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Innovative behavior in entrepreneurship: Analyzing new perspectives and challenges

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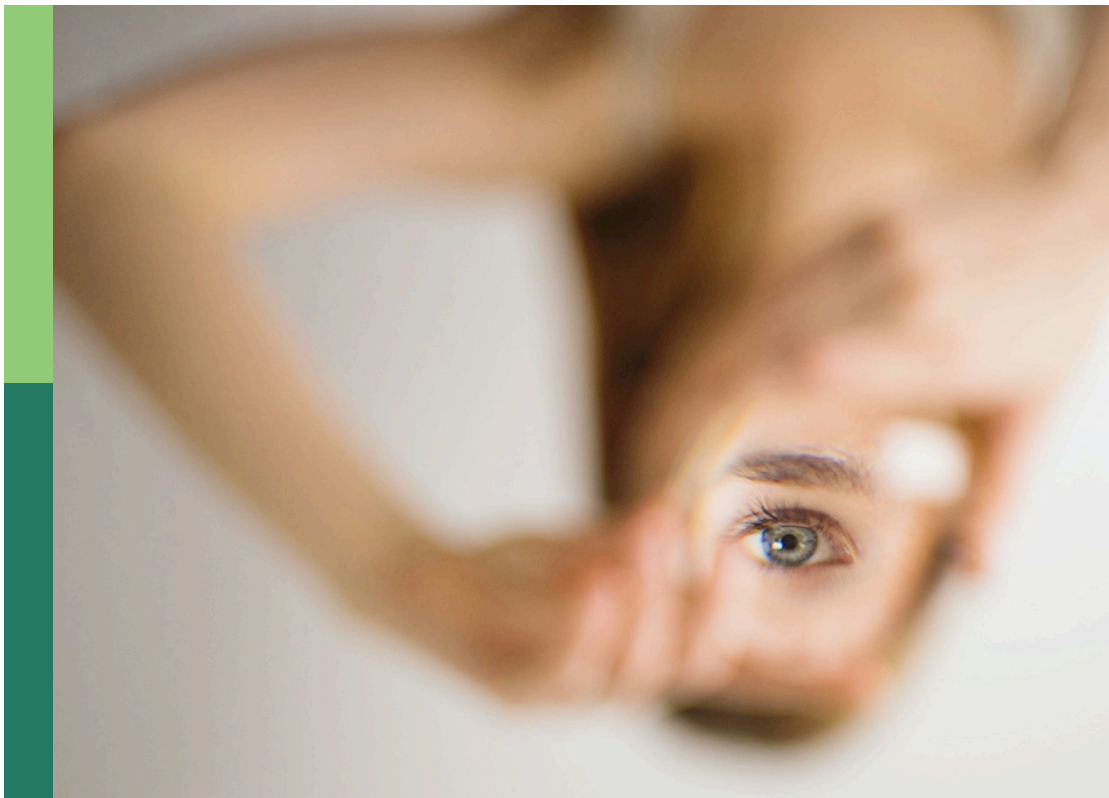

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Innovative behavior in entrepreneurship: Analyzing new perspectives and challenges

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Editorial: Innovative behavior in entrepreneurship: Analyzing new perspectives and challenges

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innovative behavior, entrepreneurship, innovation, online behavior, innovation and research

Editorial on the Research Topic
Innovative behavior in entrepreneurship: Analyzing new perspectives and challenges

In recent years, the relationship between behavior and innovation has come to be globally accepted as a prerequisite of business success (Li et al., 2022). Innovative behavior is seen as an introduction to the application and development of new ideas, processes, initiatives, or actions by qualified professionals (RoŽman and Štrukelj, 2021). Developed either individually or collectively, innovative behavior drives creativity and is directly linked to a multitude of behaviors that lead to the generation of new ideas, initiatives, and value for new companies' products and services (Barbosa et al., 2022).

In this sense, it is important to highlight the importance of entrepreneurial projects in the development of the economy or new business models. Innovation and online behavior are essential variables to promote the creation of new forms of business and behavior analysis in digital ecosystems (Ribeiro-Navarrete et al., 2021; Saura et al., 2022). This Research Topic has identified a gap in the literature concerning how human beings process and acquire new skills for work relationships that promote innovative behavior, and particularly if its development is focused on new business models, entrepreneurship projects, or innovative startups models (Saura et al., 2021a). To date, there have emerged different theories on how business management should promote innovative behavior to increase the value of their products and services (Yang, 2022). However, available literature on the forms of managing innovative behavior in new and entrepreneurship projects remains scarce (LiŽbetinová et al., 2022).

In this way, this Research Topic has been focused on understanding new forms of behavior characteristics, motivations, perceived skills in changing contexts, organization and leadership at work, role of innovation in the behavior of individuals and work groups. Similarly, it is necessary to analyze the creation of critical knowledge linked to a global economy and to better understand the role of innovation and behavior in companies' success.

In this way, authors such as Zhang, Liu et al. reveal the link between social information processing theory in the orientation of CEOs to entrepreneurs. They point out that the internal reasons for the interpretation of information by middle management teams (MMTs) is critical for the correct coordination of the behaviors of entrepreneurs linked to innovation. In another contribution to this special issue, Wu W. et al. focus their attention on the analysis of perceived environmental corporate social responsibility (ECSR) and employee's innovative

behavior. In their study, they identify positive results in relation to the perceived ECSR and organizational identification. In addition, this result encourages the innovative behavior of employees to positively influence the business organization. In addition, they discuss the influence of innovative behavior levels on the trust of employees in a company.

Also, Tang S. et al. analyze innovations in small and medium-sized enterprises (SMEs) from a dynamic capabilities' perspective. In their study, they conclude and define the links between complex causal relationship and environmental turbulence, absorptive capacity, and SMEs' radical innovation. The implications help to understand the processes of innovative behavior in SMEs. Likewise, Wu M. et al. focus their attention on understanding the role of open innovation on the adoption of innovative behaviors in companies. They show the influence of mergers and acquisitions (M&A) as one of the main ways for enterprises to obtain knowledge and technology.

In the contribution presented by Yuan and Liu the role of perceived support for innovation lead to deviant innovation behavior of knowledge workers is analyzed. The findings suggest that perceived support for innovation can significantly predict deviant innovation behavior; innovation commitment fully mediates the relationship between perceived support for innovation and deviant innovation behavior; public threat to self-identity plays a moderating role in the relationship between innovation commitment and deviant innovation behavior; and public threat to self-identity moderates the mediating effect of innovation commitment on perceived support for innovation and deviant innovation behavior.

Likewise, in the study by Tang Y. et al. innovation performance is studied from a competition perspective. The authors identify the relationship between employees' strong growth need and leader–members. The main conclusion is that this relationship gets weaker for supervisors with higher perceived status threat. In addition, this relationship drives innovation performance due to its link with competition and leadership status. In the same line of research, Chen and Liu reveal the organizational effects linked to the commitment for innovative behavior in companies. They focus on understanding the existing relationships between the team-member exchange as an effective measure to boost innovation. They conclude the importance of promoting these work methodologies at many levels of the organization.

In this context, Wang et al. study the link between innovative behavior of employees and the support of the organization's leaders and their wellbeing at work. Thus, based on social comparison theory and social exchange theory, the study results demonstrate that employee innovative behavior is directly and positively related to workplace wellbeing, employee innovative behavior is indirectly and positively related to workplace wellbeing through leader support for innovation, and finally, the negative association between employee innovative behavior and workplace wellbeing *via* coworker ostracism is unsupported.

Also focusing on innovation and leadership, Liu et al. develop a study in which they highlight the importance of the impact of self-serving leadership on employee innovation behavior. They study the roles of workplace anxiety and team psychological safety concluding that self-serving leadership is negatively correlated with employee innovation behavior, and the team psychological safety and workplace anxiety mediated this relationship. Likewise, García de Blanes Sebastián et al. reveal a model that uses UTAUT2 to determine behavioral intention factors in the use of the artificial intelligence (AI) virtual assistants in organizations (Saura et al., 2021b). The main study results reveal that factors, such as habit, trust, and personal innovation, have a significant impact on the adoption of virtual assistants. However, on the other side, performance expectancy, effort expectancy, facilitating conditions, social influence, hedonic motivation, price/value, and perceived privacy risk were not significant factors in the users' intention to adopt this service. These results are important since the adoption of virtual assistants is directly linked to innovative behavior in companies.

Another contribution to this collection is that of Hao et al. who study if venture capital cross-border syndication spur corporate innovation. The results of their study deepen the understanding of the relationship between venture capital (VC) cross-border syndication and corporate innovation and provide essential guidance to domestic VC firms promoting corporate innovation in open partnerships. Likewise, Hu et al. focus their attention on understanding how the capability reconfiguration impacts the innovation performance. Their study contributes to the theory of dynamic capability and catch-up by revealing how innovation magnitude affects capability reconfiguration and subsequent innovation performance in different catch-up stages.

Likewise, de Jaureguizar Cervera et al. focus on the economic factors of innovation and behavior by studying the factors affecting short-term rental first price. They link the results considering some of the factors affecting the psychological behavior of tourism consumers. Focused on the rural tourism area, Zhang, Sun et al. they present a study to understand the factors of poverty reduction in rural areas as an important development goal concerned by the international community. As a contribution, they propose a conceptual framework for the sustainable development of social entrepreneurship and enriches the research on the process of realizing social opportunities in social entrepreneurship. Finally, Jia et al. also analyze the relationship between executive poverty experience and innovation performance. They conclude that the impact of executive poverty experience on innovation performance is more significant in fierce market competition and provide empirical evidence for improving corporate innovation performance.

Finally, this Research Topic offers insights to specifically understand innovative behavior in entrepreneurship. The contributions published in this Research Topic identify gaps and propose future lines of research to solve future the challenges and boost new opportunities in this research field.

Author contributions

JS drafted this contribution. DP-M, MC, and BB revised and modified this contribution. All authors contributed to the article and approved the submitted version

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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A Configurational Analysis of Small and Medium-Sized Enterprises' Radical Innovations: The Perspective of Dynamic Capabilities

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Adopting a configurational perspective, this study explored the pathways for small and medium-sized enterprises (SMEs) to achieve high levels of radical innovation. On the basis of dynamic capabilities theory, six causal conditions for radical innovation were identified at both external and internal levels—that is, environmental turbulence (i.e., technological and market turbulence) and absorptive capacity (i.e., knowledge base, explorative, transformative, and exploitative learning processes). The results of a fuzzy-set qualitative comparative analysis (fsQCA) of 82 Chinese SMEs identified four solutions for high radical innovation. The six causal conditions interacted interdependently and different combinations of these conditions were equally effective pathways for SMEs to achieve radical innovation. Hence, SMEs could generate radical innovation through flexibly allocating resources and capabilities based on the environmental circumstances. By using the fsQCA method, this study contributes to the related literature with an investigation of the complex causal relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation. The results resolve some prior contradictory findings and provide new insights for future research. Other theoretical contributions, practical implications, and directions for future research are also discussed.

Keywords: environmental turbulence, absorptive capacity, SMEs, radical innovation, fsQCA

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INTRODUCTION

Small and medium-sized enterprises (SMEs) are important contributors to job creation and economic growth worldwide (Terziovski, 2010; Mamun et al., 2019). In the meantime, radical innovation, which refers to fundamentally new products or services that create discontinuities in technologies and/or the market (Chandy and Tellis, 1998; Garcia and Calantone, 2002; Alexander and van Knippenberg, 2014), is regarded as a critical source of competitive advantage and sustainable development (Christensen, 1997; Leifer et al., 2001). Although some scholars and practitioners view SMEs as the main drivers of radical innovation (Covin and Slevin, 1989; Hewitt-Dundas, 2006), some researchers find that SMEs tend to innovate less than large businesses (Schumpeter, 1942; Dewar and Dutton, 1986; Cáceres et al., 2011). Accordingly, various studies explore the different antecedents of SMEs' radical innovation vs. large companies' radical

innovation (Vossen, 1998; Hewitt-Dundas, 2006; Prajogo and McDermott, 2014). However, instead of questioning whether different factors influence radical innovation by SMEs and large companies, we suggest that SMEs and large businesses follow different paths to achieve their radical innovation from a configurational perspective (Ragin and Fiss, 2008; Fiss, 2011).

Dynamic capabilities theory (Teece et al., 1997) states that winners in the rapidly changing business environment are firms that "can demonstrate timely responsiveness and rapid and flexible product innovation, coupled with the management capability to effectively coordinate and redeploy internal and external competences" (p. 33). In this vein, although SMEs are relatively less advantaged than large businesses in terms of access to material resources (e.g., economies of scale and technological, financial, and human resources) (Rothwell, 1985; Vossen, 1998; Arias-Aranda et al., 2001), they are more flexible and closer to the market and thus can respond faster to emerging technologies and customer needs (Laforet, 2013). Hence, SMEs have a unique strength in achieving radical innovation through flexibly reconfiguring their limited resources depending on the requirements of the business environment (Rothwell, 1985; Hewitt-Dundas, 2006; Prajogo and McDermott, 2014). Therefore, we are interested in exploring how SMEs achieve high radical innovation when they experience resource constraints.

According to dynamic capabilities theory, absorptive capacity, defined as firms' ability to "identify, assimilate, and exploit knowledge from the environment" (Cohen and Levinthal, 1989, p. 569), is essential for firms to generate radical innovation in the turbulent business environment (Van den Bosch et al., 1999; Lichtenthaler and Lichtenthaler, 2009). Absorptive capacity is operationalized as a knowledge base [e.g., research and development (R&D) intensity or patents] and then reified into three learning processes (i.e., exploratory, transformative, and exploitative learning) by which firms utilize external knowledge to create new knowledge (Cohen and Levinthal, 1989; Lane et al., 2006). A firm's knowledge base and these three learning processes mutually complement and reinforce each other, and they constitute the firm's absorptive capacity (Zahra and George, 2002; Roberts et al., 2011; Carlo et al., 2012). However, it is difficult for SMEs to simultaneously invest in R&D and all three learning processes because of their resource constraints (Gupta et al., 2006). Instead, in order to achieve radical innovation, SMEs should capitalize on their organizational flexibility and adjust their innovative strategies to capture the technological and market turbulence (Covin and Slevin, 1989; Hewitt-Dundas, 2006).

In addition, SMEs' resource constraints increase their vulnerability to external changes (Covin and Slevin, 1989; Bodlaj and Cater, 2019). Thus, the business environment plays a particularly important role in SMEs' innovative processes (Prajogo and McDermott, 2014). Many studies use a contingency perspective to examine the moderating effects of environmental turbulence in the relationship between absorptive capacity and radical innovation (Jansen et al., 2006; Teece, 2007; Lichtenthaler, 2009). However, as indicated by Lane et al. (2006), environmental turbulence determines "the incentives for investing in absorptive capacity" (p. 857) and can also be an antecedent of absorptive capacity and radical innovation from a process perspective (Cohen and Levinthal, 1989; Van den Bosch et al., 1999; Bodlaj and Cater, 2019). Therefore, the causal relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation is complex. Partially because of the limitations of symmetric methods (Douglas et al., 2020), few empirical research studies capture this causal complexity or the multidimensional nature of absorptive capacity (Todorova and Durisin, 2007; Lichtenthaler, 2009; Ferreras-Méndez et al., 2016).

The fuzzy-set qualitative comparative analysis (fsQCA) method (Ragin, 1987, 2000) is used in this study because fsQCA assumes that many causal conditions (i.e., independent variables) affect an outcome interdependently and that different configurations (i.e., combinations of causal conditions) can equivalently lead to the same outcome (Ragin and Fiss, 2008; Rihoux and Ragin, 2009; Fiss, 2011; Pappas and Woodside, 2021). Therefore, by using fsQCA, we aim to make the following contributions. First, from a configurational perspective, we can explore different possible solutions that explain the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation and thus provide some fresh directions for further research into SMEs' radical innovation. Second, fsQCA identifies causal asymmetries—that is, conditions can be related, unrelated, or even inversely related to the outcome in different configurations (Meyer et al., 1993; Woodside, 2013). So the results of this study can help resolve previously contradictory findings in the relevant research literature. Third, we extend the absorptive capacity research literature by simultaneously examining the effects of the knowledge base, explorative, transformative, and exploitative learning processes in one theoretical model and their complementarity.

THEORETICAL BACKGROUND

Small and Medium-Sized Enterprises' Radical Innovation

Innovation is "the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society" (West and Farr, 1990, p. 9). The degree of newness distinguishes radical innovation from incremental innovation (Dewar and Dutton, 1986). Incremental innovation refers to simple improvements or minor extensions to current products or processes (Dewar and Dutton, 1986; McDermott and O'Connor, 2002), and radical innovation represents fundamental changes in technology and clear departures from existing products, processes, or services (Dewar and Dutton, 1986; Chandy and Tellis, 1998). Radical innovation cannot only better satisfy customers' needs but also create substantially new benefits for customers (Chandy and Tellis, 1998; Atuahene-Gima, 2005). In addition, radical innovation can offer significant improvements (e.g., $\geq$ 5-fold) in organizational performance or significant reductions ($\geq$30%) in cost (Leifer et al., 2001). Thus, for opportunity-focused SMEs, the generation of radical innovation is an important way to break the *status quo*, obtain a competitive

advantage, and guarantee growth (Christensen, 1997; Bodlaj and Cater, 2019).

Scholars have paid close attention to the determinants of radical innovation, among which firm size has drawn strong interest; however, the results are controversial (Ettlie et al., 1984; Dewar and Dutton, 1986; Covin and Slevin, 1989; Hewitt-Dundas, 2006). One reason may be that these researchers examine the determinants of SMEs' radical innovation vs. large firms' radical innovation from different perspectives (Prajogo and McDermott, 2014). According to the resource-based view of the firm and Schumpeter's classic arguments on creative accumulation, some researchers suggest that large firms possess more financial and technological resources, enjoy economies of scale and scope, and thus have a greater advantage over SMEs in adopting radical innovation (Schumpeter, 1942; Grant, 1991; Arias-Aranda et al., 2001). However, other researchers demonstrate from a behavioral perspective that large firms are more bureaucratic, tend to get trapped in their core competences, and react slowly to technological changes or changing customer needs (Levinthal and March, 1993; Mitchell and Singh, 1993; Damanpour and Wischnevsky, 2006). These behavioral constraints make large firms less innovative than SMEs in dynamic environments (Hewitt-Dundas, 2006). In contrast, SMEs are comparatively disadvantaged in terms of resources, but they are superior in their behavioral aspects—that is, they are more flexible, efficient, and motivated (Rothwell, 1985; Vossen, 1998; Prajogo and McDermott, 2014).

Adopting a configurational perspective, we argue that what matters here are not only the different determinants of radical innovation between SMEs and large businesses but also the different pathways between them to achieve high radical innovation (Slater et al., 2014; Douglas et al., 2020). Radical innovation is a complex business phenomenon characterized by high risks and uncertainties, and the innovative process is full of unpredictable challenges (Alexander and van Knippenberg, 2014; Colombo et al., 2017). Thus, resources and capabilities are essential for both SMEs' and large businesses' radical innovation (Chang et al., 2012; Zhou and Li, 2012; Tiberius et al., 2021). Firms have their own pathways to achieve radical innovation through different configurations of environmental factors and internal and external resources and capabilities (Poorkavoos et al., 2016). The strength of organizational flexibility allows SMEs to overcome the constraints of material resources by adapting their limited resources and capabilities to the changing demands; thus, SMEs are expected to be better positioned to generate radical innovation in the turbulent business environment (Covin and Slevin, 1989; Hewitt-Dundas, 2006; Laforet, 2013).

Absorptive Capacity and Radical Innovation

Teece et al. (1997) defines dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 34) and proposes that firms should continually renew their competences to achieve and maintain new forms of competitive advantages (Leonard-Barton, 1992; Teece et al., 1997). Similarly, given the growing complexity and uncertainty in the business environment, Chesbrough's open innovation model suggests that to innovate successfully, firms should shift their focus from spending on internal R&D to searching for and acquiring external knowledge and expertise outside the organization's boundaries (Chesbrough, 2003, 2006; Laursen and Salter, 2006). Accordingly, as an essential component of its dynamic capabilities, a firm's absorptive capacity—the ability to recognize the potentially valuable external knowledge, assimilate it, and apply the assimilated knowledge to commercial ends—is critical for the firm to take advantage of externally held knowledge to generate radical innovation (Cohen and Levinthal, 1989; Eisenhardt and Martin, 2000; Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009). The research literature shows that absorptive capacity can facilitate firms' radical innovation (Van den Bosch et al., 1999; Ritala and Hurmelinna-Laukkanen, 2013; Flor et al., 2018).

Absorptive capacity was initially put forward by Cohen and Levinthal (1989), who use the term to describe a firm's ability to create new knowledge by identifying, assimilating, and exploiting knowledge from the external environment. Absorptive capacity has since become one of the most important constructs in the organizational and management research literature (Lane et al., 2006). Although originally conceptualized as a firm's ability, absorptive capacity is considered to be a firm's current knowledge base and is empirically equated with the firm's R&D spending or patents (Cohen and Levinthal, 1989; Mowery et al., 1996; Ahuja and Katila, 2001). Later, some studies redefine absorptive capacity from the perspective of the firm's dynamic capabilities (e.g., Dyer and Singh, 1998; Lane and Lubatkin, 1998; Van den Bosch et al., 1999). Among these, Zahra and George's (2002) reconceptualization is widely used. They put emphasis on "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge (p. 186)" and distinguish between potential (knowledge acquisition and assimilation) and realized (knowledge transformation and exploitation) capacity (Zahra and George, 2002).

Lane et al. (2006) further integrate the insights from previous studies and extend the concept from a more process-oriented perspective. They argue that the benefits of absorptive capacity depend on the underlying exploratory, transformative, and exploitative learning processes that allow the firm to consciously create, expand, or modify its knowledge base (Eisenhardt and Martin, 2000; Ferreras-Méndez et al., 2016; Forés and Camisón, 2016). Exploratory learning refers to the process of recognizing and acquiring valuable new knowledge from the external environment, and exploitative learning involves transforming and applying the acquired external knowledge into commercial outputs (Levinthal and March, 1993; Lane et al., 2006; Ferreras-Méndez et al., 2016). These two learning processes also correspond to potential and realized absorptive capacity (Zahra and George, 2002; Lichtenthaler, 2009). Transformative learning links exploratory and exploitative learning is—that is, the firm maintains valuable knowledge and reactivates related knowledge when needed (Garud and Nayyar, 1994; Lane et al., 2006; Ferreras-Méndez et al., 2016). Thus, a firm's absorptive capacity consists of (1) its knowledge base and (2) the three

TABLE 1 | Industry distribution of the sampled SMEs.

