1	19,689	0.0321	0.0428	0.0189	0.0001	0.4565
	RISK2	19,689	0.0606	0.0796	0.0361	0.0001	0.9065
Degree centrality	Degree	19,689	0.0013	0.0008	0.0011	0.0002	0.0043
Betweenness centrality	Betweenness	19,689	0.0016	0.0022	0.0008	0.0000	0.0114
Structural hole richness	SH	19,689	0.5354	0.2393	0.6039	0.0000	0.9110
Firm size	Size	19,689	22.2491	1.2707	22.0707	19.9096	26.2497
Leverage level	Lev	19,689	0.4374	0.1980	0.4323	0.0624	0.8927
firm age	Age	19,689	2.2529	0.6445	2.3026	1.0986	3.2958
Ownership concentration	Top1	19,689	0.3411	0.1445	0.3196	0.0903	0.7349
Profitability	ROA	19,689	0.0338	0.0664	0.0341	-0.2918	0.2006
Firm growth	Growth	19,689	0.1718	0.4166	0.1056	-0.5109	2.7446
Capital expenditure level	Cap	19,689	0.0484	0.0438	0.0354	0.0008	0.2137
GDP growth rate	Gdp	19,689	6.7699	2.2185	6.9500	2.2400	14.2300

$$RISK_{i,t} = \beta_0 + \beta_1 NET_{i,t} + \beta_2 SA / R \& D_{i,t} + \beta_3 Controls_{i,t} + \sum Company_i + \sum Year_t + \varepsilon_{i,t} \quad (9)$$

where SA indicates the measure of financing constraint, and drawing on the method of Li et al. (Xiaoqing et al., 2020), the absolute number of the SA index, which is constructed based on the two variables of Size and Age with little change over time and high exogeneity, is used to calculate the level of financing constraint, and the SA index is constructed in the way shown in Equation (10). The larger the absolute number of SA index, the more serious the degree of financing constraint of the enterprise; R & D indicates the measure of corporate R&D investment, and this paper adopts the relative indicator-R&D investment intensity, the proportion of R&D expenditure to operating revenue, by referring to Yan et al.'s research (Ruosen et al., 2020).

$$SA = -0.737Size + 0.043Size^2 - 0.040Age \quad (10)$$

4. Results and discussion

4.1. Descriptive statistics

Table 2 represents the results of descriptive statistics for the main variables. The mean value (standard deviation) of RISK1 and RISK2 is 0.0321 (0.0428) and 0.0606 (0.0796) respectively. The standard deviations of both are greater than the mean, indicating that the level of corporate risk-taking among different companies is quite different. The mean (median) of Degree and Betweenness is 0.0013 (0.0011) and 0.0016 (0.0008) respectively, and the maximum (minimum) value is 0.0043 (0.0002) and 0.0114 (0.0000) respectively, indicating that although most listed companies in China have established interlocking director network, the degree of network connection varies greatly. In addition, the mean value of SH is 0.5354, which is much larger than the mean value of the network centrality index, and the difference

between the maximum value and the minimum value is 0.9110, which indicates that compared with the network centrality indicator, the structural hole richness of interlocking director network varies more significantly between listed companies.

4.2. Correlation analysis

Table 3 presents the Pearson correlation coefficient matrix of the main variables. It can be seen that the four indicators of interlocking director networks (Degree, Betweenness and SH) are significantly and positively correlated ($p < 0.01$) with the level of corporate risk-taking (RISK1 and RISK2), which is consistent with the prediction of H1 in this paper. The significant results of control variables and RISK are generally consistent with the findings of Zhang et al. (Min et al., 2015) and Faccio et al. (2016). In addition, the correlation coefficient between the control variables is less than 0.5, which indicates that the possibility of collinearity in the model is low.