Industry	n
Machinery and equipment manufacturing	17
Information technology	10
Services	8
Construction industry	7
Electric engineering	6
Trade industry	6
Medicine and health	6
Consumer products	4
Finance	4
Real estate industry	3
Education	3
Environmental protection	3
Chemical products	2
Logistics and supply chain	2
Agricultural industry	1
Total	82

learning processes through which the firm utilizes external knowledge (Cohen and Levinthal, 1989, 1990; Lane et al., 2006).

The knowledge base represents a firm's most pivotal and unique resource for radical innovation (Zhou and Li, 2012). The knowledge base determines whether a firm can accurately predict technological trends and react to the emerging opportunities in time (Cohen and Levinthal, 1994; Teece, 2007). It influences not only the breadth of external knowledge searching and recognizing but also the depth of knowledge that a firm can understand (Mowery et al., 1996; Ahuja and Katila, 2001; Lane et al., 2006). Acquired and assimilated knowledge from external sources through the exploratory, transformative, and exploitative learning processes in turn eases the scarcity of internal knowledge resources and enriches the firm's knowledge base (Cohen and Levinthal, 1990; Van den Bosch et al., 1999). Thus, a firm's knowledge base and the three learning processes interact in a complex way and interdependently affect the creation of radical innovation (Todorova and Durisin, 2007; Carlo et al., 2012; Ritala and Hurmelinna-Laukkanen, 2013). However, because of firms' internal resource constraints, high levels of R&D spending and the three learning processes may not coexist in most firms, especially in SMEs (Gupta et al., 2006). Instead, firms should constantly balance their investments in R&D and the learning processes to address the dynamically changing environment and achieve radical innovation (Teece et al., 1997; Tang et al., 2020).

Environmental Turbulence and Radical Innovation

In proposing the absorptive capacity construct, Cohen and Levinthal (1989, 1990) highlight the role of the environmental context in determining firms' investment in their absorptive capacity (Van den Bosch et al., 1999; Lane et al., 2006). The innovation research literature also considers the external environment as a primary stimulus for firms to generate radical innovation (Damanpour and Wischnevsky, 2006; Prajogo and McDermott, 2014). Based on dynamic capabilities theory, the fast-moving business environment exposes firms' current products or services to the risk of being made obsolete at any time (Teece, 2007; Lichtenthaler, 2009). Therefore, in general, with increasing dynamism and hostility in the environment, firms' emphasis will shift from incremental innovation to radical innovation that deviate from existing technologies and/or markets (Dewar and Dutton, 1986; Jansen et al., 2006; Droge et al., 2008). While resource scarcity makes SMEs more vulnerable to environmental turbulence, it also forces SMEs to become more external-oriented and more sensitive to environmental changes (Bodlaj and Cater, 2019). As a result, SMEs seek to improve their innovativeness under the prevailing conditions to stay competitive in the turbulent business environment (Covin and Slevin, 1989; Uzkurt et al., 2012).

Environmental turbulence includes both technological and market turbulence (Jaworski and Kohli, 1993; Lichtenthaler, 2009). Technological turbulence refers to "the rate of technological change" (Jaworski and Kohli, 1993, p. 57). Firms operating in a highly technologically turbulent environment must continually explore new knowledge and technologies to increase their opportunities to generate radical innovation, which can help them obtain first-mover advantages and sustain their growth (Lichtenthaler, 2009; Bodlaj and Cater, 2019). In their meta-analysis, Huang and Tsai (2014) identify a positive relationship between technological turbulence and product innovativeness. Market turbulence refers to "the rate of change in the composition of customers and their preferences" (Jaworski and Kohli, 1993, p. 57). In turbulent markets, firms' products and services must be constantly modified, updated, or even replaced to better meet their customers' changing needs (Jaworski and Kohli, 1993; Chandy and Tellis, 1998). Compared with larger firms, SMEs interact more closely with their customers and can understand and respond more quickly to their customers' inquiries (Covin and Slevin, 1989; Salavou et al., 2004). Using data from SMEs in Turkey, Uzkurt et al. (2012) find positive effects for both technological and market turbulence on the SMEs' innovativeness. Similarly, Bodlaj and Cater (2019) demonstrate a direct positive impact of market turbulence on SMEs' innovativeness.

Considering the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation, some scholars view environmental turbulence as a moderating factor (e.g., Lichtenthaler, 2009), whereas others regard it as an antecedent and examine the direct and indirect effects of technological and market turbulence on SMEs' radical innovation (e.g., Uzkurt et al., 2012; Bodlaj and Cater, 2019). However, as Slater et al. (2014) suggest, these direct effects models provide linear additive explanations but underestimate the interdependence between these causal conditions when influencing radical innovation. Likewise, Douglas et al. (2020) show that the traditional quantitative methods that dominate the literature do not sufficiently deal with the heterogeneity of complex business phenomena. Thus, by answering calls to use the fsQCA method to reveal a finer-grained understanding of the complexity of radical innovation (Fiss, 2011; Ganter and Hecker, 2014; Douglas et al., 2020), we use fsQCA to

TABLE 2 | Reliability test of the measurement.

Condition	Factor loadings*	Composite reliability	Cronbach's alpha
Radical innovation (9 items)	0.580 ~ 0.809	0.926	0.908
Technological turbulence (3 items)	0.883 ~ 0.946	0.939	0.902
Market turbulence (3 items)	0.788 ~ 0.929	0.913	0.856
Exploratory learning (6 items)	0.781 ~ 0.893	0.926	0.903
Transformative learning (6 items)	0.680 ~ 0.812	0.897	0.859
Exploitative learning (6 items)	0.695 ~ 0.873	0.927	0.903

**All the factor loadings were significant at $p < 0.05$.*

explore the various pathways by which SMEs can achieve high radical innovation. From a dynamic capabilities perspective, we identify six causal conditions at both external and internal levels: technological turbulence, market turbulence, firms' knowledge base, explorative learning, transformative learning, and exploitative learning.

MATERIALS AND METHODS

Data and Sample

The data were collected from 82 SMEs located in Wuhan, the largest city in central China. By 2020, more than 6,000 high-tech enterprises have been operating in Wuhan. We asked some top-level managers of SMEs who participated in our MBA program to recommend other top-level managers of SMEs to participate in this research. Like most fsQCA studies in management (e.g., Fiss, 2011; Poorkavoos et al., 2016), we designed a cross-sectional questionnaire to obtain the data for the conditions that we explored in this study and the background information of the SMEs and the managers. A total of 209 questionnaires were sent to top-level managers of SMEs through an online survey, and 82 were returned (39.2% response rate). The sizes of the sampled SMEs ranged from 9 to 500 employees, with a median of 80 employees. The ages of the sampled SMEs ranged from 1 to 42 years, with a median of 14 years. The SMEs operated in various industries, such as machinery and equipment manufacturing, information technology, and construction (see **Table 1** for a detailed industry distribution).

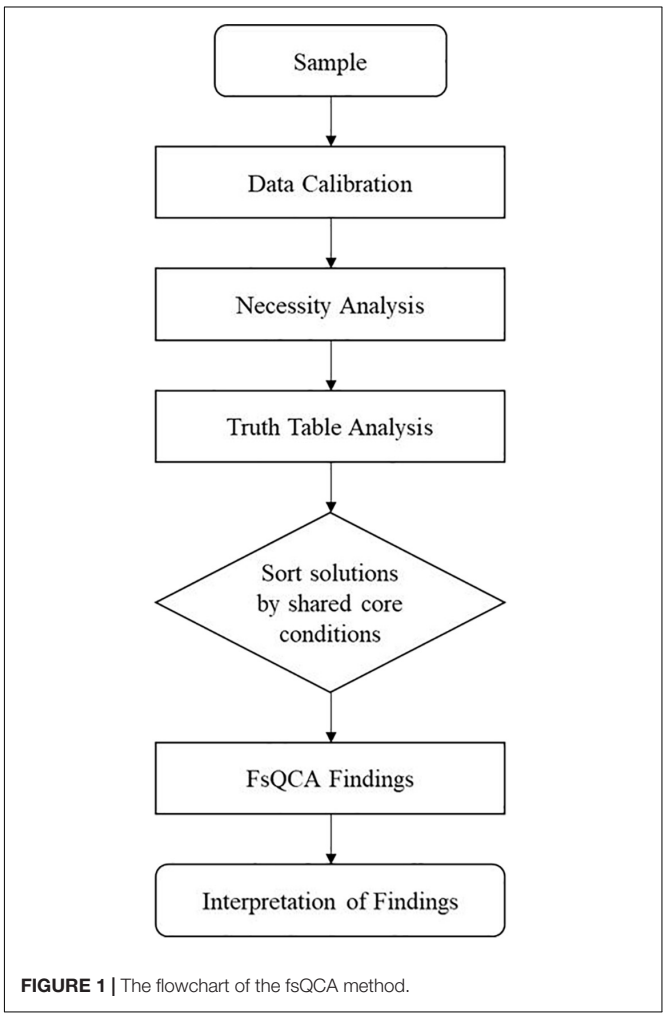

FIGURE 1 | The flowchart of the fsQCA method.

Measurement

We used the 9-item scale developed by Poorkavoos et al. (2016) to measure SMEs' *radical innovation*. The respondents were asked to rate their performance compared with their competitors operating in the same industry sector to compare the data at the cross-industry level (Oke, 2007; Poorkavoos et al., 2016). Following Bodlaj and Cater (2019), *technological turbulence* and *market turbulence* were measured by three items each from the widely used scales developed by Jaworski and Kohli (1993). *Knowledge base* is usually considered as R&D intensity, i.e., the ratio of firms' annual R&D expenditure to their sales (Cohen and Levinthal, 1989; Laursen and Salter, 2006). Because of difficulties in collecting objective data for R&D expenditure and sales, we used the proportion of firms' R&D employees to their total number of employees as a proxy of the firms' R&D intensity. The proportion of firms' R&D employees is also one of the important indicators of firms' R&D capabilities (Visalakshi and Sandhya, 1997). Finally, the *exploratory*, *transformative*, and *exploitative learning processes* were measured using the scale developed by Ferreras-Méndez et al. (2016). Exploratory learning captures firms' activities in recognizing and assimilating valuable external knowledge, transformative learning comprises the activities of maintaining and reactivating the firms' relative knowledge, and

TABLE 3 | Descriptive statistics and calibration thresholds.

Condition	Mean	SD	Fuzzy-set calibration		
			Full membership	Crossover	Full non-membership
Radical innovation	4.41	1.03	5.00	4.28	3.78
Technological turbulence	4.81	1.39	6.00	5.00	4.00
Market turbulence	4.39	1.34	5.25	4.67	3.67
R&D intensity	0.15	0.15	0.20	0.10	0.00
Exploratory learning	5.35	0.94	6.00	5.50	4.83
Transformative learning	5.60	0.70	6.00	5.50	5.04
Exploitative learning	5.22	0.90	6.00	5.25	4.83

exploitative learning refers to the activities of transmuting and applying new and existing knowledge into commercial products (Garud and Nayyar, 1994; Jansen et al., 2005; Ferreras-Méndez et al., 2016). The scale consists of 18 items, and each learning process was assessed using 6 items. The complete measurement scales used in this study are presented in **Appendix**. All items were translated to Chinese using a back-translation procedure (Brislin, 1986) and were measured using a 7-point Likert-type scale (where 1 = "strongly disagree" and 7 = "strongly agree"). **Table 2** shows the reliability test of the measurement.

Analytical Technique

The data were analyzed using fsQCA 3.0 software. Unlike variance-based methods, fsQCA is grounded in set theory and analyzes data at the case level (Ragin, 2006; Ragin and Fiss, 2008; Pappas and Woodside, 2021). Each causal and outcome condition is regarded as a fuzzy set, and all of the collected data should be transformed into fuzzy sets through a calibration process (Schneider and Wagemann, 2012). After calibration, all of the scores of the conditions range from 0 to 1, with 0 representing full non-membership, 0.5 representing the crossover point, and 1 representing full membership (Ragin, 2000, 2008). By computing each case's degree of membership in the causal and outcome condition sets, fsQCA can deal with cases of different sample sizes and data of different types. Therefore, this analytical technique goes beyond qualitative and quantitative strategies (Ragin, 1987; Rihoux and Ragin, 2009; Pappas and Woodside, 2021). A flowchart of the fsQCA method utilized in this study is presented in **Figure 1** and each step will be explained in details in the following part.

RESULTS

Calibration

We used a direct method for calibration and chose the upper quartile, median, and lower quartile values commonly used as the thresholds for the three points of membership to calibrate the SMEs' radical innovation, the technological and market turbulence, and the three learning processes (Ortiz de Guinea and Raymond, 2020; Pappas and Woodside, 2021). To calibrate SMEs' R&D intensity, we set 20, 10, and 0% as the thresholds because one of the criteria for a firm to be certificated as a high-tech enterprise in China is that the proportion of firms' R&D employees should not be lower than 10%. Following Fiss (2011), a constant of 0.001 was added to all scores below 1 after calibration to avoid values of 0.5, which cannot be analyzed by the fsQCA 3.0 software (Ragin, 2008; Wagemann et al., 2016). The descriptive statistics and the calibration thresholds for the outcome and the causal conditions are shown in **Table 3**.

TABLE 4 | Necessity analysis.

Causal condition	High radical innovation	
	Consistency	Coverage
Technological turbulence	0.588	0.592
Market turbulence	0.571	0.573
R&D intensity	0.705	0.620
Exploratory learning	0.685	0.672
Transformative learning	0.699	0.622
Exploitative learning	0.683	0.708

Necessity Analysis

To reveal the complex causal relationships between causal conditions and an outcome of interest, fsQCA views each case as a configuration of causal conditions and indicates the necessary and sufficient conditions/configurations of the outcome through a comparative analysis of cases (Ragin, 2000; Rihoux and Ragin, 2009). The necessity analysis should be conducted before the sufficiency analysis to detect the necessary condition(s) in advance (Schneider and Wagemann, 2012). A condition is considered as a necessary condition for the outcome when the outcome set is a subset of the condition set—that is, the outcome cannot be present without the presence of the condition (Caramani, 2008). **Table 4** presents the results of necessity analysis. The consistency score indicates the proportion of cases whose membership in the condition set is greater than their membership in the outcome set (Rihoux and Ragin, 2009). When it is above 0.9, the condition can be identified as a necessary condition (Ragin, 2008; Schneider, 2018). Therefore, in this study, no single condition was a necessary condition for the SMEs to achieve high radical innovation.

Sufficiency Analysis

Sufficiency analysis is conducted through the generation of a truth table with the presence of SMEs' radical innovation (i.e.,

TABLE 5 | Configurations for SMEs' high radical innovation.

Configuration	Solution			
	1	2	3a	3b
Environmental turbulence				
Technological turbulence	•	•	⊗	⊗
Market turbulence		●	⊗	⊗
Absorptive capacity				
R&D intensity	•	●		•
Exploratory learning		•	•	⊗
Transformative learning	•	●	•	⊗
Exploitative learning	•		●	●
Consistency	0.754	0.786	0.871	0.927
Raw coverage	0.343	0.270	0.165	0.103
Unique coverage	0.100	0.049	0.092	0.050
Overall solution consistency	0.806			
Overall solution coverage	0.540			

The black circles (●) represents the presence of a condition, the crossed-out circle (⊗) means the absence of a condition, and the blank space indicates a "don't care" situation. Large and small circles represent core conditions and peripheral conditions, respectively.

high levels of radical innovation) as the outcome. The truth table contains 2^k rows, where k equals the number of causal conditions and each row represents a possible configuration of the causal conditions to the presence of the outcome (Ragin, 2008). We identified six causal conditions in this study; therefore, the truth table included 64 rows with 40 observed configurations and 24 logical remainders, which are the logically possible configurations without empirical instances (Ragin, 2008). The truth table is then sorted by frequency and consistency (Ragin, 2008). Frequency refers to the number of cases reflected in each configuration. Given the sample size of this study, we set the frequency threshold at 2 (Fiss, 2011). Consistency in the sufficiency analysis refers to the extent to which the configuration constitutes the subset of the outcome set, i.e., the extent to which the configuration is a sufficient configuration for the outcome (Ragin, 2006; Rihoux and Ragin, 2009). As recommended by Ragin (2008), the consistency threshold was set at 0.75. The proportional reduction in inconsistency (PRI) consistency is also considered in fuzzy sets analysis, and the threshold was set at 0.70 (Greckhamer et al., 2018).

The truth table analysis makes counterfactual reasoning about logical remainders and provides three types of solutions: complex, parsimonious, and intermediate solutions (Ragin, 2000, 2008). Intermediate solutions and parsimonious solutions are recommended for interpreting the results (Fiss, 2011). **Table 5** shows the results of the truth table analysis for the presence of SMEs' radical innovation. Using the notation from Ragin and Fiss (2008), the black and crossed-out circles represent the presence and absence of a condition, respectively. The blank space indicates that whether the condition is present or absent is indifferent to the outcome. Conditions appearing in both intermediate and parsimonious solutions are called "core conditions" and are marked with a large circle, whereas the conditions appearing only in intermediate solutions are called "peripheral conditions" and are marked with a small circle (Ragin and Fiss, 2008). The "coreness" represents "the strength of the evidence relative to the outcome" (Fiss, 2011, p. 403). The solutions were sorted by their shared core conditions (Fiss, 2011). Coverage refers to the extent to which the configuration is the only solution leading to the outcome and thus reflects the importance of the configuration (Ragin, 2006).

This study identified four pathways that were sufficient for SMEs to achieve high radical innovation. The overall consistency was 0.806 and the overall coverage was 0.540. Solution 1 includes the presence of technological turbulence, R&D intensity, transformative learning, and exploitative learning as a configuration for high radical innovation. The outcome would not be affected whether market turbulence and explorative learning were present or absent. This solution highlights the importance of developing and maintaining the firm's own core competence. As mentioned, the firm's knowledge base is its most unique resource for standing out from others and obtaining competitive advantages (Zhou and Li, 2012). Although dynamic capabilities theory suggests that explorative learning is more important in turbulent business environments (Jansen et al., 2006; Teece, 2007), explorative learning requires the input of time and financial resources and firms' networking and managerial capabilities (Cohen and Levinthal, 1990; Oerlemans et al., 2013). For SMEs whose resources and capabilities are naturally constrained, Solution 1 suggests that SMEs should prioritize the allocation of their limited resources to R&D, transformative learning, and exploitative learning.

Solution 2 indicates the configuration of the presence of technological and market turbulence, R&D intensity, exploratory learning, and transformative learning, with market turbulence, R&D intensity, and transformative learning as the core conditions. In this solution, exploitative learning is indifferent, which shows that when both technology and customer needs change rapidly, internal exploitation is less valued. Instead, the need for exploratory learning increases, which echoes previous research into dynamic capabilities (Jansen et al., 2006; Teece, 2007). In addition, solution 2 emphasizes the roles that R&D intensity and transformative learning play in a turbulent environment. On the one hand, it becomes harder for firms to recognize and acquire potentially valuable knowledge under highly uncertain conditions, which requires SMEs to flexibly cope with external changes by maintaining and expanding a large knowledge base (Taylor and Greve, 2006; Teece, 2007). On the other hand, external knowledge acquisition might be insufficient under such circumstances, which poses challenges for transformative learning (Marsh and Stock, 2006). Transformative learning is especially significant in dynamic environments because it takes time—sometimes years—for customers to accept new technology and products. Thus, the assimilated external knowledge may need to be maintained for a long time until before it can be applied to commercial outputs for radical innovation (March, 1991).

Solutions 3a and 3b indicate two pathways to high radical innovation under stable environments, where technological and market turbulence are both absent. These pathways share the core conditions of the absence of market turbulence and the presence of exploitative learning. These two solutions show that in a

TABLE 6 | Configurations for the absence of radical innovation.

Configuration	Solution		
	1a	1b	1c
Environmental turbulence			
Technological turbulence	⊗		⊗
Market turbulence		•	•
Absorptive capacity			
R&D intensity	⊗	⊗	⊗
Exploratory learning	⊗	⊗	⊗
Transformative learning	⊗	⊗	
Exploitative learning	⊗	⊗	⊗
Consistency	0.837	0.904	0.921
Raw coverage	0.277	0.185	0.185
Unique coverage	0.136	0.044	0.044
Overall solution consistency		0.864	
Overall solution coverage		0.366	

The black circles (●) represents the presence of a condition, the crossed-out circle (⊗) means the absence of a condition, and the blank space indicates a "don't care" situation. Large and small circles represent core conditions and peripheral conditions, respectively.

relatively stable environment, SMEs can capitalize on exploitative learning to achieve radical innovation (Gupta et al., 2006). Exploitative learning is the process of applying the knowledge to match the markets (Lenox and King, 2004; Smith et al., 2005). SMEs are closer to their customers; therefore, they could perform better at understanding and fulfilling their customers' needs (Salavou et al., 2004). Solutions 3a and 3b also demonstrate that high levels of exploratory and transformative learning processes and a high level of R&D intensity can be substitutes for each other. This result verifies that radical innovation can emerge from a knowledge base either developed by the firm itself or drawn entirely from external sources (Hill and Rothaermel, 2003; Zhou and Li, 2012). The raw coverage scores for solutions 3a and 3b were smaller than those for solutions 1 and 2, which shows that SMEs will be more motivated to introduce radical innovation in a turbulent environment.

We also conducted a sufficiency analysis for the absence of radical innovation (i.e., low to medium levels of radical innovation). The frequency and PRI consistency thresholds were still set at 2 and 0.70, respectively. Considering the consistency distribution, the consistency threshold was set at 0.80. **Table 6** presents the results of the configurations for the absence of radical innovation. The overall consistency was 0.864 and the overall coverage was 0.366. The three configurations share the same core conditions of R&D intensity and explorative learning. The absence of R&D intensity, explorative learning, and exploitative learning appeared in all the solutions; therefore, we performed a supplementary analysis on the necessity of the three conditions for the absence of radical innovation. The results indicated that none of the three conditions alone were a necessary condition for the outcome. The configurations for the absence of SMEs' radical innovation revealed that whether the external environment is turbulent or not, R&D intensity and explorative learning are important sources of new knowledge to be applied to generate radical innovation. Without high levels of R&D intensity and explorative learning, it is almost impossible to achieve radical innovation (Hill and Rothaermel, 2003).

DISCUSSION

Theoretical Contributions

This study has examined the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation, detected several configurations for SMEs to achieve high radical innovation, and made some theoretical contributions as followed. First, we contribute to the research literature on SMEs and radical innovation. We examined how SMEs achieve radical innovation from a configurational perspective and identified several equally effective pathways. In comparison with traditional variance-based methods, such as multiple regression and structural equation modeling, which emphasize the "net effect" between variables, fsQCA focuses on the complex causal relationships through configurational comparative analysis (Ragin and Fiss, 2008). Based on the analysis on real cases rather than the hypothetical-average case, this method can help advance our understanding of complex business phenomena (Douglas et al., 2020). By indicating and comparing the pathways to the presence and absence of high radical innovation, we verify some prior findings on the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation (e.g., Hill and Rothaermel, 2003; Jansen et al., 2006). Besides, although explorative learning is more valued in turbulent environments (Teece, 2007), our results indicate that SMEs should give priority to R&D, transformative learning, and exploitative learning, thus providing some useful insights for SMEs into how to flexibly allocate their resources and capabilities to generate high radical innovation.

Second, we resolve some previously conflicting findings by revealing multiple pathways to high radical innovation. Among these pathways, the underlying conditions can be present, absent, or indifferent, showing that there exist alternative explanations for SMEs to achieve radical innovation. This causal asymmetry of fsQCA is particularly useful for understanding the heterogeneity of business entities and their different ways of surviving and achieving success in turbulent business environments. Previous research has adopted different perspectives and approaches to hypothesize and test the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation and has reported contradictory findings (e.g., Prajogo and McDermott, 2014; Forés and Camisón, 2016; Bodlaj and Cater, 2019). However, while the net effect detected by symmetric methods might be that the independent and dependent variables are positively related, the relationship may be negative or statistically non-significant for a minority of cases within the sample (Douglas et al., 2020). Instead of neglecting the data relationship for these minority groups, identifying the causal asymmetry and investigating these differences will help us resolve those contradictory findings and promote our understanding of the complex causal relationship between environmental

turbulence, absorptive capacity, and SMEs' radical innovation in a more holistic way.

Third, this study also contributes to dynamic capabilities theory and the absorptive capacity literature. As mentioned earlier, few research studies examine the complementary effects of the two dimensions of absorptive capacity (see Carlo et al., 2012 for an exception). We theorized SMEs' R&D intensity, explorative, transformative, and exploitative learning processes using one model and explored their interdependence with environmental factors when influencing the generation of radical innovation. The results show that R&D intensity can substitute for explorative and transformative learning processes in a relatively stable environment, which is in accordance with previous research on knowledge and radical innovation (Zhou and Li, 2012). Moreover, to address the dynamic environment, firms must balance explorative and exploitative learning (Jansen et al., 2006). The results also indicate the important role of transformative learning in the process of radical innovation. However, this learning process has not received sufficient research attention so far (Marsh and Stock, 2006). Therefore, through a deep look into the interaction between technological and market turbulence, R&D intensity, and the three learning processes, this study extends the research literature on absorptive capacity and dynamic capabilities and provides new insights for future research.

Practical Implications

This study provides several practical implications for SMEs. First, every firm should develop its own core competence. While some SMEs gain a foothold in the market through imitative innovation, this is not a long-term option. SMEs can only fully take advantage of explorative learning in a stable business environment where trends can easily be recognized. To compete and succeed in today's dynamic environment, SMEs should invest more resources into their R&D and the establishment and maintenance of their own knowledge base. Second, explorative or exploitative learning can both lead to high radical innovation. This depends on the SMEs' careful evaluations and choices because explorative learning is neither easy nor costless. When the external environment changes rapidly, especially when technological and market turbulence is at high levels, the potentially valuable external knowledge becomes difficult to recognize and assimilate. Therefore, SMEs should balance exploration and exploitation based on their internal knowledge base and external environmental circumstances. Finally, the transformative learning process should not be ignored because turning nascent technology into marketable products or services is an extensive process. Thus, firms should focus on maintaining their knowledge base over time so that related knowledge can be reactivated and applied when needed.

Limitations and Future Research

Some limitations of this study should be addressed in future research. First, we used the snowball sampling method, which may limit the generalizability of the findings. However, as indicated by Fiss (2011), the validity of the solutions provided by fsQCA is not threatened by sample representativeness because the results of the truth table analysis are not sensitive to outliers (Pappas and Woodside, 2021). Hence, the findings of this study are relatively robust. However, future studies should use a random sample. Second, the data were collected using self-reported questionnaires and calibrated using the data distribution percentiles. Future research should use more objective data and calibration thresholds. Third, because of the difficulty of data collection, we did not compare the differences between the configurations for large companies' radical innovation vs. SMEs' radical innovation. It would be interesting for future studies to examine how large businesses and SMEs achieve the same outcomes through different pathways.

CONCLUSION

Drawing on the dynamic capabilities theory, this study has conducted a fuzzy-set qualitative comparative analysis of the relationship between environmental turbulence, absorptive capacity, and SMEs' radical innovation. The results indicated that the identified causal conditions interacted in a complex way and that different combinations of these conditions can equivalently lead to high radical innovation. Thus, SMEs could achieve radical innovation through flexibly allocating their limited resources to R&D intensity and the three learning processes based on their environmental circumstances. SMEs should prioritize investment in R&D and transformative learning to store technological and market knowledge so that they can later respond quickly to changes. SMEs should also decide whether to explore or exploit depending on the environmental conditions.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Hubei University. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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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APPENDIX

Items for Causal and Outcome Conditions

a) **Items for radical innovation**

1. We develop products or services that offer greater advantages to customers than any other products or services currently available.
2. We develop products or services that better meet the needs of customers than any other product or service currently available.
3. We develop products or services that require customers to substantially alter their behavior.
4. We introduce new products/services to an existing market.
5. We introduce new products/services to a new market.
6. We develop new product/services that require significantly new technology or ideas that did not exist in the market before.
7. We create new major product/service programs leading to expansion of current markets.
8. We develop innovations that make our prevailing product/service lines obsolete.
9. We introduce new or significantly improved processes for producing or supplying products (goods or delivering services) which are new to our industry.

b) **Items for technological turbulence**

1. The technology in our industry is changing rapidly.
2. Technological changes provide big opportunities in our industry.
3. A large number of new product ideas have been made possible through technological breakthroughs in our industry.

c) **Items for market turbulence**

1. In our kind of business, customers' product preferences change quite a bit over time.
2. Our customers tend to look for new product all the time.
3. New customers tend to have product-related needs that are different from those of our existing customers.

d) **Items for explorative learning process**

1. We frequently scan the environment for new technologies.
2. We thoroughly observe technological trends.
3. We observe in detail external sources of new technologies.
4. We periodically organize special meetings with external partners to acquire new technologies.
5. Employees regularly approach external institutions to acquire technological knowledge.
6. We often transfer technological knowledge to our firm in response to technology acquisition opportunities.

e) **Items for transformative learning process**

1. We thoroughly maintain relevant knowledge over time.
2. Employees store technological knowledge for future reference.
3. We communicate relevant knowledge across the units of our firm.
4. When recognizing a business opportunity, we can quickly rely on our existing technological knowledge.
5. We quickly analyze and interpret changing market demands for our technologies.
6. New opportunities to serve our customers with existing technologies are quickly understood.

f) **Items for exploitative learning process**

1. We are proficient in transforming technological knowledge into new products.
2. We regularly match new technologies with ideas for new products.
3. We quickly recognize the usefulness of new technological knowledge for existing knowledge.
4. We regularly apply technologies in new products.
5. We constantly consider how to better exploit technologies.
6. It is well known who can best exploit new technologies inside our firm.

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The Effects of Open Innovation Based on Mergers and Acquisitions on Innovative Behavior of Enterprises: Evidence From Chinese Listed Enterprises

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Finding the factors driving enterprise innovation behavior from multiple dimensions is of great significance for promoting enterprise innovation. Open innovation based on overseas mergers and acquisitions (M&A) has become one of the main ways for enterprises to obtain knowledge and technology. However, there is still no agreement on whether open innovation based on overseas M&A can promote innovation behavior of enterprises. Based on data from M&A transaction and enterprise patent of China's Shanghai and Shenzhen A-share listed companies from 2011 to 2018, this study constructs a propensity score matching and difference-in-difference model from the perspective of innovation performance and innovation investment empirically studies the influence of open innovation mode based on overseas M&A on the innovation behavior of enterprises and finds that open innovation based on overseas M&A can significantly promote the innovation performance and innovation investment. Meanwhile dynamic effects test shows this promotion effect is sustainable; it reaches the maximum in the year of overseas M&A and decreases in the next two years. In addition, the impacts are heterogeneous due to enterprise ownership and enterprise technology intensity. The findings extends the scope of understanding innovation behavior of enterprises from overseas M&A and provide solid evidence of significant business implications for the promotion of entrepreneurial innovation.

Keywords: innovative behavior, overseas mergers and acquisitions, open innovation, independent innovation, difference-in-difference

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INTRODUCTION

Innovation is widely recognized as the main strategic driving force that leads to economic growth and development (Scuotto et al., 2020). As the main body of innovation, the improvement of an enterprise's innovation capability is the key to innovation-driven development (Jahanger, 2021). However, the complex interaction between technological paradigm and knowledge flows is making

Abbreviations: M&A, mergers and acquisitions; PSM, propensity score matching; DID, difference-in-difference; SOEs, state-owned enterprises.

innovation more difficulty and expensive. In a nutshell, it becomes increasingly difficult for enterprises to achieve independent innovation on internal resources alone (Scuotto et al., 2020). The alternative is to search the external resources to gain the chances of innovation and achieve comparative advantages in fierce global competition. This leads firms to an open innovation system. As Chesbrough (2003) proposed in the early 2000s, open innovation means using knowledge inflow and outflow to promote enterprises to speed up internal innovation and broaden the market for the use of external resources such as partnership, licensing contracts, industry-university-research, that is, multiple subjects' synergetic governance of enterprises, universities and government to promote talent cultivation and technological innovation, and other technology agreements (Duysters and Hagedoorn, 2001; Drayton and Budinich, 2010; Del Giudice and Maggioni, 2014; Carayannis et al., 2018). As one of the main way of open innovation (Berchicci, 2013), in the past ten years, mergers and acquisitions (M&A) have constantly grown (Bresciani, 2012; Öberg, 2017) and become one of the main ways used by firms to obtain knowledge and technology resources for innovation (Öberg, 2016; Shin et al., 2017) and augment their performance (Dezi et al., 2018).

The relationship between M&A and innovation has received attention from both practice and academia, but the conclusions are inconsistent. Some scholars provide evidence that M&A can promote innovation in firms. For example, M&A enables acquiring companies to learn directly from overseas acquired companies and obtain complementary R&D resources, which is conducive to breaking the dependence on technological innovation, changing the company's innovative thinking, and promoting innovation (Stiebale, 2013). Furthermore, by reconfiguring the knowledge network, providing economies of scale and scope in research, and boosting the capacity for inventive recombination, M&A can enhance the acquirer's knowledge base and improve its innovation output (Bresciani and Ferraris, 2016; Chen et al., 2021). Conversely, other scholars suggest that M&A has a negative effect on company's innovation. Specifically, M&A involves managerial problems, integration issues, and transaction expenses (Zollo and Singh, 2004; Del Giudice and Maggioni, 2014; Carayannis et al., 2017). When companies conduct M&A, the cost of integrating and adjusting resources due to cultural systems and other differences leads to technology spillover and suboptimal performance (Edamura et al., 2014). Another viewpoint is that the influence of M&A on company's independent innovation is unclear (Zhou et al., 2019). The latest empirical evidence suggests that firms completing overseas M&A witness an increase in systemic innovation but a drop in autonomous innovation (Zhang and Tong, 2021).

Given the above, the relationship between open innovation based on M&A, especially overseas M&A, and the independent innovation behavior of enterprises is still not clear. Whether open innovation based on overseas M&A can promote the independent innovation behavior of enterprises? Furthermore, what is the heterogeneity of overseas M&A in terms of ownership, and technology intensiveness? To answer the above questions, the active overseas M&A of Chinese companies in recent years provide a unique opportunity for this study. Between 2008 and 2018, the number of overseas M&A of Chinese companies increased from 126 to 627, and the amount of M&A increased from $10.4 billion to $94.1 billion, with the number and amount of M&A peaking at 920 in 2016, involving more than $200 billion (see **Figure 1**).

Specifically, about the methodology, there are many approaches towards studying M&A activities. It is possible to identify three principal streams of study. The empirical quantitative method is often used, the empirical qualitative method (case study/multiple case study) and the desk qualitative method. From the perspective of this study, in order to clearly identify the causal effect of M&A on independent innovation of enterprises, this article adopts the causal inference method in empirical quantitative method. Based on overseas M&A data and patent data of A-share listed companies from 2011 to 2018, this study takes the overseas M&A as a quasi-natural experiment, uses propensity score matching (PSM) to solve the self-selection effect of overseas M&A enterprises and constructs difference-in-difference (DID) from the perspective of innovation performance and innovation investment to study the impacts of open innovation based on overseas M&A on enterprises' independent innovation empirically. This study finds that open innovation based on overseas M&A can significantly promote the innovation performance and innovation investment. Meanwhile dynamic effects test shows this promotion effect is sustainable; it reaches the maximum in the year of overseas M&A and decreases in the next 2 years. In addition, the impacts are heterogeneous due to enterprise ownership and enterprise technology intensity.

This study may have three contributions to the current literature. First, we use data from developing country to empirically examine the causality between the open innovation based on overseas M&A and independent innovation of listed companies, which provides new evidence for understanding the relationship between overseas M&A and corporate innovation. Second, this study regards the overseas M&A of listed companies as a quasi-natural experiment and uses the DID and PSM methods to solve the sample self-selection bias and reduce the endogenous problem, which clarifies the causal identification clearly. Third, this study considers both the innovation performance and the innovation investment of enterprises innovation behavior and further analyzes the heterogeneous innovation effect of open innovation based on overseas M&A among different enterprise ownership and technology intensity. This study contributes to a comprehensive understanding of the innovation effects of open innovation based on overseas M&A.

EXPERIMENTAL DETAILS

Theoretical Analysis and Research Hypothesis

Theoretically, open innovation may have positive or negative effects based on overseas M&A on the independent innovation behavior of enterprises. The positive impact is reflected in the fact that enterprises' technology and innovation strategies rely more on open innovation, especially overseas M&A

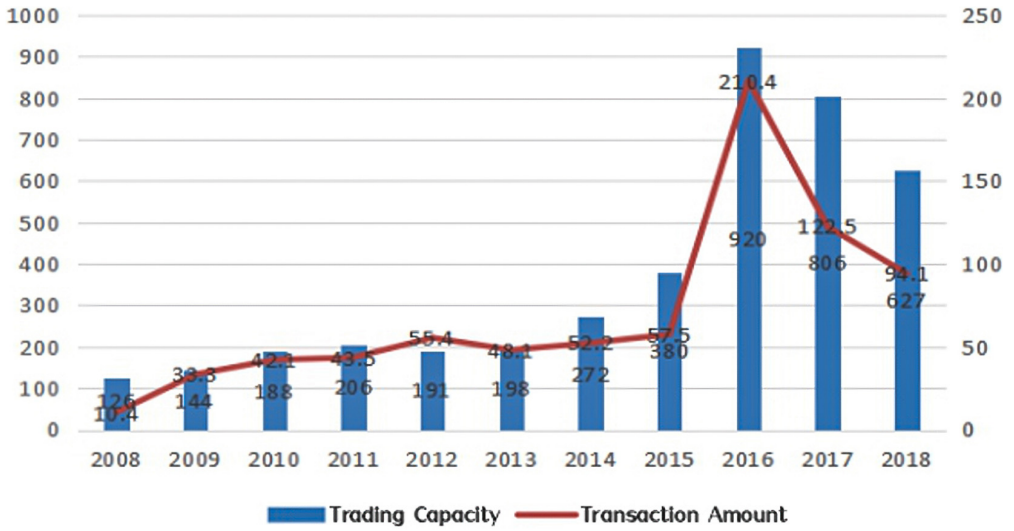

FIGURE 1 | Overseas M&A of Chinese enterprises from 2008 to 2018. Data obtained from enterprise patent database in wind.

TABLE 1 | Specific definition of variables.

Variable	Variable definition
Interpreted variable	
Patent quantity	Ln (1 + number of invention patents and utility model patents applied by an enterprise in the same year)
Patent quality invention	Ln (1 + number of invention patents applied by an enterprise in the same year)
Research and development investment (Rd)	R&D input intensity; Rd = R&D expenses/operating income
Human capital investment (Rdp)	Proportion of technicians; Rdp = the number of technicians/employees
Control variable	
Enterprise size (Size)	The size of the enterprise, expressed by log (total number of employees in that year)
Asset-liability ratio (Lev)	Asset-liability ratio, Lev = total liabilities at the end of the period/total assets at the end of the period
Labor productivity (Lap)	Labor productivity, Lap = log (operating income/total number of employees)
Capital intensity (Capital)	Capital intensity, Capital = fixed asset balance/total number of employees at the end of the period
Financing constraint (Fc)	Enterprise financing constraints, Fc = financial expenses/operating income
Enterprise age (Age)	Number of years of establishment of an enterprise
Overseas business revenue (Oversea)	Overseas business income, greater than 0, is recorded as 1, otherwise it is recorded as 0
Enterprise control attribute (State)	The attribute of enterprise control rights, the state-owned enterprise is recorded as 1, otherwise it is recorded as 0

(Watanabe et al., 2009). M&A can enable enterprises to quickly acquire high levels of expertise, R&D skills, experienced employees, and specific new technologies to meet the challenges of a dynamic and competitive environment (Bower, 2001). The innovation performance of overseas M&A enterprises is not only increased in quantity, but the quality of innovation is also significantly improved (Hull and Rothenberg, 2008), and the improvement of M&A to long-term innovation ability is more significant than the improvement of short-term innovation ability (Entezarkheir and Moshiri, 2018). The acceleration of innovation and the demand for new solutions are the main factors that drive enterprises to obtain external resources and capabilities through M&A (King et al., 2008). The negative influence is reflected in the fact that enterprises need to spend a significant amount of time and material consumption to integrate after M&A. Meanwhile, the increase in transaction costs also has a negative effect on the development of innovation after M&A (Ahuja and Katila, 2001). M&A absorbs the time and energy of managers and reduces their commitment to long-term investment in R&D, resulting in a decline in innovation performance after M&A (Hitt et al., 1991; Hoskisson et al., 1994). Moreover, when the target enterprises of overseas M&A are in the same industry as the original enterprises, M&A behavior cannot promote the innovation performance of enterprises, which may be due to the difficulty of integration after M&A and the lack of experience (Kreiser et al., 2013). In recent years, the overseas M&A activities of Chinese enterprises have taken place on a large scale, the experience of M&A has gradually accumulated, and the success rate of M&A has greatly improved.

Therefore, according to the actual situation in China, we propose the following hypothesis:

Hypothesis 1: Open innovation based on overseas M&A has a positive impact on the innovation of enterprises, and

innovation performance and innovation investment have significantly improved.

The above theoretical analysis emphasizes the role of open innovation based on overseas M&A in promoting enterprise innovation, but different enterprise ownership and whether they are technology-intensive, high-tech enterprises play a heterogeneous role in the innovation effect of open innovation based on overseas M&A (Aghion et al., 2013; Foroughi et al., 2015). Many studies have shown that the innovation efficiency of state-owned enterprises (SOEs) is significantly lower than that of foreign-funded and private enterprises (Laffont and Tirole, 1993; Jefferson et al., 2006). However, as China's economic growth momentum shifts to innovation-driven, SOEs have started to pay attention to serving the national strategy and enhancing technological innovation capabilities by acquiring knowledge, technology, and resources in overseas M&A (Bierwerth et al., 2015; Hervas-Oliver et al., 2016). This study holds that although the innovation performance and motivation of SOEs are weaker than that of non-SOEs before M&A, after adopting the open innovation model of overseas M&A to obtain advanced technology, their own technological innovation ability will be significantly improved, and their innovation performance will be significantly increased. For non-SOEs, the integration of overseas M&A is more difficulty and risky, and the adaptation time is longer. Compared with SOEs, in order to promote the absorption and transformation of foreign technology, it is necessary to further increase innovation investment and improve the intensity of R&D investment and the proportion of technical personnel (Shefer and Frenkel, 2005). Simultaneously, the expansion of the organizational scale will lead to a reduction in management limitation and an increase in information transmission costs, which will have a negative impact on the innovation performance of non-SOEs. Therefore, after the completion of overseas M&A, the innovation performance of non-SOEs will be less improved than that of SOEs in that year. In order to complete the technological transformation, investment in innovation would still have increased more than that of SOEs.

Therefore, we propose the following hypothesis:

Hypothesis 2: The promotion effect of the open innovation mode based on overseas M&A on the innovation performance of SOEs is more obvious than that of non-SOEs, but the promotion effect of SOEs' innovation input is weaker than that of non-SOEs.

There are obvious differences in innovation activities between high-tech enterprises and non-high-tech enterprises (Duysters and Hagedoorn, 2001). It is necessary to divide the samples into two subsamples, namely, high-tech enterprises and non-high-tech enterprises, and then explore the impact of open innovation based on overseas M&A on the independent innovation behavior of enterprises. Compared to non-high-tech enterprises, the innovation motive force and innovation ability of high-tech enterprises are obviously stronger and corresponding innovation input and performance are also higher. In this case, the promotion effect of open innovation behavior based on overseas M&A on the innovation performance and investment of high-tech enterprises is weaker than that of non-high-tech enterprises. Meanwhile, high-tech enterprises are based more on technical considerations to carry out overseas M&A. After the M&A of cultural integration, technology integration, and other aspects of higher requirements, it will take longer for integration to be achieved; the risk of M&A failure is greater, and M&A patent performance will be greatly affected (Aminova, 2016). This study holds that open innovation based on overseas M&A plays a greater role in promoting the innovation performance of non-high-tech enterprises than high-tech enterprises.

Therefore, we propose the following hypothesis:

Hypothesis 3: The effect of open innovation based on overseas M&A on innovation performance and investment in non-high-tech enterprises is more obvious than that of high-tech enterprises.

Research Design

Sample and Data

To examine whether open innovation based on overseas M&A promotes the independent innovation behavior of enterprises, this study uses data from State Intellectual Property Office, Wind database and China Stock Market & Accounting Research Database (CSMAR). This study selects the Shanghai and Shenzhen A-share listed companies in China from 2008 to 2018 as the initial sample. The overseas M&A data of listed companies originate from the Wind listed company M&A database (MA), and further confirm the M&A behavior and the information of the M&A party through the listed company announcement. The number of patent applications originates from the State Intellectual Property Office and CSMAR, R&D investment, the proportion of technical personnel, and other data from the Wind database. Simultaneously, the samples of missing data, enterprises with financial industry or ST (Special Treatment. It refers to an enterprise with abnormal financial or other conditions), and less than 10% of acquired shares are removed, and 733 overseas M&A transaction records of listed companies are obtained after preliminary screening. For enterprises with multiple M&A activities in different years, the completion of the first M&A prevail. Since listed companies began to disclose the proportion of technical personnel in 2011, and there were few M&A records before 2011, the final M&A sample is 247 listed companies. Through the above processing, the non-parallel panel data of 24,963 observations of 3,333 enterprises from 2011 to 2018 are finally obtained. Among them, 247 enterprises with overseas M&A are in the treatment group, and 3,086 enterprises without overseas M&A are in the control group.