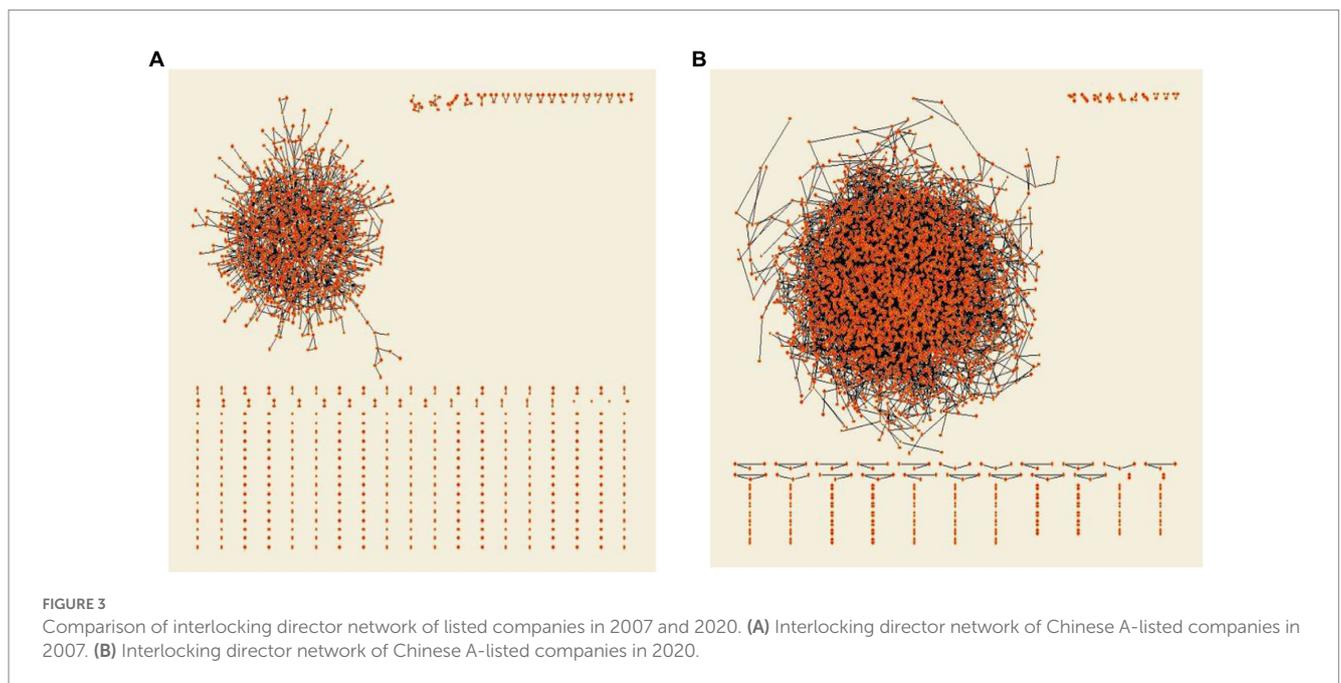
4.3. Interlocking director network characteristics

In order to describe the distribution structure and aggregation degree of the interlocking director network of Chinese listed companies more intuitively, as well as the dynamic changes of the interlocking director network over time, this paper used PAJEK software to visualize the interlocking director network of Chinese listed companies in 2007 (A) and 2020 (B) respectively, as shown in Figure 3. Observing Figure 3A, it can be found that in 2007, the interlocking director network of Chinese listed companies has already reached a certain scale, and most companies have entered the largest connected sub-network in the network, but there are still many companies in a free state. Continuing to observe Figure 3B, it can be seen that in 2020, the scale of the largest connected sub-network of the interlocking director network of Chinese listed companies has further expanded significantly, and there are few isolated nodes, which indicates that the structure of the interlocking director network of

TABLE 3 Pearson correlation coefficient matrix.

	RISK1	RISK2	Degree	Betweenness	SH	Size	Lev	Age	Top1	ROA
RISK1	1									
RISK2	0.998***	1								
Degree	0.072***	0.071***	1							
Betweenness	0.050***	0.050***	0.800***	1						
SH	0.036***	0.036***	0.733***	0.637***	1					
Size	-0.161***	-0.163***	0.103***	0.190***	0.182***	1				
Lev	0.057***	0.056***	0.097***	0.092***	0.075***	0.453***	1			
Age	0.084***	0.084***	0.072***	0.131***	0.126***	0.414***	0.323***	1		
Top1	-0.134***	-0.133***	0.053***	0.032***	0.015**	0.231***	0.072***	-0.049***	1	
ROA	-0.392***	-0.386***	0.058***	0.043***	0.021***	0.038***	-0.329***	-0.130***	0.128***	1
Growth	0.039***	0.038***	0.027***	0.004	0.010	0.036***	0.021***	-0.077***	0.0100	0.229***
Cap	-0.087***	-0.087***	0.055***	0.026***	-0.010	-0.002	-0.037***	-0.218***	0.036***	0.138***
Gdp	-0.108***	-0.108***	0.321***	0.121***	0.005	-0.137***	0.050***	-0.089***	0.079***	0.066***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.