Methods

The question explored in this study is whether open innovation based on overseas M&A promotes the independent innovation behavior of enterprises and is conducive to the high-quality development of enterprises. However, overseas M&A behavior does not occur at random. Only those enterprises with a high level of productivity, who lead industry development, and actively seek innovative technology will choose to invest abroad (Ornaghi, 2009; Mao et al., 2015); overseas M&A may have a "self-selection effect." It is unreasonable to directly compare the innovation activities of overseas M&A enterprises with those

of other enterprises. This study uses the practice of Ornaghi (2009) for reference, regards overseas M&A as a quasi-natural experiment, and adopts the PSM method to solve the self-selection effect of enterprises (Abadie and Cattaneo, 2018). On the basis of matching samples, the DID method is used to measure the impact of open innovation based on overseas M&A on enterprise innovation, which reduces the problem of endogeneity in estimation and provides clearer and more reliable results for causal inference (Doudchenko and Imbens, 2016). The first difference stems from the enterprise level, while the second layer stems from the time series level. Specifically, this study compares the differences between M&A enterprises and matching non-M&A enterprises before and after M&A. The model is defined as follows:

$$Y_{it} = \alpha + \beta did_{it} + X_{it}^{'}\varphi + \eta_j + \gamma_t + \varepsilon_{it} \quad (1)$$

Where i is the individual of the enterprise and t is the time. did_{it} is a double difference item, $did_{it} = 1$, which means that enterprise i has overseas M&A in year t. If there is more than one overseas M&A activity in the sample period, this study defines the time dummy variable only by the date of the first successful overseas M&A announcement.

This study only defines the time dummy variable by the date of the first successful overseas M&A announcement. Y_{it} is the index of enterprise innovation, including innovation performance and innovation input. This study measures the performance of enterprise innovation from the perspective of patent quantity and quality. Patent is the logarithm of the sum of the invention and utility model patents applied by the enterprise in that year plus 1, which is used to measure the number of patents. Invention is the logarithm of the number of invention patents applied for by the enterprise in that year plus 1, which is used to measure the quality of the patents. For the measurement of innovation investment, this study considers the intensity of R&D investment (Rd) and the proportion of human capital investment—the proportion of technical personnel (Rdp)—to comprehensively and accurately evaluate the impact of overseas M&A on the innovation effect of enterprises. $X_{it}^{'}$ is a series of individual-year control variables. These variables include enterprise size (Size), asset-liability ratio (Lev), labor productivity (Lap), capital intensity (Capital), financing constraint (Fc), enterprise age (Age), overseas business revenue (Oversea), and enterprise control attribute (State). The variables are shown in **Table 1**. η_j refers to the industry fixed effect, which controls all factors at the industry level that do not change with time, such as industry characteristics. γ_t stands for the time fixed effect, which controls the characteristics of the time level that do not change with the change of enterprises, such as the change in the macroeconomic situation. β is a did regression coefficient through which the influence effect of overseas M&A on enterprise innovation can be judged. In the above estimation formula, this study focuses on the coefficient β, if $\widehat{\beta} > 0$; that is, compared with the enterprises without overseas M&A, overseas M&A improves the innovation capability of M&A enterprises.

As can be seen from **Table 2**, the overall patent performance level of overseas M&A enterprises (both the number and quality of patents) is significantly higher than that of enterprises without overseas M&A. The average number of invention patents and overseas M&A enterprises is about 10.63, while the average number of overseas M&A enterprises is 3.18; the former is about 3.3 times that of the latter. Simultaneously, the average number of invention patent applications of overseas M&A enterprises is about 5.66, while the average number of overseas M&A enterprises is about 1.87; the former is about three times that of the latter, which preliminarily shows that overseas M&A not only helps to improve the innovation performance of enterprises, but also greatly improves the quality of performance.

TABLE 2 | Descriptive statistics of all variables.

Variable	Mean	Std. Dev	Min	Median	Max	Obs
All samples						
Number of patents	1.511	1.794	0.000	0.693	9.743	24,963
Patent quality	1.121	1.499	0.000	0.000	9.168	24,963
Rd	0.038	0.042	0.000	0.032	0.240	24,963
Rdp	0.168	0.179	0.000	0.121	0.827	24,963
Size	7.394	1.308	2.197	7.318	13.021	24,963
Lev	0.421	0.205	0.052	0.412	0.901	24,963
Lap	13.689	0.886	5.825	13.578	19.886	24,963
Capital	12.303	1.252	4.127	12.343	21.335	24,963
Fc	0.015	0.035	–0.063	0.007	0.207	24,963
Age	17.353	6.054	1.000	17.000	64.000	24,963
Oversea	0.572	0.495	0.000	1.000	1.000	24,963
State	0.283	0.450	0.000	0.000	1.000	24,963
Overseas M&A enterprises						
Number of patents	2.454	2.035	0.000	2.565	9.743	1,953
Patent quality	1.896	1.821	0.000	1.609	9.168	1,953
Rd	0.038	0.040	0.000	0.033	0.240	1,953
Rdp	0.210	0.189	0.000	0.153	0.827	1,953
Non-overseas M&A enterprises						
Number of patents	1.431	1.749	0.000	0.000	9.524	23,010
Patent quality	1.055	1.450	0.000	0.000	8.918	23,010
Rd	0.038	0.043	0.000	0.032	0.240	23,010
Rdp	0.165	0.178	0.000	0.118	0.827	23,010

The overall innovation investment of overseas M&A enterprises is higher than that of enterprises without overseas M&A. In terms of R&D investment intensity, the average of the two is the same; R&D capital investment accounts for less than 4% of business income, indicating that enterprises still do not pay enough attention to R&D capital investment. However, in terms of the proportion of scientific researchers, 21.0% of the enterprises engaged in overseas M&A, while only 16.5% of the enterprises did not carry out overseas M&A; the former was about 3.5 percentage points higher than the latter. It can be preliminarily considered that overseas M&A have effectively promoted the investment of enterprises in scientific researchers, but what should not be ignored is that there are also great individual differences. If accurate results are to be obtained, further empirical tests are needed.

RESULTS

In this section, we conduct a series of empirical analyses on whether and how open innovation based on overseas

M&A contributes to the independent innovation behavior of enterprises. Firstly, we match the overseas and non-overseas M&A enterprises using the PSM method in section "Results of PSM." Then, we conduct an empirical analysis using the DID method in section "Results of DID." Finally, we perform a heterogeneity analysis in section "Results of Heterogeneity Analysis."

Results of PSM

This study uses the PSM method to match overseas and non-overseas M&A enterprises to ensure the reliability of the matching results. Before using PSM to control the endogeneity of overseas M&A, it is necessary to determine which factors are more likely to lead to overseas M&A (Ornaghi, 2009). Based on the standard proposed by Smith and Todd (2005), this study selects the following variables: enterprise size (Size), asset-liability ratio (Lev), labor productivity (Lap), capital intensity (Capital), enterprise financing constraint (Fc), enterprise age (Age), Overseas business income (Oversea > 0 is marked as 1, otherwise 0), and enterprise nature (State). The Logit model is used to predict the probability of overseas M&A, and the results are shown in **Table 3**.

According to the estimated results in **Table 3**, the coefficient of Size is significantly positive at the 1% level, which indicates that the larger the scale of enterprises, the greater the probability of overseas M&A. This is because these enterprises have more resources, have more strength to merge with other enterprises, can provide full play to the role of synergy and economies of scale, and can cope with all kinds of risks faced by overseas M&A. The coefficient of Lap is significantly positive at the 1% level, indicating that enterprises with higher labor productivity are more likely to produce overseas M&A. This is because these enterprises can overcome the investment barriers and information processing costs of the host country, which means that Chinese enterprises have a self-selective effect in the open innovation model based on overseas M&A (Mao et al., 2015), The coefficient of Age is significantly positive at the 1% level, indicating that the longer the establishment of enterprises, the higher the probability of overseas M&A. Simultaneously, the coefficient of Oversea is significantly positive at the 1% level, indicating that if enterprises have already carried out business overseas, they will be more likely to engage in overseas M&A. The fuller the understanding of the overseas market, the higher the business income and the more motivated the M&A of foreign companies, thus further improving the overseas market share. In addition, the uncertainty of information is also reduced, and the success rate of M&A is improved. The coefficient of Lev is significantly negative at the 1% level, which indicates that the higher the asset-liability ratio, the smaller the probability of overseas M&A. This is because enterprises with a high asset-liability ratio may face higher financial risks; thus, there are not enough self-owned funds to carry out overseas M&A. If overseas M&As are carried out, the financial risks they face expand further. It will even affect the normal business activities of the enterprise. The coefficient of Capital is significantly negative at the 5% level, which indicates that the higher the capital intensity, the smaller the probability of overseas M&A. The coefficient of Fc is significantly positive at the 1% level, which indicates that the greater the financing constraint, the easier it may be for enterprises with greater financing constraints to adopt a policy of radical expansion to carry out overseas M&A, so as to seek new technologies and resources to expand the market scale and their own business income. However, the State coefficient is significantly negative at the 1% level, which indicates that SOEs are not inclined to carry out overseas M&A. According to the data of the statistical bulletin of China's foreign direct investment, the contribution of non-SOEs to cross-border M&A investment gradually exceeds that of SOEs, and occupies a major position in cross-border M&A.

Through the Logit model, it can be found that only those enterprises with productivity and technological advantages can carry out open innovation based on overseas M&A, which verifies that overseas M&A open innovation enterprises have a self-selection effect.

In order to solve this problem, according to the propensity score estimated by the Logit model, this study matches the control group enterprises closest to the experimental group in order to minimize the sample selection bias, and uses the k nearest domain matching method (k = 4, r = 0.001) to analyze the matching effect (In this study, different matching methods are used to obtain similar results); the premise of using the PSM model to match is to satisfy the parallel hypothesis and the common support hypothesis. **Table 4** shows the test results of the control variables before and after matching. The results show that the P-value of all the matched (M) variables is greater than 0.1, and the overall LR (Likelihood Ratio. It is a kind of index reflecting authenticity, which is a composite index reflecting sensitivity and specificity at the same time) test shows that P = 1.000 after matching; thus, there is no significant difference between the experimental group and the control group, and the parallel trend hypothesis is satisfied.

As shown in **Figure 2**, the kernel density distribution between the experimental and control groups is quite

TABLE 3 | Regression results of Logit model.

	Estimation coefficient	Z value
Enterprise scale	0.604***	(26.54)
Asset-liability ratio	−1.711***	(−9.79)
Labor productivity	0.528***	(14.43)
Capital intensity	−0.063**	(−2.31)
Financing constraint	8.902***	(9.38)
Enterprise age	0.016***	(3.79)
Overseas business income	1.143***	(17.37)
Enterprise control attribute	−1.279***	(−17.69)
Industry effect	Yes	Yes
Time effect	Yes	Yes
N	24,946	
Pseudo-R	0.116	

****, **, * represent the significant level of 1, 5, 10%, respectively, and the numbers in parentheses are robust standard errors. Unless with specification, the following are the same.*

TABLE 4 | Results of equilibrium test using the PSM method.

Variable	Matching	Mean			% Reduced bias	T-test	
		Treated	Control	% Bias		*t*	*P* > *t*
Size	U	8.0156	7.3418	51.2		22.07	0.000
	M	8.0082	7.9905	1.3	97.4	0.40	0.687
Lev	U	0.4347	0.42002	7.2		3.04	0.002
	M	0.43417	0.42766	3.2	55.6	1..01	0.315
Lap	U	13.812	13.676	15.2		6.41	0.000
	M	13.808	13.814	−0.7	95.5	−0.21	0.836
Capital	U	12.321	12.301	1.6		0.66	0.507
	M	12.321	12.319	0.2	88.3	0.06	0.952
Fc	U	0.01646	0.01493	4.3		1.82	0.069
	M	0.01649	0.01577	2.0	52.3	0.65	0.514
Age	U	17.802	17.315	8.4		0.41	0.001
	M	17.794	17.797	−0.1	99.2	−0.02	0.984
Oversea	U	0.78136	0.5545	49.6		19.60	0.000
	M	0.7808	0.78337	−0.6	98.9	−0.19	0.846
State	U	0.20072	0.29	−20.9		−8.42	0.000
	M	0.20123	0.19995	−0.3	98.6	0.10	0.920

different before matching, but the kernel density distribution of the treatment and control groups tends to coincide after matching; thus, the common support hypothesis is verified. Therefore, this study has a good matching effect, and the choice of matching variables is more reasonable. The DID method can be further used to analyze the impact of open innovation based on overseas M&A on enterprise innovation.

Results of DID

In this section, we conduct an empirical analysis to examine the impact of open innovation based on overseas M&A, including the full sample DID analysis and PSM-DID analysis.

The Results for the Full Sample

The regression results of the DID fixed effect are shown in **Table 5**. The four models are the influence of overseas M&A on enterprise innovation: (1) the total number of invention patents and utility model patents applied by enterprises in that year (Patent); (2) the number of invention patents applied by enterprises in that year (Invention); (3) the intensity of R&D investment (Rd); and (4) the proportion of technical personnel (Rdp). The results show that the regression coefficients of did are significantly positive at the 1% level, which indicates that overseas M&As can significantly improve the innovation performance and investment of enterprises. After overseas M&A, the quantity and quality of patent performance are significantly increased, and the intensity of R&D investment and the proportion of technical personnel are also significantly increased.

The Results for PSM-DID

Table 6 shows the results of the PSM-DID regression. The four models are as follows: (1) the impact of overseas M&A on enterprise innovation, that is, the total number of invention patents and utility model patents; (2) the number of invention patents applied by enterprises in that year; (3) the R&D investment intensity (Rd); and (4) the proportion of technical personnel (Rdp). The results are shown in columns (1) to (4). The regression coefficients of Did are significantly positive at the 1% level, which indicates that after enterprises carry out open innovation based on overseas M&A, the quantity and quality of patent performance are significantly increased, and the intensity of R&D investment and the proportion of technical personnel are also significantly increased, indicating that open innovation based on overseas M&A can significantly improve the innovation performance and investment of enterprises. The high-quality development of the enterprise validates theoretical Hypothesis 1 of this study.

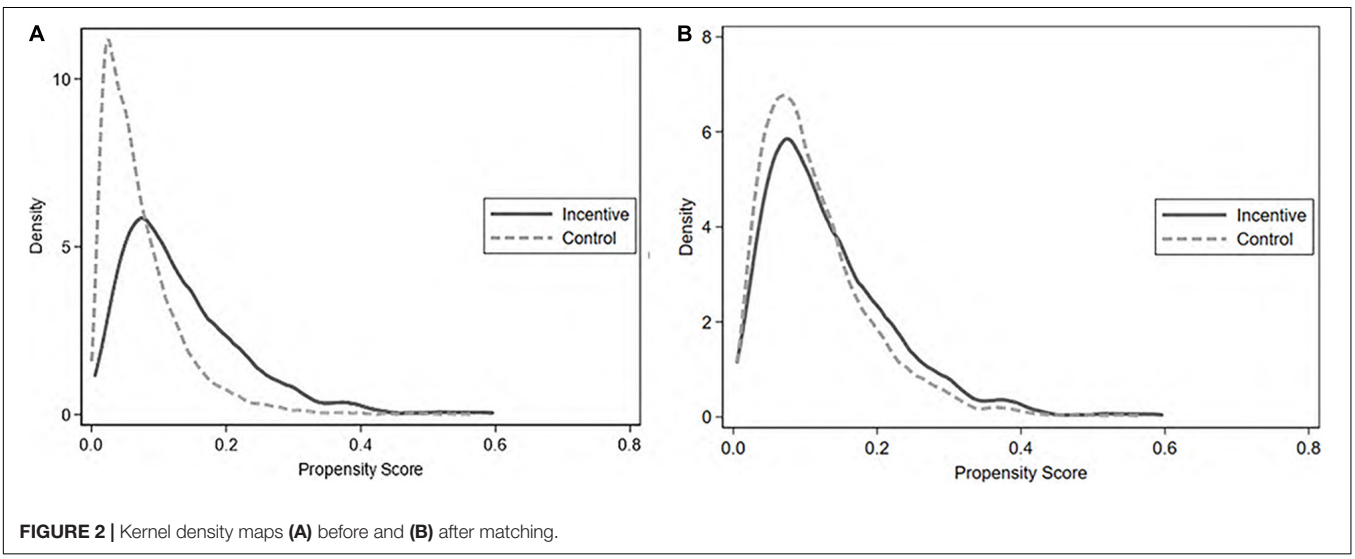

FIGURE 2 | Kernel density maps **(A)** before and **(B)** after matching.

TABLE 5 | DID regression results.

Variable	(1)	(2)	(3)	(4)
	Patent	Invention	Rd	Rdp
Did	0.513***	0.455***	0.006***	0.034***
	(9.84)	(9.30)	(5.67)	(6.93)
Size	0.582***	0.483***	–0.005***	–0.002***
	(61.69)	(55.81)	(–25.54)	(–2.71)
Lev	–1.283***	–1.029***	–0.019***	–0.123***
	(–22.25)	(–20.80)	(–13.14)	(–19.45)
Lap	0.268***	0.248***	–0.009***	0.014***
	(20.45)	(21.43)	(–23.80)	(9.64)
Capital	0.105***	0.070***	–0.001***	0.000
	(11.81)	(9.10)	(–5.07)	(0.22)
Fc	1.195***	1.074***	–0.079***	0.026
	(3.88)	(4.10)	(–7.86)	(0.73)
Age	0.021***	0.016***	–0.001***	0.001***
	(12.53)	(10.94)	(–17.12)	(7.95)
Oversea	0.421***	0.326***	0.008***	0.013***
	(20.53)	(18.67)	(14.42)	(5.71)
State	0.356***	0.308***	–0.001**	0.038***
	(14.30)	(13.86)	(–2.11)	(15.73)
Cons	–9.348***	–7.966***	0.198***	–0.106***
	(–41.81)	(–40.65)	(37.27)	(–4.80)
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Adj_R^2	0.381	0.343	0.386	0.279
N	24,963	24,963	24,963	24,963
F	358.261	258.150	412.819	158.190

*The t-value calculated based on the standard error of robustness is shown in brackets. ***, **, * represent the significant level of 1, 5, 10%, respectively.*

Since the influence of overseas M&A on enterprise innovation is not limited to that year, there may be a continuous impact in the following years. In order to better evaluate the impact of M&A, it is necessary to further investigate the dynamic effects, investigate the changes of innovation input and performance in the two years after M&A, and construct the following model:

$$y_{it} = \beta_0 + \beta_1 did_0 + \beta_2 did_1 + \beta_3 did_2 + X_{it}^{'}\varphi + \eta_j + \gamma_t + \varepsilon_{it} \quad (2)$$

Where did_0,did_1, did_2 is a virtual variable, indicating the dynamic effects of the current year, the first year, and the second year after overseas M&A.

The empirical results, as shown in **Table 7**, show that the coefficient of $did_0 and did_1$ is significantly positive at the 1% level. The coefficient of did_2 is significantly positive at the 5% level (at least), indicating that open innovation based on overseas M&A plays a significant role in promoting enterprise innovation performance and innovation investment compared with enterprises without overseas M&A. This promotion effect is sustainable, and in general, it shows a decreasing trend with the increase in years.

The empirical results verify Hypothesis 1; that is, open innovation based on overseas M&A can significantly promote enterprise innovation. Enterprise innovation performance and innovation investment are significantly increased, and the role of promotion is sustainable. In the years of M&A, the promotion role reaches the maximum. Since then, it has shown a decreasing trend with the increase in years.

TABLE 6 | Regression results of PSM-DID analysis.

Variable	(1)	(2)	(3)	(4)
	Patent	Invention	Rd	Rdp
Did	0.443***	0.365***	0.005***	0.037***
	(8.20)	(7.23)	(4.78)	(7.06)
Size	0.671***	0.584***	-0.005***	–0.010***
	(36.92)	(34.34)	(–15.56)	(–6.40)
Lev	–1.302***	–1.073***	–0.016***	–0.094***
	(–10.74)	(–9.99)	(–5.88)	(–7.71)
Lap	0.295***	0.273***	–0.010***	0.007***
	(11.27)	(11.45)	(–16.65)	(2.80)
Capital	0.116***	0.092***	–0.001**	–0.000
	(6.34)	(5.64)	(–2.56)	(–0.19)
Fc	2.030***	1.692***	–0.086***	–0.151**
	(3.22)	(3.10)	(–4.38)	(–2.27)
Age	0.017***	0.013***	–0.000***	0.002***
	(5.21)	(4.49)	(–6.76)	(6.04)
Overseas	0.407***	0.313***	0.009***	0.011**
	(9.02)	(7.97)	(9.63)	(2.18)
State	0.341***	0.344***	0.002**	0.035***
	(6.29)	(6.85)	(2.08)	(7.38)
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Adj_R^2	0.415	0.378	0.375	0.310
N	7,691	7,691	7,691	7,691
F	140.149	104.820	134.711	54.432

*Standard error is robust standard error. ***, **, * represent the significant level of 1, 5, 10%, respectively.*

TABLE 7 | Dynamic effect regression results.

Variable	(1)	(2)	(3)	(4)
	Patent	Invention	Rd	Rdp
did0	0.691***	0.589***	0.006***	0.057***
	(7.11)	(6.41)	(2.91)	(5.65)
did1	0.649***	0.517***	0.006***	0.034***
	(6.72)	(5.59)	(3.09)	(3.39)
did2	0.380***	0.330***	0.007***	0.025**
	(3.84)	(3.47)	(3.21)	(2.55)
Control variable	Control	Control	Control	Control
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Adj_R^2	0.381	0.342	0.385	0.279
N	24,963	24,963	24,963	24,963

*The control variables are the same as in **Table 6** and are not fully listed for savings. The following is the same. ***, **, * represent the significant level of 1, 5, 10%, respectively.*

Results of Heterogeneity Analysis

To verify Hypotheses 2 to 3 and explore the impact of enterprise ownership, and enterprise characteristics on the innovation effect

of open innovation based on overseas M&A, a heterogeneity analysis is carried out by sample.

Heterogeneity Analysis of Enterprise Ownership

The empirical test results of Hypothesis 2 are presented in **Table 8**. It can be seen that when the patent quantity (Patent) and quality (Invention) are used as explained variables, the estimation coefficient of did is significantly positive at the 1% level, indicating that the ownership of ownership does not affect the promotion of open innovation based on overseas M&A on the innovation performance of enterprises; thus, there has been a significant improvement in both the quantity and quality of patent performance. Simultaneously, in terms of the number of patent performance (Patent), there is no significant difference in the promoting effect of open innovation based on overseas M&A on SOEs and non-SOEs. However, in terms of patent performance quality (Invention), the effect of open innovation based on overseas M&A on the improvement of patent quality of SOEs is obviously higher than that of non-SOEs. This means that SOEs absorb foreign advanced technology through overseas M&A, and promote their own R&D ability to obtain more obvious improvement, so that the number of invention patents is significantly increased.

When R&D investment (Rd) and human capital investment (Rdp) are used as explained variables, for SOEs, the estimation coefficient of did corresponding to R&D investment (Rd) was not significant, indicating that the overseas M&A of SOEs did not significantly affect the intensity of R&D investment, while the estimation coefficient of did corresponding to human capital investment (Rdp) was significantly positive at the 5% level. This shows that overseas M&As can significantly increase the proportion of technical personnel in SOEs. For non-SOEs, the estimation coefficients of did corresponding to R&D investment (Rd) and human capital investment were significantly positive at the 1% level, indicating that non-SOEs adopt the open innovation mode of overseas M&A to significantly increase the intensity of R&D investment and the proportion of scientific research personnel. Thus, the innovation investment of non-SOEs is significantly increased. It can be found from the coefficient that overseas M&A, an open innovation method, plays a much more important role in promoting the innovation investment of non-SOEs than those of SOEs. Through the open innovation model of overseas M&A, non-SOEs are more aware of the importance of technology and innovation, and are more willing to increase investment in capital and researchers. In summary, the empirical results support Hypothesis 2.

Heterogeneity Analysis of High-Tech Enterprises

In order to verify Hypothesis 4, the samples are divided into high-tech enterprises and non-high-tech enterprises, and the influence of open innovation based on overseas M&A on the innovation activities of M&A enterprises is studied. The empirical test results are shown in **Table 9**. It is found that when the patent quantity (Patent) and quality (Invention) are explained variables, the did

TABLE 8 | Heterogeneous regression results of enterprise ownership.

Variable	SOEs				Non-SOEs			
	(1) Patent	(2) Invention	(3) Rd	(4) Rdp	(5) Patent	(6) Invention	(7) Rd	(8) Rdp
Did	0.513***	0.575***	0.001	0.020**	0.520***	0.436***	0.008***	0.035***
	(4.05)	(4.59)	(0.91)	(2.02)	(4.07)	(8.26)	(6.69)	(6.14)
Control variable	Control	Control	Control	Control	Control	Control	Control	Control
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj_R^2	0.478	0.435	0.345	0.258	0.331	0.290	0.359	0.304
N	7,065	7,065	7,065	7,065	17,898	17,898	17,898	17,898

*The t-test showed that there was no significant difference in the coefficients of did between columns (1) and (5), while columns (2) and (6), columns (3) and (7), column (4), and column (8) had significant differences in the coefficients of did. ***, **, * represent the significant level of 1, 5, 10%, respectively.*

TABLE 9 | Heterogeneous regression results of high-tech enterprises.

Variable	High-tech enterprises				Non-high-tech enterprises			
	(1) Patent	(2) Invention	(3) Rd	(4) Rdp	(5) Patent	(6) Invention	(7) Rd	(8) Rdp
did	0.147**	0.159**	0.006***	0.025***	0.491***	0.447***	0.005***	0.032***
	(2.00)	(2.11)	(3.49)	(3.25)	(7.51)	(7.35)	(3.77)	(5.11)
Control variable	Control	Control	Control	Control	Control	Control	Control	Control
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj_R^2	0.439	0.386	0.384	0.404	0.341	0.302	0.388	0.263
N	5912	5912	5912	5912	19051	19051	19051	19051

*The t-test showed that there was no significant difference in the did coefficients between columns (3) and (7), columns (1) and (5), columns (2) and (6), and columns (4) and (8). There was a significant difference in the did coefficient between columns (1) and (5), columns (2) and (6), and columns (4) and (8). ***, **, * represent the significant level of 1, 5, 10%, respectively.*

coefficient is significantly positive at the 5% level (at least), and the corresponding coefficient of non-high-tech enterprises is much higher than that of high-tech enterprises. This means that overseas M&As play a significant role in promoting the innovation performance of high-tech enterprises and non-high-tech enterprises, the quantity and quality of patent applications are significantly increased, and the promotion of non-high-tech enterprises is stronger. This result supports Hypothesis 5.

When R&D investment (Rd) and human capital investment (Rdp) are taken as explained variables, the coefficients of did corresponding to high-tech and non-high-tech enterprises are significantly positive at the 1% level, indicating that open innovation based on overseas M&A can promote the innovation investment of high-tech and non-high-tech enterprises. However, in terms of the regression coefficient, there is no significant difference in R&D investment. In the proportion of technical personnel, the open innovation mode based on overseas M&A plays a greater role in promoting non-high-tech enterprises than high-tech enterprises. This may be because the proportion of technical personnel in high-tech companies is inherently high; thus, the promotion effect brought about by M&A is not as obvious as that of non-high-tech companies.

In summary, for non-high-tech enterprises, open innovation based on overseas M&A plays a more obvious role in promoting the innovation activities of this type of enterprise. Specifically, the promoting effect on the quantity and quality of patent performance and the proportion of technical personnel is higher than that of high-tech enterprises, which means that for non-high-tech enterprises, the open innovation mode based on overseas M&A can obtain foreign technology. It is effective to improve the level of innovation, and such enterprises should be encouraged to go abroad.

DISCUSSION

Innovation is the first impetus that leads to development. The independent innovation behavior of enterprises is the first factor to achieve high-quality growth. More and more enterprises are using overseas M&A as the main way of open innovation to obtain external resources and promote innovation. However, the details of the impact of open innovation based on overseas M&A on enterprises' independent innovation behavior are still in the black box. Therefore, the main objectives of this study were to empirically analyze the extent to which overseas M&A can enhance enterprises' independent innovation behavior and examine the impact of enterprise ownership and enterprise characteristics on the innovation effect of overseas M&A.

In view of this, this paper focuses on the key variable of enterprise independent innovation behavior. Taking the overseas M&A of enterprises as a quasi-natural experiment, this paper uses the DID method to investigate the impact of open innovation based on overseas M&A on enterprises' independent innovation behavior, and tests the robustness and heterogeneity. The empirical results answer the above questions well.

First, on the whole, on the basis of controlling other factors, open innovation based on overseas M&A can significantly promote enterprises' innovation performance and innovation investment. This finding is consistent with previous studies' conclusions that M&A enhances the innovation performance of enterprises (Yu et al., 2019; Cirjevskis, 2021), and provide empirical evidence that quantitatively answers the innovation effect of overseas M&A. In addition, through dynamic effect analysis, we found that this promotion effect of overseas M&A on enterprises' independent innovation behavior is persistent. Specifically, this innovation effect reaches the maximum in the year of M&A, and then decreases in the next two years, but remains. This result is an important contribution to the academic literature because it not only provides empirical evidence for overseas M&A promote the independent innovation behavior of enterprises, but also shed light on the dynamics of this impact. This finding was lacking in previous studies. Based on this finding, when enterprises seek to enhance their innovation capabilities through external resources, overseas M&A is a recommended route. Enterprises should better put more attention on the first year after an overseas M&A, because the innovation effect is strongest in this year. The government should create a good M&A environment for enterprises, and encourage enterprises to conduct overseas M&A from the aspects of preferential tax policies, strengthening intellectual property protection, and broadening financing channels.

Second, the impact of open innovation based on overseas M&A on enterprise innovation is heterogeneous due to enterprise ownership, and technology intensity. In terms of enterprise ownership, open innovation based on overseas M&A has innovation effect for both SOEs and non-SOEs but different in the innovation performance and the innovation investment. To be specific, overseas M&A has a stronger promotion effect on the patent performance quality (Invention) among SOEs and the R&D investment (Rd) and human capital investment (Rdp) among non-SOEs. In terms of technology intensity, for non-high-tech enterprises, the promoting effect of open innovation based on overseas M&A on the quantity and quality of patent and the proportion of technical personnel is higher than that of high-tech enterprises. Previous studies provided a little discussion of the heterogeneity of the impact of M&A on innovative behavior of enterprises, which addressed that firm age have an important role in open innovation (Krishna and Jain, 2020). Our finding contributes to the academic literature since this result expands the understanding of the effects of open innovation based on M&A on innovative behavior of enterprises from the perspective of enterprise ownership and technology intensity, which are considered to be closely related to enterprise innovation (Yu et al., 2016; Liu et al., 2017; Shen et al., 2019). Based on this finding, overseas M&A enterprises should also increase R&D intensity and efficiency, cultivate innovative talents by various ways, and build a competitive innovation system, which can not only improve the success rate of overseas M&A transactions, but also promote the technology complementarity and integration among enterprises (Wang and Liu, 2018), and benefit from the open innovation mode based on overseas M&A to a greater extent. The government should formulate more detailed and targeted support policies for overseas M&A, create favorable conditions for open innovation and cooperation among enterprises, universities, colleges and other institutions, and guide various types of enterprises' open innovation behavior based on overseas M&A.

CONCLUSION

Taking the results of the study into account, this research make several contributions to the existing literature. First, this study uses the relevant data of Chinese listed companies from 2011 to 2018 to empirically study the causal relationship between the open innovation of listed companies based on overseas M&A and enterprise independent innovation behavior. Second, in the research method, the overseas M&A of listed companies is regarded as a quasi-natural experiment, and the DID and PSM method are used to solve the self-selection bias of samples and reduce the endogenous problem, which makes the causal identification of this paper clearer in a certain process. Third, this study contributes to a comprehensive understanding of the innovation effects of open innovation based on overseas M&A, as this study considers both the innovation performance and investment of enterprises and further analyzes the heterogeneous innovation effect of open innovation based on overseas M&A among different enterprise ownership and technology intensity.

This study is not without limitations and future work may explore the following issues. First, this study uses the data of listed companies and lacks an examination of the relationship between overseas M&A and innovation in small and medium-sized enterprises. Second, only Chinese list companies are considered in this study; due to differences in national policies and stages of development, using data of companies from other countries to answer this question would make this study more robust. Third, in the process of M&A, through the outflow, inflow and integration of knowledge, the acquired company also engages in open innovation. It would be interesting to compare whether the result would be the same for acquired company in future research.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: State Intellectual Property Office, www.cnipa.gov.cn; Wind database, www.wind.com.cn; China Stock Market & Accounting Research Database (CSMAR), www.gtarsc.com.

AUTHOR CONTRIBUTIONS

MW led and designed the study, led the data collection, analysis, and interpretation. TL contributed to the study design, provided input into the data analysis, and wrote the first draft of the manuscript. YT contributed to the study design, reviewed the manuscript and helped the writing of the final draft manuscript. All authors read and approved the final manuscript.

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Perceived Environmental Corporate Social Responsibility and Employees' Innovative Behavior: A Stimulus–Organism–Response Perspective

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Drawing from the stimulus-organism-response (S-O-R) model, this study examines how and under what circumstances perceived environmental corporate social responsibility (ECSR) affects innovative behavior of employees in the context of environmental protection. Using a sample of 398 employees from different firms in the high energy-consuming industry of China, the results indicate that, at first, perceived ECSR provides a positive effect on organizational identification. Secondly, organizational identification has a positive influence on the innovative behavior of employees. Thirdly, organizational identification plays an important mediating effect between perceived ECSR and the innovative behavior of employees. Fourthly, both the effect of perceived ECSR on organizational identification and the indirect effect of perceived ECSR on the innovative behavior of the employees *via* organizational identification will be stronger when the levels of organizational trust are high. These findings add new insights into the perceived ECSR-employees' innovative behavior relationship and provide important managerial implications for enhancing ECSR perception to improve the innovative behavior of employees.

Keywords: environmental corporate social responsibility, employees' innovative behavior, organizational identification, organizational trust, S-O-R model

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INTRODUCTION

There is now considerable agreement that the activities of the firms are the main cause of environmental degradation (Tian and Robertson, 2019). In China, firms, especially those in the high energy-consuming industry, are at the heart of persistent debates around whether they have enough respect for the natural environment (Li et al., 2017). Controlling pollutant emissions from high energy-consuming firms and developing cleaner energy sources have become the core requirements of the economic construction of China (Zhang and Liu, 2019; Han, 2021). In such a context, firms that want to meet these requirements and survive need to depend more on innovation (Tang et al., 2021; Wang et al., 2021). As is widely accepted, employee innovation is the foundation of the innovation of firms (Shin et al., 2017; Liu et al., 2019). Existing research has suggested that innovative behavior of employees is extremely important not only because it can play a key role

in the sustainable development of firms, but also helps their firms gain competitive advantages in the rising pressure associated with environmental protection (Galbreath, 2019; Javed et al., 2020). Therefore, it is worth exploring how to effectively promote the innovative behavior of employees at the present stage. The innovative behavior of employees is defined as a series of positive behavioral responses that employees recognize, generate new ideas for products, services, and implement new ideas (Scott and Bruce, 1994; Kwon and Kim, 2020; Yuan, 2021). Many studies on the effects of organizational-level factors on the innovative behavior of employees are mainly from the economic perspective, including work process-related lead userness (e.g., Wu C.-H. et al., 2020), public service motivation (e.g., Miao et al., 2018), high-performance work practices (e.g., Farrukh et al., 2021), and perceived innovation job requirement (e.g., Shin et al., 2017), but a strong theoretical understanding from the non-economic perspective remains lacking.

In the high energy-consuming industry, environmental corporate social responsibility (ECSR) activity of firms is often presented as a non-economic activity (Roeck and Delobbe, 2012). ECSR is described as a voluntarily environmental behavior that aims to mitigate the influence of firms on the natural environment (Rahman and Post, 2012). ECSR can reflect the efforts of firms in a kind of environmental protection activities, such as waste emission reduction, pollution reduction, and product recycling (Flammer, 2013; Shah et al., 2021; Zhang and Ouyang, 2021). In addition, with the rapidly growing environmental awareness in employees (Ahmed et al., 2020), employees are more likely to have a passion for challenging and creative tasks related to the environmental activities of the firms (Hur et al., 2018). In this context, when employees perceive that their firms are responsible for the natural environment, they are more likely to offer their new ideas to the overall ECSR program of the organization and put such new ideas into implementation. Previous research has indicated that ECSR, as an issue of concern to employees within firms, has increasingly been valued by firms as one environmental stimulus to elicit the behavioral responses of employees (Orazalin, 2020), which help firms obtain the attention and support of employees (Su and Swanson, 2019). Thus, it is worth exploring whether perceptions of employees toward ECSR activities of firms positively affect the innovative behavior of employees.

However, the internal mechanisms in the relationship between perceived ECSR and the innovative behavior of employees also remain unclear. Some studies have shown that perceived corporate social responsibility (CSR) may influence the organizational identification of employees (Cheema et al., 2020), while others discovered that individual identification is an important factor that could impact employee innovations (Litchfield et al., 2018). Considering organizational identification as a cognitive process, scholars have investigated the mediating effect of organizational identification in the relationship between individual perception and behavior (Tian and Robertson, 2019; Van Dick et al., 2020). As such, organizational identification might act as the role of a bridge in the relationship between perceived ECSR and employee innovation. Although prior research has indicated that a direct relationship exists between the perceptions of employees on CSR and employee innovation (e.g., Hur et al., 2018), the internal mechanisms in the relationship between perceived ECSR and the innovative behavior of employees are rarely known. Hence, our work focuses on the mediating role of organizational identification, which enables us to penetrate internal mechanisms in perceived ECSR - employees' innovative behavior relationship.

Moreover, the boundary conditions of the relationship between perceived ECSR and the innovative behavior of employees have also not been fully explored by researchers. Previous research has suggested that the direct effect of the perceptions of employees on CSR on employee creativity was significant (Brammer et al., 2015), but others pointed out that perceived CSR has no direct impact on employee creativity (Kim et al., 2021). The reason for such inconsistencies is that scholars may ignore the influence of moderating factors on CSR perception – employee innovation relationship. Some scholars have pointed out that the perceptions of employees to firms' behaviors are shaped by the level of organizational trust (Taniguchi and Marshall, 2018). Organizational trust is an important element in a work environment that creates a collaborative environment by giving employees a feeling of integrity, commitment, and dependence (Chathoth et al., 2011; Bak, 2020). As a concept that describes the extent to the trust of employees in the organization (Chathoth et al., 2011), organizational trust can inevitably strengthen or weaken the degree to which the ECSR affects the attitudes and behaviors of employees (Alfes et al., 2012). Therefore, the influence of organizational trust should be considered in our research framework to investigate the perceived ECSR - organizational identification - employees' innovative behavior of relationship.

Accordingly, using the stimulus-organism-response (S-O-R) model, we examine the relationship between perceived ECSR as a stimulus and the innovative behavior of employees as the response, and the mediating role of organizational identification (organism) in perceived ECSR-employees' innovative behavior relationship, and the moderating role of organizational trust in the relationship between perceived ECSR and the innovative behavior of employees. The S-O-R model originated from the field of behavioral psychology and is widely applied in the consumer behavior literature and organizational behavior literature (Ahmed et al., 2020; Huang et al., 2021). The S-O-R model is used to analyze how environmental stimulus effectively affects internal state of an individual, and then elicits individual behavior (Mehrabian and Russell, 1974; Jang and Namkung, 2009; Xu and Wang, 2019). The objectives of this study are threefold: First, we examine how perceived ECSR as a stimulus affects the innovative behavior of employees as a response by using the extended S-O-R model in the context of environmental protection. Second, organizational identification as the mediating role through which perceived ECSR affects the innovative behavior of employees, further offers new insight into how the perceptions of employees on implemented ECSR of firms affect the responses of employees. Finally, by assessing how organizational trust

positively enhances the direct effect of perceived ECSR on organizational identification and strengthens the indirect effect of perceived ECSR on the innovative behavior of employees through organizational identification, we identify a potential boundary condition to these relationships, and thus, reveal under what circumstances employees are more (or less) motivated to improve their innovative behavior. This study tests these hypotheses based on a dataset of 398 employees from different firms in high energy-consuming industries of China. At present, firms in China are often related to social negligence and environmental pollution in the eyes of the public (Wei et al., 2017; Xu et al., 2018; Tian and Robertson, 2019; Li et al., 2020). Moreover, there is a need to fill knowledge gaps in the relationship between perceived environmental corporate social responsibility (ECSR) and the innovative behavior of Chinese employees from the high energy-consuming industry. Hence, China provides a suitable context to investigate these relationships among perceived ECSR, organizational identification, organizational trust, and innovative behavior of employees.

Our study makes three contributions: first, this study on the effects of perceived ECSR on the innovative behavior of employees will contribute to enriching the predictors of innovative behavior literature by identifying another organizational means of promoting the innovative behavior of employees. Although previous studies have suggested that CSR perception may be an important predictor for the innovation of employees (Hur et al., 2018), the role of perceived ECSR as a key antecedent to the innovative behavior of employees remains unclear. In addition, understanding that the theoretical connection between the perceived ECSR and the innovative behavior of employees from the stimulus-organism-response perspective can provide different effective methods to reduce the pressure of environmental protection for firms in China. Second, this study highlights the role of organizational identification in the enactment of innovative behavior. Although prior studies have suggested that individual identification has a positive effect on innovative behavior (Litchfield et al., 2018), scholars have not fully explored the role of organizational identification in the relationship between the perceived ECSR and the innovative behavior of employees. Based on the S-O-R model, this study expands the work in previous studies by examining the mediating effect of organizational identification in perceived ECSR- employees' innovative behavior relationship. Finally, this study contributes to extending the boundary conditions of the innovative behavior of employees from the perspective of organizational trust. Previous studies have rarely explored under what circumstances perceived ECSR can effectively promote employee innovation (Hur et al., 2018).

RESEARCH BACKGROUND AND HYPOTHESES DEVELOPMENT

Stimulus-Organism-Response Model

Based on the stimulus-response theory, Mehrabian and Russell (1974) posited the S-O-R model which states that environmental stimulus impacts the internal state of an individual, and then influences approach behaviors or averting behaviors of an individual. The stimulus refers to environmental factors that can be conceptualized as stimulating individuals and impacting their internal state in the S-O-R model (Eroglu et al., 2001). According to the research by Jacoby (2002), the environmental factors include everything we usually understand as external stimuli, such as perceived quality (product, atmospherics, and service), brand image, reputation, policy, and countless other influencing factors (Jang and Namkung, 2009; Kim and Lennon, 2013; Tang et al., 2019). The organism is considered to be an internal process which plays an intervening role in the relationship between the stimulus and the response emitted by an individual (Mehrabian and Russell, 1974; Jang and Namkung, 2009; Bigne et al., 2020). Besides, the response is regarded as the final outcomes that can be approached or averting behavior. Approach behavior is a positive action in a particular setting, yet averting behavior is an opposite behavior (Mehrabian and Russell, 1974).

The S-O-R model provides an explanatory perspective on the innovative behavior of employees with regard to environmental effects (Xu and Wang, 2019). This model states that when an organism is stimulated by environmental factors, its internal processes, including its cognitive response (Ferdous et al., 2021), will change, resulting in it approaching or avoiding the environment that provides the stimulation. Organizational identification is a cognitive process that can be viewed as cognitive episodes (Jang and Namkung, 2009). The cognitive nature is regarded as "the mental structures and the processes involved in thinking about, understanding, and interpreting the stimuli and events of the environment" (Sánchez et al., 2006, p. 395). Therefore, organizational identification mediates the impacts of environmental factors on behaviors of employees. Under the setting of environmental protection, the stimuli consist of perceived ECSR. The internal psychological states of the organism include employee identification and other internal responses (e.g., emotional response; Jani and Han, 2015) that could elicit the behavioral responses of employees, including innovative behavior. Accordingly, we adopt the S-O-R model to examine the relationship among perceived ECSR, organizational identification, and innovative behavior of employees. Furthermore, previous studies have investigated that organizational trust plays a key role in improving perceptions of individuals and promoting positive workplace attitudes, such as perceived HRM practices (Alfes et al., 2012) and job satisfaction (Lee et al., 2013). Organizational trust describes the extent to which employees believe their organization (Chathoth et al., 2011). Organizational trust is regarded as an important element in a work environment and creates a collaborative environment by giving employees a feeling of integrity, commitment, and dependence (Chathoth et al., 2011; Ertürk and Vurgun, 2015). According to the S-O-R model, when perceived ECSR- organizational identification - employees' innovative behavior relationship is considered as a stimulus-organism-response relationship, organizational trust might affect this relationship by creating a collaborative environment. Thus, we introduce organizational trust as the moderator into our extended S-O-R model (presented in **Figure 1**).