Chinese listed companies has become more complex and closer as time goes on.

4.4. Baseline regression results

Table 4 reports the baseline regression results of the impact of NET on RISK. Columns (1)–(4) use the network centrality indicator, and columns (5) and (6) use the structural hole richness indicator. Table 4 shows that the interlocking director network centrality indicator (Degree, Betweenness and SH) positively affects corporate risk-taking (RISK1 and RISK2) at the 1% significance level, and the structural hole richness positively affects corporate risk-taking at the 5% level, which indicates that the higher the network centrality and

the richer the structural hole, the higher the level of corporate risk-taking. Accordingly, H1 is supported.

The regression results for the control variables in Table 4 are generally consistent with studies of Li et al. (Wengui and Minggui, 2012) and Zhang et al. (Min et al., 2015): the coefficient of Size is significantly negative, indicating that small firms have a stronger risk appetite; the estimated coefficient of Lev is significantly positive, indicating that the higher the level of debt, the higher the level of risk-taking; the regression coefficient of Age is significantly positive, indicating that the longer the firm has been listed, the higher the level of risk-taking; the coefficient of ROA is significantly negative, indicating that the less profitable the firm is, the more it wants to improve its profitability through risk-taking behavior; the regression coefficient of Growth is significantly positive, indicating that the more

TABLE 4 Interlocking director network and corporate risk-taking.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)
		RISK1	RISK2	RISK1	RISK2	RISK1	RISK2
Degree centrality	Degree	1.432***	2.713***				
		(2.76)	(2.78)				
Betweenness centrality	Betweenness			0.497***	0.929***		
				(2.87)	(2.87)		
Structural hole richness	SH					0.004**	0.008**
						(2.50)	(2.51)
Firm size	Size	-0.020***	-0.038***	-0.021***	-0.039***	-0.020***	-0.039***
		(-11.48)	(-11.46)	(-11.51)	(-11.49)	(-11.49)	(-11.47)
Leverage level	Lev	0.038***	0.071***	0.038***	0.072***	0.038***	0.071***
		(5.51)	(5.58)	(5.52)	(5.58)	(5.50)	(5.57)
Firm age	Age	0.017***	0.033***	0.018***	0.033***	0.018***	0.033***
		(5.85)	(5.87)	(5.87)	(5.88)	(5.88)	(5.90)
Ownership concentration	Top1	-0.013	-0.024	-0.013	-0.024	-0.013	-0.023
		(-1.44)	(-1.36)	(-1.44)	(-1.36)	(-1.42)	(-1.35)
Profitability	ROA	-0.213***	-0.384***	-0.213***	-0.385***	-0.213***	-0.384***
		(-17.95)	(-17.50)	(-17.97)	(-17.52)	(-17.94)	(-17.49)
Firm growth	Growth	0.006***	0.011***	0.006***	0.011***	0.006***	0.011***
		(5.30)	(5.26)	(5.32)	(5.28)	(5.29)	(5.25)
Capital expenditure level	Cap	-0.011	-0.025	-0.011	-0.025	-0.011	-0.024
		(-1.08)	(-1.28)	(-1.09)	(-1.30)	(-1.05)	(-1.26)
GDP growth rate	Gdp	-0.001***	-0.002***	-0.001***	-0.002**	-0.001**	-0.002**
		(-2.81)	(-2.77)	(-2.62)	(-2.58)	(-2.51)	(-2.47)
Constant	Cons	0.459***	0.862***	0.460***	0.865***	0.458***	0.860***
		(11.51)	(11.49)	(11.54)	(11.52)	(11.50)	(11.47)
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	N	19,689	19,689	19,689	19,689	19,689	19,689
Goodness of fit	Adj. R ²	0.249	0.246	0.249	0.246	0.249	0.246
F-value	F	38.81***	39.36***	38.76***	39.31***	38.74***	39.30***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *T*-statistics are listed in parentheses, which have been clustered at the company level, and the following table is the same. Estimates of control variables are omitted from subsequent tests due to space constraints.

growth opportunities the firm has, the more it tends to increase its level of RISK in order to make full use of investment opportunities; the regression coefficient of Gdp is obviously negative, indicating that overheating economy will reduce the risk tolerance of firms.

4.5. Robustness tests

4.5.1. Endogeneity test

Although the panel data fixed effects model used in this study can control for partial omitted variable bias, the above regression analysis may also suffer from the endogeneity problem due to reverse causality. Enterprises with higher risk-taking level may be more likely to attract interlocking directors who are at higher network centrality and occupy more structural holes to serve. Therefore, in order to mitigate the

potential endogeneity problem, we adopted the two-stage least squares (2SLS) method to re-examine the baseline regression results. Based on Wang et al. (Yongqing et al., 2019), we chose one-period lagged indicators of network centrality and structural holes as instrumental variables (IV), and the results are shown in Table 5. In the first stage, the coefficients of the IV are significantly positive, and the K-P rk LM statistic rejects the hypothesis of “under-identification of instrumental variables” at the 1% level, indicating that there is no under-identification problem. The C-D Wald F and K-P rk Wald F statistics for testing weak instrumental variables are both much larger than the critical value of 16.38 at the 10% significance level, indicating that there is no problem of weak instrumental variables. In addition, since the number of selected instrumental variables is exactly equal to the number of endogenous variables, there is no over-identification problem. In summary, the selected instrumental variables are valid. In

TABLE 5 Regression results of the two-stage least squares (2SLS).

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)
		RISK1	RISK2	RISK1	RISK2	RISK1	RISK2
Degree centrality	Degree	3.479***	6.482***				
		(2.94)	(2.95)				
Betweenness centrality	Betweenness			1.303***	2.441***		
				(2.88)	(2.90)		
Structural hole richness	SH					0.013**	0.025**
						(2.44)	(2.51)
Constant	Cons	0.438***	0.822***	0.443***	0.832***	0.434***	0.816***
		(9.67)	(9.72)	(9.71)	(9.76)	(9.67)	(9.72)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	<i>N</i>	15,857	15,857	15,857	15,857	15,857	15,857
Goodness of fit	Adj. <i>R</i> ²	0.269	0.267	0.268	0.266	0.269	0.266
Results of the first stage	The first stage	0.449***		0.400***		0.349***	
Underidentification test	K-P rk LM statistic	1290.159***		645.574***		858.418***	
Weak identification test	C-D Wald <i>F</i> statistic	3782.805***		2672.932***		1832.166***	
	K-P rk Wald <i>F</i> statistic	2077.445***		935.649***		1081.699***	

K-P rk LM, Kleibergen-Paap rk LM statistic. C-D Wald *F*, Cragg-Donald Wald *F* statistic. K-P rk Wald *F*, Kleibergen-Paap rk Wald *F* statistic. **p*<0.1, ***p*<0.05, ****p*<0.01.

the second stage, the regression results in columns (1)–(6) show that the network centrality (Degree and Betweenness) and structural holes (SH) are significantly and positively correlated with RISK, which indicates that the contribution of NET to RISK still holds after controlling for possible endogeneity.

Although the endogeneity problem due to reverse causality could be controlled to a certain extent by adopting the 2SLS method, in order to avoid possible non-random interference of NET affecting RISK, this study further adopted the propensity score matching method (PSM) to further mitigate the endogeneity problem due to sample selection bias. Specifically, following Zhou et al.'s study (Xuefeng et al., 2021), the sample was divided into two groups based on the median of the centrality and structural holes representing the interlocking director network position, with the higher network position being the treatment group and the lower network position being the control group, and matched according to the 1:1 nearest neighbor matching method, with the matching variables containing all the control variables in Model 1. The matched sample was tested again and found that, after controlling for endogeneity caused by sample selectivity bias, interlocking director network position was still significantly and positively correlated with corporate risk-taking, again providing a robustness check for the previous findings (results omitted due to space constraints).

4.5.2. The replacement of dependent variable

To further verify the robustness of this paper, the level of corporate risk-taking was re-measured (RISK3 and RISK4) with an observation period of 5 years (*t*–4, *t*) by referring to the study of He et al. (Ying et al., 2019). At the same time, referring to Su's study (Kun, 2015), the volatility of stock returns (the logarithm of the standard deviation of

annualized daily returns and the logarithm of the standard deviation of annualized weekly returns) was also used to re-measure corporate risk-taking (RISK5 and RISK6). Tables 6 and 7 show the regression results for the alternative risk-taking indicators. As can be seen from columns (1) to (6), the regression coefficients of the NET on the above risk-taking indicators are still significantly positive.