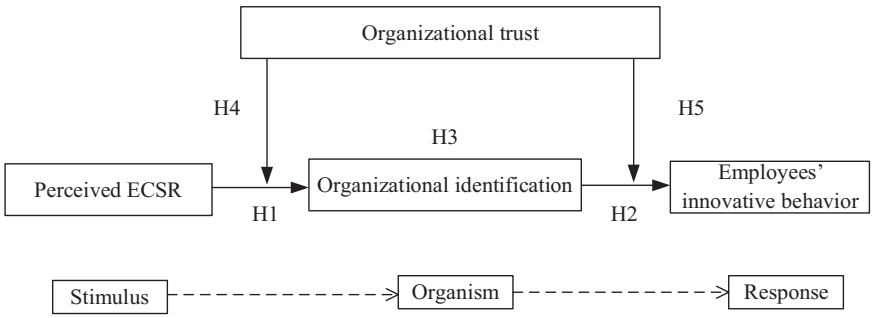

FIGURE 1 | Proposed theoretical framework and hypotheses.

Perceived Environmental Corporate Social Responsibility and Employee Responses

Environmental corporate social responsibility (ECSR) is from the notions of environmental management and CSR (Chuang and Huang, 2018). ECSR plays a vital part in the process of the impact of the activities of firms on the natural environment (Kim et al., 2017; Shah et al., 2021). According to Baughn et al. (2007), American enterprises have higher levels of CSR compared to other countries, but the ECSR level of American enterprises is lower. As such, high CSR does not always produce high ECSR (Chuang and Huang, 2018). Mazurkiewicz (2004) has defined ECSR as "the duty to cover the environmental implications of the operations, products, and facilities; elimination of waste and emissions; maximization of the efficiency and productivity of its resources; and minimization practices of the company that might adversely affect the enjoyment of the resources of the country by future generations." According to the extant definitions of ECSR and the purpose of our study, we defined perceived ECSR as the subjective perception that employees perceive the extent to which the ECSRs of organizations are to be fulfilled and to evaluate his/her organization.

To date, however, the vast majority of studies in the ECSR literature mainly paid attention to the organizational level of analysis (Cordeiro and Tewari, 2014; Forcadell et al., 2021; Rela et al., 2021). For instance, studies on the organizational level have examined the effect of ECSR on organizational performance, such as financial performance (Lioui and Sharma, 2012; Zhang and Ouyang, 2021), export performance (Xu et al., 2018), innovation performance (Wu W. et al., 2020), business competitiveness, and environmental performance (Chuang and Huang, 2018; Orazalin, 2020). Recently, studies on the ECSR literature have begun to focus on the individual-level analysis of the effect of perceived ECSR on responses (Hur et al., 2018; Su and Swanson, 2019). Within the individual-level ECSR literature, it is a large number of studies on how the ECSR activities of a firm affect the responses of employees, such as trust and pride (Roeck and Delobbe, 2012; Su and Swanson, 2019), organizational commitment and identification (Hofman and Newman, 2014; Kim et al., 2016; Zhou et al., 2018), empathy (Tian and Robertson, 2019), and job satisfaction of employees (Ilkhanizadeh and Karatepe, 2017; Kim et al., 2018). Another stream of the individual level of ECSR literature has also shown how ECSR perception affects the behavioral responses of employees (Ruepert et al., 2017; Ahmad et al., 2021). For example, many researchers have reported that employees who positively perceive the ECSR activities of the firms are more likely to make a kind of the behavioral response of employees, such as employee creativity (Hur et al., 2018) and organizational citizenship behavior (Cheema et al., 2020).

Perceived Environmental Corporate Social Responsibility and Organizational Identification

Organizational identification refers to "the degree to which a member defines him or herself by the same attributes that he or she believes define the organization" (Dutton et al., 1994; Roeck and Farooq, 2017). The psychological process of organizational identification explains internal processes that intervene between external stimulus to the establishment or maintenance of a relationship with their social groups of reference and attitudes of individuals (Dutton et al., 1994; Roeck and Farooq, 2017). In the context of environmental protection, the ECSR perception of employees can serve as a stimulus that affects the attitudes of employees (Ilkhanizadeh and Karatepe, 2017). Perceived ECSR focuses on the evaluation and understanding of individuals on the environmental responsibility of the organization in various aspects (Parker et al., 2003; Turker, 2009).

According to Kim et al. (2010), Korschun et al. (2014), and Afsar et al. (2018), employees who are attracted by the organizational image from the effort of environment protection are more likely to identify with environmentally responsible firms. This suggests that employees who are impacted by image evaluation of the organization are especially sensitive to the ECSR activities of their firm (Vlachos et al., 2010; Lee et al., 2013; Farrington et al., 2017) because ECSR can reflect the image of firms whether a firm strives to protect the natural environment (Rahman and Post, 2012). The other way round, the ECSR perceptions of employees impact the attractiveness of image of their organization because it contributes to increasing the consistency between values of employees and organizational values (Kim et al., 2010; Glavas, 2016; Afsar et al., 2018).

According to Dutton et al. (1994), organizational identification of their organization is reinforced when employees believe to have the same attributes (e.g., values, beliefs, and goals) with the organization. Supporting these theoretical arguments, firms positively engaged in ECSR activities tend to enhance the image so that employees are more likely to increase organizational identification of the employee for the company (De Roeck et al., 2016; Islam et al., 2016; Afsar et al., 2018; Su and Swanson, 2019; Cheema et al., 2020). Thus, the perception of employees of ECSR activities of their firms may positively impact the degree of their organizational identification. In association with the literature above, we proposed the following hypothesis:

> ***Hypothesis1.*** *Perceived ECSR has a positive effect on organizational identification.*

Organizational Identification and Innovative Behavior of Employees

Existing studies have suggested that organizational identification is related to the behavioral responses of individuals toward their firms (e.g., Dukerich et al., 2002; Madjar et al., 2011). Employees tend to integrate organizational values, goals, and beliefs into the belief categories related to themselves (Dutton et al., 1994; Roeck and Farooq, 2017), and then adopt positive behavioral responses consistent with their values, goals, and beliefs (Ashforth et al., 2008; Madjar et al., 2011; Barba-Sánchez and Atienza-Sahuquillo, 2017).

The innovative behavior of employees represents a type of individual behavioral response in the S-O-R model and is defined as a series of behaviors that employees recognize, generate new ideas for products and services, and implement new ideas (Scott and Bruce, 1994), and is consistent with the organizational values, beliefs, and goals (Dutton et al., 1994; Roeck and Farooq, 2017). Previous research has provided support in that when employees identify with their organization, they will positively vest in the success and survival of the firm and are motivated to adopt positive behavioral responses of individuals (Ashforth and Mael, 1989; Song et al., 2019). Thus, this study states that organizational identification may be a crucial factor that affects the innovative behavior of employees. More specifically, our study argues that employees who identify with a firm because of the same values, goals, and beliefs with organizations are more likely to support their firms (Ashforth et al., 2008), which may positively promote the behavioral responses of employees (e.g., innovative behavior of employees) that support their firms, such as generating new ideas and securing all resources to implement these novel and useful ideas. Thus, we hypothesize:

> ***Hypothesis2****. Organizational identification has a positive effect on the innovative behavior of employees.*

The Mediating Role of Organizational Identification

The pattern of relationships discussed above indicates the potential impacts of ECSR, such that perceived ECSR as a stimulus may indirectly affect the innovative behavior of employees (i.e., behavioral responses of individuals) through organizational identification. Consistent with the S-O-R model, some studies indicate that perceived ECSR is regarded as a vital environmental stimulus factor that can impact the degree of identification of employees, and then the propensity of employees to produce different behavioral responses in the organization (Castro-Gonzalez et al., 2019; Boan and Dedeolu, 2020; Cheema et al., 2020; Shah et al., 2020). For instance, Tian and Robertson (2019) confirmed that perceived CSR (include environmentally responsible practices; Turker, 2009) could influence tendency of employees to identify with the firm and then influence behavioral response of employees to participate in supporting firm. They also proved that perceived CSR could indirectly influence the behavioral responses of individuals *via* organizational identification (Brammer et al., 2015). As a result, organizational identification is considered as an important organism that plays an intervening role in the relationship between perceived ECSR (i.e., stimulus) and innovative behavior of employees.

In the S-O-R model, the organizational identification of employees as the organism is related to perceived ECSR and innovative behavior of employees. More specifically, our study suggests that employees tend to identify with their company when they regard their company as an organization responsible for the environment (i.e., ECSR; Turker, 2009), and therefore may be motivated to generate new ideas for products, services, and implement new ideas that support their firms (Xu and Wang, 2019). In particular, employees who identify with their company because of its environmental responsibility tend to support the ECSR activities of the company by fostering innovative behavior (Madjar et al., 2011; Wu W. et al., 2020). Taken together, we suggest that organizational identification of employees, as a mediator, enhances the positive effect of perceived ECSR on the innovative behavior of employees. Therefore, this study proposed the following hypothesis:

> ***Hypothesis3.*** *Organizational identification positively mediates the relationship between ECSR and innovative behavior of employees.*

The Moderating Role of Organizational Trust

Perceived Environmental Corporate Social Responsibility, Organizational Trust, and Organizational Identification

Organizational trust is conceptualized as positive expectations of employees for the intentions and behaviors of multiple organizational members based on organizational roles, relationships, experiences, and interdependencies (Chathoth et al., 2011). The organizational trust consists of integrity, commitment, and dependence (Chathoth et al., 2011). Integrity refers to the principles and values that the trustee adheres to and accepted by the trustor, while commitment is about "a sense of loyalty in the action of the individual leading to identification and association with a given organization" (Chathoth et al., 2011). Dependability captures factors that relate to the loyalty of the organization to its employees and is considered as the degree of credibility of employees to the

organization (Chathoth et al., 2011). Studies on the literature state that organizational trust is considered to be a critical variable that affects organizational effectiveness (Ertürk and Vurgun, 2015). In the context of environmental protection, organizational trust represents the level of positive expectation that employees perceive toward a voluntarily environmental behavior of firms and the degree to which they believe what firms show the efforts of firms in a kind of environmental protection activities (Hosmer, 1995). It suggests that employees with high levels of organizational trust are those who tend to have positive expectations about organizational activities.

Recently, it has been argued that high organizational trust affects the relationships between the perception of employees of voluntarily environmental behaviors and the organizational identification of firms (Dirks and Ferrin, 2002; Farooq et al., 2014, 2017). By doing so, a high level of organizational trust is more likely to strengthen the effect of perceived ECSR on organizational identification. In addition, high organizational trust can also make it easier for employees to perceive the environmental responsibility of firms, bolstering the positive effect of perceived ECSR on organizational identification. In contrast, employees with low levels of organizational trust do not react strongly to the image of the organization (Perry and Mankin, 2007). Specifically, when employees are at a low level of organizational trust, they have low expectations for any activity of the organization because these employees have questioned the integrity and commitment of the organization and reduced their dependence on the organization (Thomas, 2015). As such, low organizational trust is less likely to enhance the organizational identification that employees may experience under ECSR perception. According to the above studies, we add organizational trust as a moderator in the S-O-R model, we hypothesize:

> ***Hypothesis4.*** *Organizational trust positively moderates the relationship between perceived ECSR and organizational identification, such that the positive relationship is stronger for employees with higher levels of organizational trust.*

Perceived Environmental Corporate Social Responsibility, Organizational Trust, and Innovative Behavior of Employees

Organizational trust is viewed as a critical moderating variable that impacts employee behavior (Ertürk, 2010; Su and Swanson, 2019; Bak, 2020) because it seems to provide more insights into employee behavior based on organizational environment. In an organizational setting, a high level of organizational trust positively strengthens the impact of organizational identification on the behaviors of employees (Ertürk, 2010). For instance, employees with high levels of organizational trust are more likely to identify with the focus of organizational activities on improving the quality of the environment where engaging in innovative behaviors in response to organizational environmentally responsible is expected (Brammer et al., 2015; Hur et al., 2018).

It follows that the employees with a high level of organizational trust will be positively motivated to generate new ideas in response to organizational activities they perceive at work but also encourage them to engage in innovative behavior by implementing such ideas for the success and survival of firms (Hansen et al., 2011; Alfes et al., 2012; Lee et al., 2013). Specifically, when employees perceive the image of the organization, that the firms will be responsible for the quality of the environment, employees with high levels of organizational trust will positively identify with their firms because of their ECSR perceptions, and they are more inclined to contribute their new ideas and secure all resources to implement new ideas that support the values, goals, and beliefs of the firm. Conversely, employees with low levels of organizational trust will not be impacted by the image of organization (Pučėtaitė and Lämsä, 2008), such employees are less likely to respond positively to their organizational activities (Archimi et al., 2018). As such, even if employees with low levels of organizational trust identify with their organization due to the ECSR perceptions, the indirect effect of perceived ECSR on the innovative behavior of employees will be weaker. Altogether, we proposed the following hypothesis:

> ***Hypothesis5.*** *Organizational trust positively moderates the indirect effect of perceived ECSR on innovative behavior of employees via organizational identification, such that the indirect effect will be stronger when the levels of organizational trust are high.*

METHODOLOGY

Sample and Data Collection

To test all hypotheses of the current study, we collected data from employees of firms in the high energy-consuming industry of China. The survey was conducted from April to July 2020. According to "National Bureau of Statistics of the People's Republic of China (2011)" issued by the Chinese government (National Bureau of Statistics), high energy-consuming industries mainly include power, steel and instrument manufacturing, petrochemicals and chemicals, non-ferrous metals, pharmaceuticals, paper, coal, building materials, textiles, and mining. Because a list of firms with the telephone numbers and e-mail addresses of employees has not been fully disclosed in China, many studies obtain such lists through government agencies (Walker et al., 2014; Wei et al., 2017). Thus, we approached the government agencies and got a list of high energy-consuming firms with the contact information of Human Resource (HR) managers. The high energy-consuming firms in this list are more than 14,000 firms, from which we randomly selected 500.

To recruit employees as participants, we first discussed the objectives and procedures of our study with HR managers of firms. The HR managers randomly selected employees and provided us with a list of 500 participants. The survey participants mainly included managers, technical staff, and production personnel involved in innovation activities of their firms. Then, the researchers sent recruitment emails to all participants before the investigation, informing them of the academic purpose of this survey. We have promised them that the questions they answered

are confidential and only used for academic research. We changed the order of predictor variable (perceived ECSR), mediating variable (organizational identification), moderating variable (organizational trust), and control variables in our questionnaire. Next, we asked participants to answer all survey questions. Based on the feedback of participants, we confirmed that all items included in the survey were clear and comprehensive.

The researchers conducted a questionnaire survey after obtaining the consent of all participants included in the study. Data were collected in two stages: in the first stage, participants completed Questionnaire A regarding perceived ECSR, organizational trust, and control variables (gender, age, education, industry, and tenure of employees). After 1 month, in the second stage, participants were asked to complete Questionnaire B on organizational identification and innovative behavior of employees. During the questionnaire survey, the researchers asked managers, technical staff, and production personnel to complete the questionnaire survey. We conducted a Kruskal-Wallis H to test the position distributions of the respondents ($x^2 = 2.793$, Asymp. Sig. $= 0.425 > 0.05$). The results revealed that there is no significant difference in their positions.

According to Comrey (1988), a sample size of below 100 is not suitable for factor analysis, a sample size of about 200 is good for ordinary factor-analytic work, and a sample size of over 300 is great. We sent a total of 500 questionnaires to employees working in high energy-consuming industries (e.g., non-ferrous metals) in China. After excluding missing data and those failing to meet the questionnaire requirements, our final sample consists of 398 employees, representing an overall response rate of 79.60%. The final sample displays about 52.76% of employees were male. Of the 398 responding employees, 16.08% held board senior managers, middle managers, and general managers, and 33.17% were technical staff, 28.64% were production personnel, and 22.11% were others. Most employees were under 30 years old, 13.57% of organizational tenure of employees have been employed for 11–20 years, 5.28% have been employed for more than 20 years within the firm, and 53.02% of the education of employees were bachelor's degrees.

Measures

Walker et al. (2014) pointed out that due to the lack of public data in China, academic research often needs to rely on surveys to collect the data required by the research. Our survey is based on face-to-face interviews and previous research. According to the method of back translation, all items were translated into Chinese (Reynolds et al., 1993). All items were measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) and depicted in **Table 1**.

Perceived Environmental Corporate Social Responsibility

Based on the research of Turker (2009), we retained six items from the social and nonsocial dimension of stakeholders of the CSR scale to measure the perception of employees in that which employees perceived activities of their organization protect the natural environment (Roeck and Delobbe, 2012). A sample item is "I can feel our company implements special programs to minimize its negative impact on the natural environment."

Organizational Identification

Based on the research of Mael and Ashforth (1992) and Brammer et al. (2015), our study adapts a measure of organizational identification on six items measuring employees' degree of identification in an organization. Sample items include: "Our company's successes are my successes" and "When I talk about our company, I usually say we rather than they."

Organizational Trust

According to the work of Chathoth et al. (2011), we adapt a measure of organizational trust based on the five items that are used to evaluate degree of trust of employees in the organization. The five items are used to measure organizational trust appear in **Table 1**.

Innovative Behavior of Employees

Since the innovative behavior of employees has been conceptualized as a workplace behavior by Yuan and Woodman (2010) and Wu C.-H. et al. (2020), we measure the innovative behavior of employees based on a six-item scale from Scott and Bruce (1994). Sample items are "I can search out new technologies and new processes in work" and "I often generate creative ideas in my work."

Control Variables

Past ECSR research implies that some demographic characteristics of employees, such as age, gender, education, and tenure, have been related to general workplace behaviors, which may impact the results of the hypothesized relationships in our study (Rahman and Post, 2012; Tian and Robertson, 2019). Therefore, we controlled for the gender, age, education, and organizational tenure (years) of employees in our analyses. The gender of employees was coded as "1" for males and "2" for females. Age of employees was coded as "1" for employees aged between 18 and 30, "2" for employees aged between 31 and 40, "3" for employees aged between 41 and 50, and "4" for employees aged 51 or above. The education of employees was coded as "1" for a high school education or below, "2" for college, "3" for a bachelor's degree, and "4" for a master's degree or above. Tenure was coded as "1" for 2 years or below, "2" for 3 to 5 years, "3" for 6 to 10 years, "4" for 11 to 20 years, and "5" for 21 years or above. In addition, this study controlled for industry, as this may affect innovative behavior of employees. This study surveys these employees from high energy-consuming companies in a variety of high energy-consuming industries, including power, steel and instrument manufacturing, petrochemicals and chemicals, non-ferrous metals, pharmaceuticals, paper, coal, building materials, textiles, and mining. The industry was coded as "1" for power, "2" for steel and instrument manufacturing, "3" for petrochemical and chemical, "4" for non-ferrous metals, "5" for pharmaceutical, "6" for paper, "7" for coal, "8" for building materials, "9" for textiles, "10" for mining, and "11" for other industries.

TABLE 1 | Measurement items.

Variables	Items	Factor loading	CR	AVE	Cronbach's alpha
Perceived ECSR	PECSR1: "I can feel our company implements special programs to minimize its negative impact on the natural environment."	0.804	0.923	0.665	0.922
	PECSR2: "I can feel our company participates in activities which aim to protect and improve the quality of the natural environment."	0.829			
	PECSR3: "I can feel our company has the necessary equipment to reduce its negative environmental impact."	0.817			
	PECSR4: "I can feel our company makes well-planned investments to avoid environmental degradation."	0.825			
	PECSR5: "I can feel our company targets sustainable growth which considers future generations."	0.813			
	PECSR6: "I can feel our company makes investment to create a better life for future generations."	0.805			
Organizational identification	O11: "Our company's successes are my successes"	0.791	0.917	0.647	0.916
	O12: "When I talk about our company, I usually say we rather than they."	0.776			
	O13: "When someone criticizes our company, it feels like a personal insult."	0.826			
	O14: "I am very interested in what others think about our company."	0.793			
	O15: "When someone praises our company, it feels like a personal compliment."	0.842			
	O16: "If a story in the media criticized our company, I would feel embarrassed."	0.797			
Organizational trust	OT1: "Our company treats me fairly and properly."	0.767	0.908	0.663	0.907
	OT2: "Our company communicates with me openly and honestly."	0.855			
	OT3: "Our company tells me everything that I want to know."	0.833			
	OT4: "Our company considers my advice valuable."	0.840			
	OT5: "Our company maintains a long-term relationship with me."	0.772			
Employees' innovative behavior	EIB1: "I can search out new technologies and new processes in work."	0.831	0.941	0.725	0.940
	EIB2: "I often generate creative ideas in my work."	0.877			
	EIB3: "I often promote and champion new ideas to others."	0.852			
	EIB4: "I often investigate and secure founds needed to implement new ideas."	0.824			
	EIB5: "I often develop adequate plans and schedules for the implementation of new ideas."	0.872			
	EIB6: "Generally speaking, I am an innovative person."	0.852			

CR, composite reliability; AVE, average variance extracted.

Reliability and Validity Analysis

The KMO of perceived ECSR, organizational identification, organizational trust, and innovative behavior of employees were all over 0.70, the significance of Bartlett's test is 0.000, and the cumulative variance contribution rate of common factors extracted by each variable is more than 70%, which reveals that it is suitable for factor analysis. We examined all the items using the exploratory factor analysis (EFA). By adopting the principal component analysis method, EFA was carried out for all items. The results showed that four factors were extracted: perceived ECSR, organizational identification, organizational trust, and innovative behavior of employees. In addition, the minimum standardized factor loading was 0.697, more than 0.5. Taken together, the four-factor structure was confirmed.

We tested the reliability and validity of our four variables *via* SPSS 21 and Amos 21. Cronbach's alpha values of perceived ECSR, organizational identification, organizational trust, and innovative behavior of employees were greater than 0.70 (**Table 1**), indicating that all survey scales show good reliability. This study used confirmatory factor analysis (CFA) to test our model fit. The AVE values of all of the constructs are above 0.5, and the composite reliability (CR) of each variable is larger than 0.8 in **Table 1**, thereby suggesting that has a high convergent validity (Fornell and Larcker, 1981). Moreover, results show that the off-diagonal coefficients are less than the square root of AVE

for each construct (see **Table 3**). Meanwhile, the results in **Table 2** indicate that the four-factor model was significantly superior to other models. Thus, there is a good discrimination validity among the variables.

Common Method Variance

As this study collected data using questionnaires, there might be a problem with the Common Method Variance (CMV) (Podsakoff et al., 2003). To reduce the issues related to common method bias (Spector, 1994), first, we changed the order of all variables in our questionnaire to reduce predictions of participants. Second, we set the answers to the questionnaire as anonymous and signed a confidentiality agreement with employees. Participants were able to answer the questions by their spontaneous opinions, as this study emphasized that there was no definite answer to these questions. For the statistical control, based on the single factor test (Harman, 1961), we used SPSS 21.0 to analyze all the data. A total of 73.73% of the total variance of item interpretation is more than 60%, and 42.80% of the total variance of the first-factor interpretation is less than 50% (Fuller et al., 2016). We further conduct confirmatory factor analysis (CFA) to test the possibility of CMV. These results corroborated that the four-factor model is in good agreement with the data ($x^2 = 358.995$, $df = 224$, $x^2/df = 1.603$, RMSEA = 0.039, NFI = 0.949, RFI = 0.943, CFI = 0.980, IFI = 0.980, TLI = 0.978, SRMR = 0.039) and was significantly superior to one factor model ($x^2 = 3433.044$, $df = 230$, $x^2/df = 14.926$, RMSEA = 0.187, NFI = 0.515, RFI = 0.467, CFI = 0.531, IFI = 0.532, TLI = 0.484, SRMR = 0.152). Thus, these precautions effectively prevent the problems that would occur in the data of our study due to common method bias.