4.5.3. The replacement of regression model

The data used in this paper is an unbalanced panel data, which may face the problem of residual autocorrelation due to time trends in addition to the cross-sectional correlation problem at the company level. Therefore, in order to mitigate the influence of intra- and inter-group serial correlation problems on the regression results, this paper further adopted a more robust estimation method with two-way clustering of company and year for the *t*-values in the regression analysis. The details are shown in Table 8. The estimation results in columns (1)–(6) show that the empirical results remain consistent with the main regression results after using the two-way clustering of company and year.

5. Influence mechanism analysis

The above findings suggest that the interlocking director network can enhance corporate risk-taking, and the findings remain robust after a series of robustness tests. In order to further analyze the influence mechanism of NET on RISK, this paper uses stepwise regression and Sobel test to verify whether financing constraints (SA) and R&D investment (R&D) play a mediating role in the process of NET impact on RISK.

TABLE 6 Indicator sensitivity test: changing the observation period.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)
		RISK3	RISK4	RISK3	RISK4	RISK3	RISK4
Degree centrality	Degree	1.326**	3.459***				
		(2.42)	(2.60)				
Betweenness centrality	Betweenness			0.477***	1.206***		
				(2.62)	(2.70)		
Structural hole richness	SH					0.004**	0.011***
						(2.51)	(2.73)
Constant	Cons	0.364***	0.861***	0.366***	0.866***	0.363***	0.858***
		(9.39)	(9.26)	(9.45)	(9.32)	(9.37)	(9.24)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	N	16,315	16,315	16,315	16,315	16,315	16,315
Goodness of fit	Adj. R ²	0.232	0.222	0.232	0.222	0.232	0.222
F-value	F	31.37***	32.52***	31.24***	32.37***	31.31***	32.52***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 7 Indicator sensitivity test: volatility of stock returns.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)
		RISK5	RISK6	RISK5	RISK6	RISK5	RISK6
Degree centrality	Degree	1.548**	3.140***				
		(2.57)	(2.90)				
Betweenness centrality	Betweenness			0.953***	1.562***		
				(2.82)	(2.76)		
Structural hole richness	SH					0.002**	0.010***
						(2.45)	(2.90)
Constant	Cons	-2.773***	-1.548***	-2.781***	-1.556***	-2.775***	-1.551***
		(-23.59)	(-10.50)	(-23.65)	(-10.53)	(-23.63)	(-10.53)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	N	16,293	16,293	16,293	16,293	16,293	16,293
Goodness of fit	Adj. R ²	0.580	0.490	0.580	0.490	0.580	0.490
F-value	F	1128***	780.9***	1134***	781.9***	1125***	780.2***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.1. The mediating effect of SA

Models (7)–(9) are used in this paper to verify the mediating role of SA and R&D in the process of interlocking director network affecting corporate risk-taking. Table 9 reports the test results of the mediating effect of SA. Columns (1), (4), (7) show the regression results of the effect of interlocking director network on financing constraints, the regression coefficients of Degree, Betweenness and SH are significantly negative at the 1% level, indicating that the embedding of interlocking director network is beneficial to reduce the level of financing constraints. Columns (2), (5), (8) and (3), (6), (9) demonstrate the

effects of Degree, Betweenness and SH on RISK1 and RISK2 after the inclusion of financing constraints, respectively. The coefficient of SA is significantly negative and the regression coefficients of Degree, Betweenness and SH are significantly positive and significantly smaller than the coefficients of the baseline regression results in Table 3, which indicates that there is a partial mediating effect of financing constraint between NET and RISK. In addition, in order to enhance the robustness of the results, the Sobel test is conducted on the basis of stepwise regression, and the test results are shown in the last row of Table 9. The Z value of the Sobel test is significantly positive ($p < 0.01$), which indicates that the mediating effect is robust. In summary, the

TABLE 8 Two-way cluster analysis of company and year.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)
		RISK1	RISK2	RISK1	RISK2	RISK1	RISK2
Degree centrality	Degree	1.432**	2.713**				
		(2.12)	(2.14)				
Betweenness centrality	Betweenness			0.497**	0.929**		
				(2.33)	(2.34)		
Structural hole richness	SH					0.004**	0.008**
						(1.98)	(2.02)
Constant	Cons	0.459***	0.862***	0.460***	0.865***	0.458***	0.860***
		(4.48)	(4.45)	(4.48)	(4.45)	(4.47)	(4.45)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	N	19,689	19,689	19,689	19,689	19,689	19,689
Goodness of fit	Adj. R ²	0.446	0.445	0.446	0.445	0.446	0.445

*p<0.1, **p<0.05, ***p<0.01.

TABLE 9 Results of the mediating effect of SA.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		SA	RISK1	RISK2	SA	RISK1	RISK2	SA	RISK1	RISK2
Degree centrality	Degree	-6.261***	1.199**	2.276**						
		(-5.50)	(2.29)	(2.31)						
Betweenness centrality	Betweenness				-2.712***	0.396**	0.740**			
					(-6.13)	(2.25)	(2.25)			
Structural hole richness	SH							-0.026***	0.003*	0.006*
								(-8.07)	(1.90)	(1.91)
Financing constraints	SA		-0.037***	-0.070***		-0.037***	-0.070***		-0.037***	-0.070***
			(-3.40)	(-3.41)		(-3.38)	(-3.39)		(-3.39)	(-3.40)
Constant	Cons	3.609***	0.593***	1.114***	3.599***	0.594***	1.115***	3.613***	0.560***	1.112***
		(37.83)	(9.51)	(9.54)	(37.84)	(9.53)	(9.55)	(38.05)	(9.94)	(9.51)
Control variables	Controls	Yes								
Company FE	Company	Yes								
Year FE	Year	Yes								
Observations	N	19,689	19,689	19,689	19,689	19,689	19,689	19,689	19,689	19,689
Goodness of fit	Adj. R ²	0.872	0.251	0.248	0.873	0.251	0.248	0.873	0.251	0.248
F-value	F	953.9***	37.26***	37.79***	959.4***	37.20***	37.73***	966.2***	37.19***	37.72***
Sobel-test	Sobel Z		5.892***	5.915***		6.226***	6.256***		6.282***	6.310***
	Sobel Z-p		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)

*p<0.1, **p<0.05, ***p<0.01.

interlocking director network can enhance corporate risk-taking by reducing financing constraints. Therefore, H2 is supported.

5.2. The mediating effect of R&D

Table 10 shows the results of the mediating effect of R&D. The regression coefficients in columns (1), (4), and (7) are significantly positive, indicating that the interlocking director network can promote

corporate R&D investment. Columns (2), (5), (8) and (3), (6), (9) demonstrate the regression results of the effect of NET on RISK when the mediating variable of R&D is added. The results show that the coefficients of R&D are significantly positive and the coefficients of the effects of Degree, Betweenness and SH on corporate risk-taking (RISK1 and RISK2) are reduced but are significantly positive at the 5% level (p<0.05). In addition, the Z value of the Sobel test is significant at the 1% level (p<0.01), which also demonstrates a partial mediating effect of R&D. Thus, interlocking director network can increase

TABLE 10 Results of the mediating effect of R&D.

Name	Code	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		R&D	RISK1	RISK2	R&D	RISK1	RISK2	R&D	RISK1	RISK2
Degree centrality	Degree	5.809***	1.248**	2.361**						
		(9.96)	(2.38)	(2.39)						
Betweenness centrality	Betweenness				2.165***	0.428**	0.797**			
					(6.54)	(2.43)	(2.42)			
Structural hole richness	SH							0.017***	0.004**	0.007**
								(12.13)	(2.15)	(2.16)
R&D investment	R&D		0.032**	0.061**		0.032**	0.061**		0.032**	0.061**
			(1.99)	(2.03)		(1.97)	(2.02)		(2.01)	(2.06)
Constant	Cons	0.086***	0.456***	0.857***	0.093***	0.457***	0.859***	0.082**	0.455***	0.855***
		(2.69)	(11.47)	(11.45)	(2.92)	(11.49)	(11.48)	(2.54)	(11.46)	(11.44)
Control variables	Controls	Yes								
Company FE	Company	Yes								
Year FE	Year	Yes								
Observations	N	19,689	19,689	19,689	19,689	19,689	19,689	19,689	19,689	19,689
Goodness of fit	Adj. R ²	0.0561	0.250	0.247	0.0571	0.250	0.247	0.0545	0.250	0.247
F-value	F	25.68***	37.23***	37.82***	24.77***	37.19***	37.79***	29.93***	37.17***	37.77***
Sobel-test	Sobel Z		4.363***	4.470***		4.382***	4.495***		4.353***	4.457***
	Sobel Z-p		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)

*p<0.1, **p<0.05, ***p<0.01.

corporate risk-taking by increasing R&D investment. On this basis, H3 is supported.