TABLE 2 | Results of confirmatory factor analysis.

Model	x^2	df	x^2/df	Δx^2	RMSEA	NFI	RFI	CFI	IFI	TLI	SRMR
1.Four-factor model	358.995	224	1.603	–	0.039	0.949	0.943	0.980	0.980	0.978	0.039
2.Three-factor model (OI & OT = 1 factor)	1015.342	227	4.473	656.347	0.094	0.857	0.840	0.885	0.885	0.871	0.075
3.Three-factor model (PECSR & OT = 1 factor)	1124.245	227	4.953	765.250	0.100	0.841	0.823	0.869	0.869	0.854	0.088
4.Three-factor model (OT & EIB = 1 factor)	1463.318	227	6.446	1104.323	0.117	0.793	0.770	0.819	0.820	0.798	0.144
5.Three-factor model (PECSR & OI = 1 factor)	1651.478	227	7.275	1292.483	0.126	0.767	0.740	0.791	0.792	0.767	0.124
6.Three-factor model (OI & EIB = 1 factor)	1711.826	227	7.541	1352.831	0.128	0.758	0.731	0.783	0.783	0.758	0.149
7.Three-factor model (PECSR & EIB = 1 factor)	1766.763	227	7.783	1407.768	0.131	0.750	0.722	0.774	0.775	0.749	0.146
8.Two-factor model (PECSR & EIB = 1 factor; OI & OT = 1 factor)	2391.665	229	10.444	2032.670	0.154	0.662	0.627	0.683	0.684	0.650	0.160
9.Two-factor model (PECSR & OT = 1 factor; OI & EIB = 1 factor)	2429.049	229	10.607	2070.054	0.156	0.657	0.621	0.678	0.679	0.644	0.168
10.Two-factor model (PECSR & OI = 1 factor; OT & EIB = 1 factor)	2718.791	229	11.872	2359.796	0.165	0.616	0.576	0.635	0.637	0.597	0.191
11.One-factor model	3433.044	230	14.926	3074.049	0.187	0.515	0.467	0.531	0.532	0.484	0.152

N = 398. PECSR, perceived ECSR; OI, organizational identification; OT, organizational trust; EIB, innovative behavior of employees.

TABLE 3 | Descriptive statistics and correlations of variables.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1.Perceived ECSR	3.857	1.065	**0.816**								
2.Organizational identification	3.984	0.967	0.417***	**0.804**							
3.Organizational trust	3.855	1.051	0.668***	0.615***	**0.814**						
4.Employees' innovative behavior	3.809	1.045	0.320***	0.369***	0.355***	**0.852**					
5.Gender	1.472	0.500	−0.018	0.024	0.026	−0.030	–				
6.Age	1.807	0.984	0.087*	0.132***	0.113**	0.077	0.207***	–			
7.Education	2.666	0.893	−0.045	−0.003	−0.114**	0.001	0.055	−0.257***			
8.Industry	6.701	3.576	−0.119**	−0.022	−0.050	−0.091*	0.141***	−0.134***	0.059	–	
9.Tenure	2.309	1.220	0.113**	0.125**	0.094*	0.010	−0.161***	0.285***	−0.141***	−0.189***	–

*N = 398, *p < 0.10, **p < 0.05, ***p < 0.01 (two-tailed test). Bold stands for the square root of AVE.*

TABLE 4 | Hierarchical regression analysis results.

Variables	DV: Organizational identification			DV: Employees' innovative behavior		
	b	SE	*t*	*b*	SE	*t*
Predictors						
Perceived ECSR	0.103*	0.051	2.033	0.096	0.060	1.597
Organizational identification				0.372**	0.068	5.498
Organizational trust	0.631**	0.049	12.789	0.185	0.072	2.572
Perceived ECSR × Organizational trust	0.148**	0.028	5.301			
Organizational identification × Organizational trust				0.171**	0.042	4.132
Controls						
Gender	0.005	0.079	0.059	−0.101	0.100	−1.008
Age	0.053	0.042	1.255	0.054	0.054	0.999
Education	0.118**	0.043	2.723	0.059	0.056	1.055
Industry	0.007	0.011	0.604	−0.022	0.014	−1.647
Organizational tenure	0.059	0.033	1.802	−0.066	0.042	−1.576
R^2	0.434			0.221		
F-value	37.336**			12.195**		

*$p < 0.05$, **$p < 0.01$, Bootstrap sample: n = 5,000. SE, standard error.*

RESULTS

Descriptive Statistics

Table 3 reports the means, standard deviations, and correlations of variables. The variance inflation factors for perceived ECSR (1.806), organizational identification (1.608), and organizational trust (2.400) are below the cutoff of 10, indicating that multicollinearity is not a problem in the current study. As expected, perceived ECSR is significantly related to the innovative behavior of employees ($r = 0.320$, $p < 0.01$). Furthermore, the correlations are consistent with the mediation of this study. The results report that perceived ECSR is significantly associated with organizational identification ($r = 0.417$, $p < 0.01$), and organizational identification significantly affects the innovative behavior of employees ($r = 0.369$, $p < 0.01$). We also tested the control variables. Particularly, age ($r = 0.132$, $p < 0.01$) and tenure ($r = 0.125$, $p < 0.05$) are significantly related to organizational identification. Industry ($r = 0.091$, $p < 0.1$) is significantly related to the innovative behavior of employees. We found gender and education are not significantly related to organizational identification or innovative behavior of employees in **Table 3**. Organizational trust is significantly associated with organizational identification and innovative behavior of employees, which suggests that organizational trust may strengthen the effect of perceived ECSR on both organizational identification and innovative behavior of employees.

Hypothesis Testing

This study adopted PROCESS macros (Hayes, 2013) to test all of our hypotheses. The bootstrapping procedure with 5,000 bootstrapped samples was employed to test these effects. If 95% confidence intervals (CI) do not include zero, the direct and indirect effects are significant. From **Table 4**, the results indicated that perceived ECSR affects positively organizational identification ($b = 0.103$, $p < 0.01$), thereby supporting Hypothesis 1. Meanwhile, education ($b = 0.118$, $p < 0.01$) has a positive effect on organizational identification. Results confirmed that organizational identification has a positive impact on the innovative behavior of employees ($b = 0.372$, $p < 0.01$). Therefore, Hypothesis 2 is supported. Additionally, this study tested the control variables: gender (b = −0.122, $p > 0.05$), age (b = −0.088, $p > 0.05$), education (b = 0.225, $p < 0.01$), industry (b = −0.017, $p > 0.05$), and tenure (b = −0.006, $p > 0.05$) and found only education to be significant.

Supporting Hypothesis 4, we found that the coefficient of the interaction involving perceived ECSR and organizational trust is positive and significant (b = 0.148, $p < 0.01$) in **Table 4**. As shown in **Table 5**, testing the effects on organizational identification at specific values (i.e., the mean and plus/minus one SD from mean) of organizational trust values indicated that the conditional direct effect of organizational trust values on organizational identification was significant at high levels of organizational trust [i.e., the mean plus one SD; conditional direct effect: b=0.258, p<0.01, CI [0.126, 0.391)] and medium levels of organizational trust (i.e., the mean; conditional direct effect:b=0.103, p<0.01, CI (0.003, 0.203)], but not at low levels of organizational trust [i.e., the mean minus one SD; conditional direct effect: b=0.05, p>0.05, CI (−0.147, 0.042)].

In **Table 4**, the coefficient of the interaction between organizational identification and organizational trust is significantly positive (b=0.171, p<0.01), which demonstrated the moderating positive effect of organizational trust on the link between organizational identification and innovative behavior of employees. Further, **Table 6** displays the results of the indirect effect of the level of organizational trust. The findings suggest that perceived ECSR is indirectly and significantly related to the innovative behavior of employees through organizational identification for employees with high [i.e., the mean plus one SD; conditional indirect effect: b=0.143, p<0.05, CI (0.045, 0.282)], but not at medium [i.e., the mean; conditional indirect effect: b=0.038, p>0.05, CI (−0.005, 0.1)] and low [i.e., the mean

TABLE 5 | Conditional effects of perceived environmental corporate social responsibility (ECSR) on organizational identification at values of organizational trust.

Organizational trust	Effect	SE	*t*	*p*	LLCI	ULCI
Low (M-1SD)	−0.052	0.048	−1.084	0.279	−0.147	0.042
M	0.103	0.051	2.033	0.043	0.003	0.203
High (M+1SD)	0.258	0.068	3.830	0.000	0.126	0.391

Bootstrap sample: n = 5,000. SE, standard error. Values for organizational trust represent the mean and plus/minus one SD from mean.

TABLE 6 | Conditional indirect effect of perceived ECSR on employees' innovative behavior through organizational identification moderated by organizational trust.

Dependent variable	Moderator: Organizational trust				
	Condition	Effect	BootSE	Boot 95% CI	
				LLCI	ULCI
Employees' innovative behavior	Low (M-1SD)	−0.01	0.015	−0.044	0.017
	M	0.038	0.027	−0.005	0.100
	High (M+1SD)	0.143	0.061	0.045	0.282

Bootstrap sample: n = 5,000. SE, standard error. Values for organizational trust represent the mean and plus/minus one SD from mean.

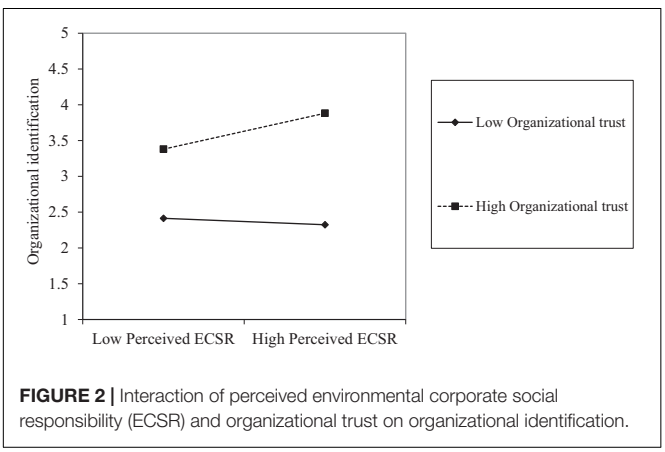

FIGURE 2 | Interaction of perceived environmental corporate social responsibility (ECSR) and organizational trust on organizational identification.

minus one SD; conditional indirect effect: b=0.01, p>0.05, CI (−0.044, 0.017)] levels of organizational trust. Taken together, our findings support Hypothesis 3 and Hypothesis 5.

Figures 2, **3** show when organizational trust value is high, as perceived ECSR increases, the increase in organizational identification and innovative behavior of employees is much steeper than under the condition of low organizational trust. It suggests that the effect of perceived ECSR on organizational identification and the indirect effect of perceived ECSR on the innovative behavior of employees *via* organizational identification became stronger when the level of organizational trust is higher.

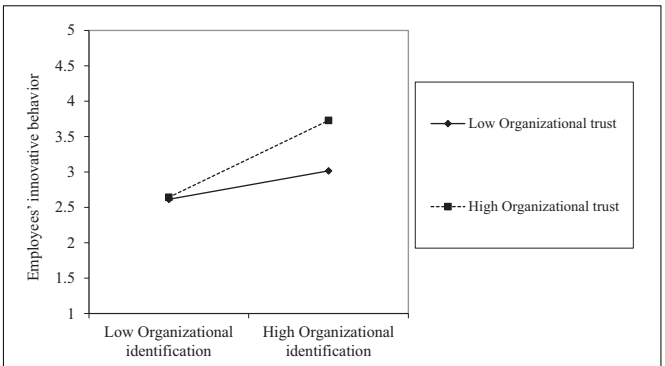

FIGURE 3 | Interaction of organizational identification and organizational trust on the innovative behavior of employees.

DISCUSSION

Based on a sample of employees from high energy-consuming industries and drawing upon the S-O-R model, our findings suggest that employees who perceive their firms are responsible for the natural environment tend to identify with their organization, and in turn affect the innovative behavior of employees. Our findings also suggest that organizational trust moderates positively the link perceived ECSR and organizational identification, while organizational trust also positively moderates the strength of the positive indirect link between the perceived ECSR and the innovative behavior of employees through organizational identification. Thus, a few key theoretical contributions and managerial implications are made in this study.

Theoretical Contributions

Our research contributes several theoretical insights. First, our first contribution is to the innovative behavior literature. This study extends the investigation of ECSR perception into the innovative behavior domain and identifies the predictive role of perceived ECSR on the innovative behavior of employees. Although previous studies have verified that perceived ECSR is a crucial predictor for the behavioral responses of employees (Ruepert et al., 2017; Ahmad et al., 2021), the exploration for innovation of employees has only emerged in some recent literature. Besides, while previous research has stated that CSR perception might have a positive influence on employee creativity (Hur et al., 2018), few studies have linked perceived ECSR to the innovative behavior of employees in China. This study addressed this gap in our work by adding new insights regarding the important link in employees perceiving ECSR to promoting their innovative behavior. We conceptualize the perceived ECSR as a stimulus to elicit the innovative behavior of employees, which also echoes previous research (e.g., Shin et al., 2017; Boan and Dedeolu, 2020) to emphasize how some of the stimulus factors of innovative behavior are rooted in the perception of employees of environmental management and environmentally responsible activities. Moreover, this study clarifies the utility of the extended S-O-R model that can include perceived ECSR as a stimulus and

innovative behavior as an employee response in the context of environmental protection. Furthermore, our findings extend the work in previous studies (e.g., Hur et al., 2018) by establishing the theoretical connection between perceived ECSR and innovative behavior from the stimulus–organism–response perspective.

Second, this study sheds a new theoretical light on both ECSR and innovative behavior literature by identifying the mediation effects of organizational identification. Previous research has investigated how individual identification can impact innovative behavior (Litchfield et al., 2018), but the role of organizational identification in the relationship between the perceived ECSR and the innovative behavior of employees is neglected in the existing literature. Because previous empirical studies have shown that organizational identification is a cognitive process in which individuals' perception will affect their behavior (Tian and Robertson, 2019; Cheema et al., 2020). Thus, this study investigated organizational identification plays a mediating role in the relationship between the perceived ECSR and the innovative behavior of employees. Based on the S-O-R model, we highlighted that perceived ECSR is an important stimulus to gain organizational identification when perception stimulus occurs during the organizational identification judgment process. Our findings also strongly support our argument that the mediation process is conducive to better understanding the internal cognitive process of the impact of perceived ECSR on the innovative behavior of employees. Specifically, the serial mediation process in our study means that there is a process that increases their organizational identification when they perceive their firm as environmentally responsible, and thereby improves the innovative behavior of employees. Additionally, our findings responded to the recent call made by Tian and Robertson (2019) to pay more attention to the individual-level analysis in the ECSR research by revealing how organizational identification can act as a mediating role in perceived ECSR – innovative behavior of employees relationship.

Third, our study contributes to a better explanation of boundary conditions under which the relationship between the perceived ECSR and the innovative behavior of employees be maximized. Although previous studies have highlighted the value of perceived ECSR (Ahmad et al., 2021), there has been little understanding of when perceived ECSR can promote the innovative behavior of employees in the context of environmental protection. This limited understanding is because previous studies neglect the contextual factors that condition the effectiveness of the ECSR perception of employees. We addressed this gap in our work by identifying the appropriate boundary conditions that help firms to increase the potential benefits of the innovative behavior of employees. Considering trust as a positive and an essential element in the work environment, we attempted to integrate the influence of organizational trust in our S-O-R model to identify whether perceived ECSR – organizational identification – employees' innovative behavior relationship varies across organizational trust levels. In combination with previous studies that treated organizational trust to be antecedents to the behavioral responses of individuals, our findings indicate organizational trust can be viewed as the moderator in the S-O-R model, providing insightful implications for academia and expanding the prior studies (e.g., Jani and Han, 2015). Overall, this study provides a better understanding that increased organizational trust in employees moderates positively the strength of the mediated relationship between ECSR perception and innovative behavior based on the S-O-R model, by strengthening not only the relationship between perceived ECSR and organizational identification, but also the indirect effect of perceived ECSR on employees' innovative behavior via organizational identification. Thus, this study extends the boundary conditions of the effect of corporate social responsibility. Our findings also highlight the important role of organizational trust plays in impacting employees' attitudes and behaviors.

Practical Implications

Our findings also provide important practical implications for managers. First, the results indicate that the innovative behavior of employees is affected by ECSR perception. When employees perceive their firms as environmentally responsible, they are more likely to generate innovative behaviors so that firms could obtain a competitive advantage through the enhanced employee environmental performance (Lee et al., 2018; Tian and Robertson, 2019). Therefore, we suggest that firms who are willing to reduce the pressure of environmental protection through the innovative behavior of employees ought to take measures to strengthen the ECSR perceptions of employees. For example, managers can increase ECSR perception by involving employees in their ECSR activities. Further, managers should share the information with employees, such as waste emission reduction, pollution reduction, product recycling, and effective outcomes feedback.

Second, considering the significant effect of perceived ECSR on the innovative behavior of employees throughout the mediation of organizational identification, this study suggests that increasing the organizational identification of employees in their firms could be beneficial for eliciting the innovative behavior of employees. Thus, managers should pay more attention to fostering the organizational identification of employees toward firms. For instance, managers can enhance the organizational identification of employees by implementing ECSR activities of their firm and showing such activities as consistent with the values, beliefs, and goals of the firm to the employees. The shared values, beliefs, and goals of firms can help employees understand how the businesses operations in the natural environment, helping them foster a sense of identity with the environmental behavior of firms and then improving innovative behavior among employees at the individual levels. Besides, managers also can establish a working environment in which employees work in cooperation rather than compete with each other. In addition, to increase organizational identification of employees, managers should provide regular training (e.g., organizational culture training) to employees with low levels of education.

Finally, this study suggests that organizational trust, as a moderator, can effectively enhance the impact of perceived ECSR

on the innovative behavior of employees in an organization, which provides a managerial implication. Thus, increasing the organizational trust of employees toward their firms could be beneficial from both environmental and ethical/moral perspectives, and particularly for the innovative behavior of employees. In this respect, managers should cultivate and enhance the organizational trust of employees in the HR processes (e.g., recruitment, training, or incentive design; Roeck and Delobbe, 2012) to maximize the potential return of the perceptions of ECSR. In the HR processes, to improve organizational trust, managers should adopt an effective way of sharing information, which might be future ECSR strategies, environmental performance feedback, and other work-related issues. Managers should offer employees complete and reliable information at work, and express a sense of unity. Furthermore, managers need to put more effort into showing integrity, which is important for building long-term commitment and developing trust.

Limitations and Future Research

Although it has made contributions, our research still has some limitations which should be solved in future research. First, this study only investigated employees from some types of industries (e.g., non-ferrous metals, power, coal, mining, and pharmaceuticals) in China. It is difficult to generalize other countries and cultures by only relying on the sample data from one country. Future research should focus on examining different countries, such as industries or firms in more developed countries, and compare the results with this study. Second, we only tested the influence of organizational identification and organizational trust on the link between the perceived ECSR and the innovative behavior of employees based on the S-O-R framework. But the relationship between the perceived ECSR and the innovative behavior of employees is highly complex. To fully examine this complex relationship, future research should identify additional contingency factors (e.g., firm visibility; Wu W. et al., 2020) based on different theoretical perspectives, such as stakeholder theory. Third, only the innovative behavior of employees was examined in our study. In this respect, person-organization fit means that individuals and organizations can have a positive interaction, which may have a direct influence on innovative behavior and have an indirect impact on innovative behavior under the influence of internal motivation (Vilela et al., 2008). The innovative behavior of employees can be divided into two dimensions: idea generation and idea implementation (Scott and Bruce, 1994; Amabile and Pratt, 2016). Future research could further explore the effects of perceived ECSR on idea generation and idea implementation.

CONCLUSION

In conclusion, this research sought to extend insights into the psychological mechanism between the perceived ECSR and the innovative behavior of employees using the S-O-R model. Our findings suggest that perceived ECSR positively affects organizational identification, which in turn are expected to influence the innovative behavior of employees. Further, our study extends the previous theory to confirm that organizational trust strengthens the effect of perceived ECSR on organizational identification and the effect of organizational identification on the innovative behavior of employees. We hope that this research has taken an important step toward the development of ECSR theory by explaining the effects of perceived ECSR on the innovative behavior of employees.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the institutional review board of Harbin Institute of Technology of China. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

WW and LY contributed to the conceptualization and design of the study. LY wrote the original draft. HL contributed to analyzing. TZ contributed to the review and editing of the manuscript. All authors contributed to the article and approved the submitted version.

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The Digital Entrepreneurship Era: How to Motivate Innovativeness in Middle Management Teams? The Vertical Organisational Pervasiveness of Chief Executive Officer Entrepreneurial Orientation

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Social information processing theory suggests that the chief executive officer's entrepreneurial orientation (CEO EO) is an organisational signal that influences the members' innovativeness. Middle management teams (MMTs) are expected to be more innovative as they connect senior managers with frontline managers in the dynamic competitive environment of the digital economy. How CEOs guide MMT innovations through EO becomes critical in the process of capturing opportunities and creating value. However, previous research has failed to adequately identify distinct CEO EO manifestations with organisational contexts configurations that influence MMTs innovation. Thus, based on differences in organisational contexts and MMTs' cognition, this study thoroughly investigates how the vertical manifestation of CEO EO impacts the innovativeness of MMTs. We used fuzzy-set qualitative comparative analysis (fsQCA) on a sample of 117 organisations to determine which configurations of CEO EO vertical penetration within an organisation can stimulate MMT innovativeness. The study discovered four first-level configurations that support stimulating MMT innovativeness respectively when the CEO EO is fully or partially manifested, and without the CEO EO. Moreover, we found the internal reasons for MMTs' information interpretation heterogeneity, which is critical for realising the coordination and unity of entrepreneurial cognition and behaviours. Finally, these findings' theoretical and practical implications are discussed.

Keywords: CEO entrepreneurial orientation, middle management team innovativeness, social information processing theory, fsQCA, digital entrepreneurship era

INTRODUCTION

Chief executive officer entrepreneurial orientation (CEO EO) is an emerging topic in entrepreneurship research (Liu and Xi, 2021; Liu et al., 2021). Several studies have found that CEOs with high EO have a positive impact on their organisations (Keil et al., 2017). Although we are becoming more aware of the benefits of CEO EO, the literature on innovative, CEO personal outcomes brought about by CEO EO is significantly less developed. Furthermore, the role that

CEO EO can play in the complex business environment and various organisational contexts is awaiting in-depth exploration of new research methods. Moving forward, it is critical to gain a better understanding of the innovative and CEO personal consequences of CEO EO (Liu and Xi, 2021; Liu et al., 2021).