6. Further analysis

To further explore the differences in the relationship between NET and RISK in different situations, this paper explores whether there are significant differences in the effects of NET on RISK under the influence of the nature of the ownership and the intensity of industry competition from the enterprise and industry levels.

6.1. Grouping test for the nature of ownership

The nature of ownership is an important factor influencing corporate risk-taking (Sila et al., 2016). Because of the difference in ownership, there is a significant difference in the ability to access resources between state-owned and private enterprises. Compared to state-owned enterprises (SOEs), non-SOEs are smaller, subject to a higher degree of financing constraints, have a greater need for resources, and therefore have a greater need to access resources by resorting to the informal system of interlocking director network. SOEs, although they are more likely to obtain resources for risk-taking behavior through the interlocking director network, also tend to adopt a more prudent investment strategy due to their more severe government intervention. Therefore, this paper argues that the nature of ownership will weaken the positive effect of NET on RISK.

To test whether the above analysis is true, following the method of Li et al. (Wenggui and Minggui, 2012), this study groups the nature of ownership (SOE) of the sample enterprises according to the nature of the ultimate controller. If the final controller of the enterprise is a state-owned entity, it is a state-owned enterprise (SOE = 1), or else SOE = 0. The grouping regressions are shown in Table 9. Columns (1)–(3) are the regression results for the state-owned enterprises group, and columns (4)–(6) are the regression results for the non-SOEs group. From the regression results in Table 11, it is clear that in the SOEs group, the regression coefficients of the indicators related to the interlocking director network are not significant, while in the non-SOEs group, the coefficients of Degree, Betweenness, and SH are significantly positive, which indicates that the nature of ownership weakens the positive effect of NET on RISK. Compared with state-owned enterprises, the effect of NET on RISK is more significant in non-SOEs.

6.2. Grouping test for the intensity of industry competition

Corporate risk-taking is also influenced by the intensity of industry competition. On the one side, the industry competition can reduce the internal and external information asymmetry of enterprises, help enterprises to effectively unblock and improve the collection and transmission channels of relevant information, and alleviate the agency conflict of enterprises; on the other side, the fierce industry competition will accelerate the rapid flow of information between industries, reduce the level of financing constraints and increase the level of risk-taking of enterprises. The more competitive

TABLE 11 Further analysis of the nature of ownership.

Name	Code	RISK1					
		SOE=1			SOE=0		
		(1)	(2)	(3)	(4)	(5)	(6)
Degree centrality	Degree	0.326 (0.55)			1.743** (2.15)		
Betweenness centrality	Betweenness		0.211 (1.20)			0.599** (2.03)	
Structural hole richness	SH			0.002 (0.99)			0.005** (2.20)
Constant	Cons	0.403*** (7.50)	0.404*** (7.51)	0.403*** (7.51)	0.547*** (9.42)	0.548*** (9.43)	0.546*** (9.41)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	<i>N</i>	7,588	7,588	7,588	12,101	12,101	12,101
Goodness of fit	Adj. <i>R</i> ²	0.091	0.091	0.091	0.324	0.324	0.324
<i>F</i> -value	<i>F</i>	7.482***	7.392***	7.492***	39.58***	39.30***	39.29***

p*<0.1, *p*<0.05, ****p*<0.01.

TABLE 12 Further analysis of the intensity of industry competition.

Name	Code	RISK1					
		HHI=1			HHI=0		
		(1)	(2)	(3)	(4)	(5)	(6)
Degree centrality	Degree	0.344 (0.48)			2.169*** (2.98)		
Betweenness centrality	Betweenness		0.124 (0.51)			0.797*** (3.14)	
Structural hole richness	SH			0.002 (0.97)			0.005** (2.14)
Constant	Constant	0.494*** (8.78)	0.494*** (8.80)	0.494*** (8.80)	0.488*** (7.57)	0.491*** (7.60)	0.486*** (7.52)
Control variables	Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FE	Company	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	<i>N</i>	11,210	11,210	11,210	8,479	8,479	8,479
Goodness of fit	Adj. <i>R</i> ²	0.255	0.255	0.255	0.242	0.242	0.241
<i>F</i> -value	<i>F</i>	22.17***	22.16***	22.15***	16.51***	16.44***	16.49***

p*<0.1, *p*<0.05, ****p*<0.01.

the industry is, the more complex the environment in which the enterprise is located. The interlocking director network can help companies cope with the pressure brought by industry competition. Therefore, this paper argues that the intensity of industry competition will promote the positive effect of NET on RISK.

To test whether the above analysis is correct, this study refers to the academic operation of Du and Ma (Shanzhong and Lianfu, 2022), using the Herfindahl–Hirschman Index (HHI) to measure the intensity of industry competition. The larger the HHI, the lower the industry competition. Specifically, the HHI is calculated by the sum of squares of the proportion of the

operating income of listed companies in the industry in the total operating income of the industry. Then, using the annual median as the boundary, samples larger than the annual median are classified as the group with low industry competition (HHI = 1), and samples smaller than the median are defined as the group with high industry competition (HHI = 0), and the results of the grouping test are shown in Table 12. Columns (1)–(3) are the regression results for the group with low industry competition, and columns (4)–(6) are the regression results for the group with high industry competition. The regression results in Table 12 show that the coefficients of Degree, Betweenness, and SH are

significantly positive in the group with high industry competition, while the coefficients of the indicators related to interlocking director network are not significant in the group with low industry competition, indicating that the enhancement of NET on RISK is more pronounced when industry competition is high.

7. Conclusion and insights

Based on the social network embeddedness perspective, this paper selects Chinese A-listed companies in Shanghai and Shenzhen from 2007 to 2020 as the research sample to empirically examine the influence mechanism of NET on RISK. Consistent with previous studies (Larcker et al., 2013; Min et al., 2015), we find that NET does significantly improve the level of RISK, and this finding still holds after robustness tests using the instrumental variables method, changing the regression model and replacing the dependent variable. In terms of the influence mechanism, the NET enhance RISK by reducing SA and increasing R&D. Further discussion reveals that the effect of NET on RISK is more pronounced in non-SOEs and enterprises with high industry competition than in SOEs and enterprises with low industry competition.

The research in this paper provides the following insights into the construction of inter-enterprise interlocking director network and the enhancement of risk-taking level: (1) Listed companies should pay attention to the construction of interlocking director network and make full use of their unique “resource effect” and “governance effect” to help companies obtain external resources and network information required for risk-taking and further enhance corporate risk-taking level. (2) The government and relevant departments should encourage and guide enterprises to build a reasonable interlocking director network system and further optimize its resource allocation function to alleviate the financing constraints faced by enterprises and promote their R&D investment intensity. (3) Due to the fact that the function of interlocking director network is more significant in non-SOEs and enterprises with high industry competition. Therefore, enterprises should also reasonably select and use the interlocking director network according to their own situation and the external market competition environment they are in.

Still, our study has certain limitations on which further research will be explored. First, we failed to comprehensively consider the differences in the role of different types of interlocking director networks. Interlocking directors can be divided into independent directors and non-independent directors, and the impact of the two on corporate risk-taking may differ. Future research can further subdivide the interlocking director network into independent director network and non-independent director network for comparative research. Second, this study lacks further exploration of the intrinsic relationship between the two. The interlocking director network may not only improve corporate risk-taking through the two channels of reducing financing constraints and increasing R&D

investment, but there may also be other paths of action between the two. We will further explore the influence mechanism between the two in the future. Third, we did not verify the differential effects of other types of social networks on corporate risk-taking. There are various ways of forming social network relationships among firms, but in this paper, we only considered interlocking director network relationships embedded among firms. Future research can examine the impact of multiple types of social networks on corporate risk-taking. Fourth, the research conclusions of this paper are based on the “static” basis, without considering the impact and mechanism of NET on RISK under the dynamic situation. In future research, we can establish a dynamic model to break the bottleneck of horizontal comparison and make the research results more consistent with the actual situation.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

HL and YL: conceptualization and data collection, and writing—original draft preparation. HL: formal analysis. YL: software and validation. HL and QS: funding acquisition, and writing—review and editing. All authors contributed to the article and approved the submitted version.

Funding

This research was funded by the Natural Science Foundation of China (No. 71771112), and Project of Liaoning Provincial Federation Social Science Circles of China (No. L20BGL047).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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