Research on the role of the CEO EO within the organisation must be discussed in a specific context to be meaningful (Wales et al., 2020; Liu and Xi, 2021). Digital technology developing is currently the most important trend that businesses must deal with. Digital technology penetrates deep into the core of product and service operations. It fundamentally changes the nature of product and service innovation, making digitalisation an essential component of enterprise innovation processes (Yoo et al., 2012). While the digital economy brings innovation opportunities and value to enterprises, it also creates difficulties and challenges. Today's enterprises are operating in a complex and fast-paced innovation environment due to the rapid rate of changes and uncertainties. Liu and Xi (2021) suggest that CEO EO can manifest CEOs' entrepreneurial spirit and high commitment. CEO EO can achieve top-down penetration within the organisation and has an impact on other members' innovative behaviour (Wales et al., 2011). Faced with the uncertainties and challenges of the digital economy era, how CEOs guide the cognition and behaviour of members through EO become critical in the process of capturing opportunities and creating value (Plsek, 2003).

An information-based and team-centric characteristic structure is the dominant trend for developing relationships between organisational members in the digital innovation era (Drucker, 1999). The uncertainty environment makes strategic decision-making and execution difficult, particularly for management teams (Plsek, 2003). Especially, middle management teams (MMTs) play a critical role in organisational management. The processes used by middle managers to obtain information quickly, while achieving full transmission and sharing within organisations, are critical in the digital entrepreneurship era. As the "horizontal information brokers and capability integrators" who connect senior managers with frontline managers, MMT innovativeness and management skills are increasingly being demanded (Tseng et al., 2019).

However, Plsek (2003) argues that MMTs are more likely to choose traditional management models, which emphasises the safety of adhering to standard operating procedures but produces a general lack of initiative for innovation in the changing environment. Furthermore, it is difficult for MMTs to form unified cognitive models because of the different department functions; this is not conducive to effective communication and information sharing among organisation members (Bartram, 2000). Exploring how to increase MMT innovativeness helps companies better deal with the challenges posed by the digital economy.

Chief executive officer entrepreneurial orientation is important to MMT innovativeness (Wales et al., 2020; Liu and Xi, 2021). According to social information processing theory, CEO EO is a significant source of organisational information (Lau and Liden, 2008) and affects MMT innovativeness (Wales et al., 2011). However, MMTs interpret CEO EO differently due to different situations within and outside organisations, as well as differences in individual perceptions (Wales et al., 2011). This cognitive difference affects how information is transmitted and shared within organisations, which impacts entrepreneurship outcomes differently (Kuratko et al., 2005). Therefore, this study explores the impact of CEO EO vertical penetration on MMT innovativeness in different settings. CEO EO facilitates information sharing and transmission within organisations and assists internal managers in dealing with the challenges brought about by the digital economy.

In sum, this study investigates the configurations that affect the relationship between CEO EO and MMT innovativeness in the digital entrepreneur era. The external environment is complex and dynamic; consequently, organisational structures become flattened to adapt to dynamic and competitive changes (Rajan and Wulf, 2006). Furthermore, performance pressure is exacerbated by complexity and changes environment. Thus, the dynamic competitive environment is the external situational condition in this study, and organisational structure and performance pressure are internal situational conditions. Then, we consider MMTs cognition: confidence in the organisation's prospects and achievement orientation. Our research method, fuzzy-set qualitative comparative analysis (fsQCA), considers both configuration comparison and set theory, treats social phenomena as a complex combination of attributes, and investigates "multiple concurrent causalities" as a result of the set relationship (Ragin, 2000). Considering the external and internal environment, and personal factors involved in the research question, fsQCA is suitable.

The main contributions are as follows. First, based on the vertical penetration perspective of CEO EO, this study specifically investigates how CEO EO impacts MMT innovativeness, which contributes to the CEO EO research literature. Second, using the digital economy as a backdrop, this study investigates how to improve MMT innovativeness in response to the complexity environment, which has both theoretical and practical implications. Third, using social information processing theory, this study aims to unlock the CEO EO vertical penetration model's black box in terms of MMT innovativeness, thereby giving a novel theoretical approach for EO research. Fourth, this study employs fsQCA to thoroughly examine the various configuration pathways that CEO EO has on MMT innovativeness. This is because fsQCA enables the evaluation of multiple concurrent causalities by identifying context-specific causal paths that lead to the same outcome. Thus, it is possible to acquire a deeper understanding of the internal process of CEO EO vertical penetration into different levels of organisations.

LITERATURE REVIEW

Social Information Processing Theory

The essence of enterprise digital innovation is using a combination of information, computing, communication, and connectivity technologies in the innovation process, as well as the resultant new products, improved production processes, changes in organisational models, and creation of innovation

models (Nambisan, 2017). The digital entrepreneurial era has produced disruptive changes in the subject and elements of innovation, the innovation process, and the innovation platform. This is because digital technology enables organisations to start searching for rules and summarising knowledge from big data and then apply the knowledge and use it to accomplish specific goals and tasks. To deal with the impact of external uncertainties, the development of digital technology innovation companies increasingly relies on information provided by massive amounts of data (Haenlein and Kaplan, 2019).

According to social information processing theory, the process of cognition formation involves individuals processing information on external things (Salancik and Pfeffer, 1978). Bandura (1986) thinks that persons' social attributes determine the interaction between humans and the environment. The interaction of individuals, external situations, and the organisational environment impacts personal cognition and behaviour. Furthermore, Gurbin (2015) suggests that the specific characteristics and environments of individuals significantly impact how an individual processes information; this influence runs through every stage of information processing. Thus, in a dynamic and complex environment, individuals rely on information provided by their social information environment to adjust their attitudes and behaviours (Salancik and Pfeffer, 1978). In the digital entrepreneurship era, when confronted with complicated digital information, organisational members typically demand the ability to quickly process data to realise their entrepreneurial consciousness and better seize market opportunities. Specifically, organisational members should receive, store, encode, convert, recycle, and transmit received information through a series of processing links to continuously improve their innovativeness (Wyer and Srull, 1986). In this process, members' innovation attitudes and behaviours are influenced not only by their needs and goals but also by the surrounding environment. Moreover, when confronted with uncertainty and complexity in the digital economy era, individuals are more optimistic about obtaining social information regarding innovative attitudes and behaviours from their social environment.

Organisational models have changed in the digital economy, and teamwork has received increasing attention in the digital transformation of enterprises (Bouncken et al., 2021). Cognition is not limited to individuals and teams are also information processors (Hinsz et al., 1997). Teams form their cognition as a result of information sharing and integration among members. However, the cognition of individuals and teams differs significantly. Teamwork is a significant social context that influences individuals' thinking, attitudes, and behaviours (Bhave et al., 2010). Therefore, social information processing theory researchers are currently focussing on how to coordinate innovativeness among teams and members (Rego et al., 2017). The process primarily consists of the following stages. First, based on the external context and development trend, organisational leaders deliver information to members who are compatible with the enterprise's innovation strategy. Then, the information input. Individuals' cognitive activities are triggered by external information. Specifically, individuals screen and enter data based on their prior experiences. Third, the cognitive subject pays attention to specific information selectively, because individuals typically cognise and process information through existing cognitive models. The fourth step is to re-encode, categorise, and interpret the information so that it can guide subsequent cognitive activities. Finally, the coordination and integration of various individual cognitions unifies individual and team cognition (Gurbin, 2015).

Chief Executive Officer Entrepreneurial Orientation Vertical Penetration

Digital technology promotes organisational changes in the digital innovation age. Digital technology has produced changes in transaction processing, decision-making, office methods, and organisational forms. To remain competitive in the digital disruption era, firms should generate a durable competitive edge and prioritise the innovation capabilities, which are growing in tandem with technology advances (Salamzadeh et al., 2021). Furthermore, if enterprises want to achieve disruptive innovation and development, CEOs should coordinate the organisation's internal resources as a whole and promote the integration of the organisation's operation model with digital technology. As the primary decision-maker, the CEO's cognition and execution ability are critical to realising a digital transformation and enhancing the enterprise's competitive advantage (Liu and Xi, 2021). The key to digital transformations of companies is whether their CEOs can capture market changes and innovation opportunities, whether they are sensitive to innovation, and whether they can guide internal organisational members to form a cognition that matches digital innovation (Liu and Xi, 2021).

Chief executive officers develop their ongoing concern and willingness for innovation and entrepreneurship, also known as CEO EO, by receiving, filtering, interpreting, reacting, and processing environmental information (Hambrick and Mason, 1984). CEO EO reflects the CEO's strong commitment to innovativeness, proactiveness, and risk-taking activities in the company's innovation and entrepreneurship development processes (Keil et al., 2017). As an important source of internal information, CEO EO delivers market information to organisations (Rego et al., 2017; Liu and Xi, 2021). It has a significant impact not only on corporate innovation strategy decisions but also on others' attitudes and behaviours.

Chief executive officer entrepreneurial orientation, a type of information, can penetrate vertically into different levels within an organisation and influence the innovation and entrepreneurship cognition, attitudes, and behaviours of organisational members (Rego et al., 2017; Wales et al., 2011, 2020; Liu and Xi, 2021). First, CEO EO is the core decision maker's self-awareness, which influences the senior management team's goals and directions, as well as the enterprise's overall strategic decision-making for innovation (Keil et al., 2017). Employees need clear goals and tasks to activate their internal motivation for innovation. Second, the specific configuration of organisational elements influences CEO EO, and different organisational element configurations have different effects on employee innovative cognition and behaviour

(Wales et al., 2020). Third, innovative CEOs set certain role expectations for their employees in the process of developing innovation and entrepreneurship. Furthermore, CEOs should use specific methods to align their entrepreneurial cognition with the organisation's innovation and entrepreneurial cognition model. Specifically, CEO EO is shared and transmitted across organisational levels (Wales et al., 2011, 2020; Liu and Xi, 2021). It assists in unifying the CEO EO with the organisation's cognitive model of innovation, ultimately motivating the innovative attitudes and behaviours of other members (Gurbin, 2015). Therefore, we think that CEO EO can vertically penetrate an organisation and is critical for enterprise digital innovation and entrepreneurship.

Middle Management Team Innovativeness

According to social information processing theory, middle managers play an important role in an organisation's input, processing, and sharing of information (Salancik and Pfeffer, 1978; Liu and Xi, 2021). The main task of an MMT as information flow facilitators is to ensure the effective transfer of information from top-level management to operating-level managers (Floyd and Lane, 2000). Middle managers accurately search, process, and integrate complex information, while interacting and coordinating to achieve effective communication and information sharing among organisational members. The knowledge spillover resulting from information transfer can serve as a catalyst for innovative activities (Ramadani et al., 2017). Moreover, it is important for deepening team members' mutual coordination of values and cognition (Bhave et al., 2010; Ren and Guo, 2011).

Organisational forms become increasingly flat in digital innovation era. Relationships between organisational members are dominated by information-based, team-centred structures (Drucker, 1999); teams are now considered the norm for navigating complex environments (Salas et al., 2005). As intermediaries who connect the different levels of an organisation, how middle managers respond to changes in organisational development models, structure, and members' relationships brought about by digital innovation is important for developing digital innovation in organisations (Hornsby et al., 2002). Furthermore, MMT innovativeness plays a significant role in identifying, improving, and guiding entrepreneurial opportunities, as well as in acquiring and allocating entrepreneurial resources (Ren and Guo, 2011). Therefore, it is difficult for the traditional MMT operating model to adapt to the changes and challenges enterprises face in the digital innovation era. Companies should stimulate the innovative thinking of MMTs if they are to fully realise their substantive role in the digital innovation process (Rego et al., 2017; Liu and Xi, 2021).

Some researchers have found that other members' innovativeness, forms of information sharing, and methods of organisational element configuration influence the MMT innovativeness (Kuratko et al., 2005). Thus, the vertical penetration mode of CEO EO within an organisation impacts the innovation and behaviours of MMTs (Ren and Guo, 2011; Wales et al., 2011). Moreover, managers have different understandings of CEO EO due to differences working roles and functional scope (Wales, 2016; Liu and Xi, 2021). CEO can unify and guide the senior management team's innovativeness directly (Liu and Xi, 2021). However, due to differences in their situations and characteristics, MMTs cognitive perspectives on CEO EO differ from those of senior managers, according to social information processing theory (Wales et al., 2011; Liu and Xi, 2021). Thus, researching how to encourage MMTs to positively interpret CEO EO plays a critical role in stimulating their innovativeness.

Variables

According to social information processing theory, individuals' or teams' innovativeness, attitudes, and behaviours are influenced by the combination of external conditions, personal needs, and organisations' internal environment (Salancik and Pfeffer, 1978). Therefore, in terms of contextual variables, this study thoroughly investigates the three areas of external contextual factors, internal organisational factors, and MMT cognition.

External Environment Variable: Dynamic Competitive Environment

Entrepreneurial orientation and innovativeness should be analysed in the context of the external environment, such as its dynamics (Engelen et al., 2014). External competition for businesses has grown stronger, and the market environment has become more diverse in the digital economy era (Rosenbusch et al., 2013). Firms often engage in entrepreneurial activities to ensure their success and survival in highly dynamic and competitive contexts (Dana et al., 2022). The dynamic environment of market competition significantly impacts corporate innovation and entrepreneurship. An enterprise's dynamic competitiveness primarily includes two aspects: dynamics stresses the speed and instability of changes in the external environment (Barrales-Molina et al., 2010), while environmental competitiveness refers to the level of competition in a company's external environment, including the number of competitors in the industry market and the market's capacity (Mithas et al., 2013). As the dynamic competitive environment becomes more visible, organisations increase employees' requirements to innovate and proactively recognise and capitalise on prospective market possibilities.

Based on social information processing theory, specific social information in the social environment is more likely to capture individual attention and consequently influence individual attitudes and behaviours (Bhave et al., 2010). Dynamically competitive markets have become the main trend in the digital economy, and enterprises should be innovative, proactive, and risk-taking when such an environment emerges (Rosenbusch et al., 2013). As a major source of information transmission in an organisation, CEOs are important in the process of identifying innovation prospects and making development plan decisions. Therefore, CEOs with an entrepreneurial orientation are more acutely aware of the dynamic and competitive changes in the market environment, allowing them to provide more accurate and comprehensive innovative market information to middle

managers (Liu and Xi, 2021). Some scholars argue that when individuals perceive their surroundings as unstable, they rely more on the information provided by their surroundings to gain a sense of certainty and stability (Hogg, 2001). When a CEO is entrepreneurial, the organisational members' innovativeness and entrepreneurial behaviours, as well as the entrepreneurial activities involved in value creation, are encouraged (Keil et al., 2017). Organisational members are more likely to constantly adjust their innovativeness and behaviours to match the information or signal their feelings of certainty and stability (Yang et al., 2018).

Internal Environment Variable: Organisation Structure

Research shows that the main factor that influences how CEO EO penetrates within an organisation is the organisational structure (Wales et al., 2011; Yoo et al., 2012; Wales, 2016). Organisational structures have shifted from vertical to flat, and an organisation's internal governance mechanisms have become more democratic in the digital entrepreneurship era. This change impacts the degree of penetration of CEO EO, as well as how members of the organisation interpret and share information sources (CEO EO). Second, an autonomous organisational structure emphasises mutual trust, cooperation, and information sharing, which can ensure smooth communication, collaboration, and coordination between departments, as well as organic integration of various departments' capabilities (Rhee et al., 2017). Thus, as information communicators, MMTs in an autonomous organisational structure can more effectively transmit CEO EO to other members, thereby realising individual cognition and team-wide cognition coordination (Wales et al., 2020). Third, an autonomous organisational structure transforms the flow of information and decision-making within an organisation from one-way to a flow that is widely spread throughout the organisation. This allows CEO EO to be fully perceived within the organisation, facilitating positive interactions among organisational members and encouraging enthusiasm and initiative for innovation (Wales, 2016). In addition, discovering and resolving problems is part of the innovation process when there is uncertainty and ambiguity. The essence of technological innovation is reducing uncertainty and ambiguity; however, achieving this goal requires information exchange and organisational resource support. An autonomous organisational structure promotes smoother information communication than a mechanical organisational structure and gives more autonomy to internal teams and individuals (Menon and Varadarajan, 1992), allowing for team innovation.

Performance Pressure

Managers and employees face a more complex working environment and increased corporate performance pressure to effectively adapt to the complexity and uncertainty environment (Neal and Hesketh, 1999). The work pressure caused by factors such as performance appraisals is referred to as performance pressure. The difference between the company's expected performance and its potential performance creates performance pressure and causes individuals to be concerned about the company's ability to meet its expected profit goal (Durham et al., 2000). On the one hand, performance pressure motivates managers and employees to work hard to obtain performance (Gardner, 2012); on the other hand, performance pressure forces them to improve performance to avoid the perceived negative consequences, emphasising that performance pressure is subjective (Mitchell et al., 2018).

Performance pressure has a dual effect within an organisation as it generates both positive and negative side effects (Mitchell et al., 2018). Moreover, previous research has demonstrated that performance pressure elicits both functional and dysfunctional behaviour (Eisenberger and Aselage, 2009). Therefore, we think that performance pressure causes dynamic changes in the attitudes and behaviours of organisational members. Based on social information processing theory, the team's perception of performance pressure is transmitted within the organisation as a type of information. This information motivates team members to constantly assess the distance between themselves and the target task, which eventually leads to different innovative cognitions and behaviours (Kluger and DeNisi, 1996). When team members perceive performance pressure as threatening, they may develop negative emotions. However, positive cognitive behaviours, such as creativity and intrinsic interest, can be produced when team members view performance pressure as an intriguing challenge (Ganster and Rosen, 2013). Thus, we consider that regarding performance pressure as a causal variable to investigate its impact on MMT innovativeness is critical to organisational internal entrepreneurial activities in the digital innovation era.

Confidence in the Organisation's Prospects

Confidence in the organisation's prospects can be described as members' positive evaluation of and belief in the organisation's development (Liu and Xi, 2021). Based on information processing theory (Benjamini and Hochberg, 1995), members receive information from both inside and outside the organisation and judge its development prospects based on their cognition. First, when investigating the vertical penetration of CEO EO in organisations, CEOs that have an innovative and entrepreneurial orientation pass their ideas, plans, and actions to the organisation and then execute them (Covin and Slevin, 1989), with the ultimate goal of gaining more market share and excess profits (Monsen and Wayne Boss, 2009). Compared with grassroots employees, MMTs may learn information (CEO EO) earlier and more thoroughly. This is because MMTs are an important part of CEOs' communication of innovative ideas and the implementation of innovative and entrepreneurial plans. If MMTs interpret CEO EO as positive information, they may put more effort into their work (Liu and Xi, 2021). Second, CEOs with an entrepreneurial orientation are more receptive to new ideas and suggestions for improving the implementation of innovation and entrepreneurship, as well as encouraging and supporting organisational members' participation in innovative activities. These factors contribute to MMTs positive perceptions of an organisation's prospects (Kellerman, 2008).

Middle management teams who are more confident in the organisation's prospects are more willing to invest in team innovation. When CEOs vertically penetrate innovation, they

send a message of seizing market profits and creating wealth (Monsen and Wayne Boss, 2009), which encourages MMTs to be optimistic about organisational innovation (Chaston and Sadler-Smith, 2012). The cognition of individuals influences their behaviours (Bandura, 1991). Thus, middle managers are more willing to improve team innovativeness when they have positive ideas about innovation and entrepreneurship.

Achievement Orientation

A person's desire and psychological proclivity to overcome difficulties, achieve success, and pursue perfection are referred to as achievement needs; this is an important personal characteristic that encourages people to strive to realise worth (Murray, 1938). McClelland (1987) indicated that achievement motivation is an internal driving force that individuals acquire to attain success. McClelland's research since the 1960s has shown that achievement needs are positively correlated with economic development and are closely related to innovation and entrepreneurship. In addition, McClelland and Burnham (2017) pointed out that achievement needs are important for the success of small business owners or managers. Thus, many researchers investigate achievement motivation as a key psychological characteristic of entrepreneurs or employees. This is because individuals with achievement orientation are more likely to be drawn to positions requiring innovation and entrepreneurship to meet their needs (MacKenzie and MacKenzie, 1995). Furthermore, some scholars think that innovative processes are real events that are influenced by complex social backgrounds and internal organisational contexts. Therefore, innovation research should incorporate the achievement orientation of entrepreneurs and employees into a complex situation for research (Weerawardena and Sullivan Mort, 2006). Finally, achievement-oriented motivation is regarded in this study as the psychological motivation that stimulates MMT innovativeness.

Based on the discussion, the conceptual model is presented in **Figure 1**.

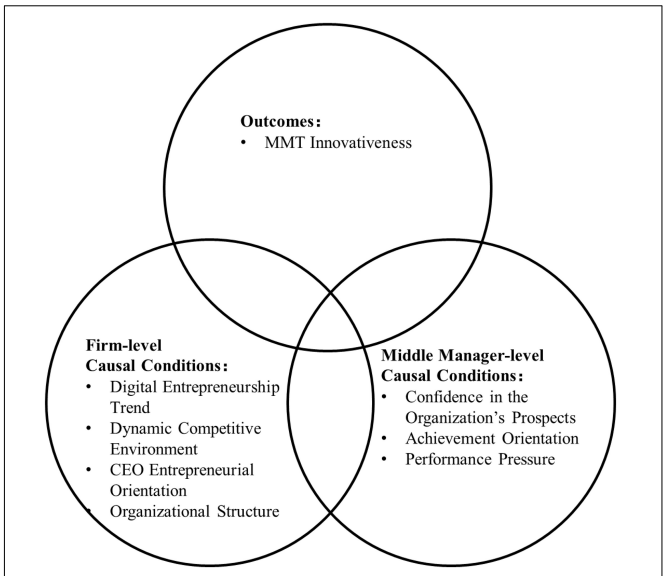

FIGURE 1 | Conceptual model.

METHODOLOGY

Sample

This study employs a multi-source research design to test how to shape the MMT innovativeness in the face of the complex and changing organisational environments, the CEO EO, and the personal characteristics of middle managers. Our sample enterprises from the four economic and technological development zones in China's Yangtze River Delta Industrial Zone. Choosing the Yangtze River Delta Industrial Zone for two reasons: first, it is China's largest comprehensive industrial base, with a developing high-tech industry; then, it has a high technological level and the most comprehensive structure in China. Thus, the area is rich in technological innovation resources.

Aside from the digital enterprise infrastructure construction investments in each province, the questionnaire used a 7-point Likert scale and was translated into Chinese and English using standard back-translation methods (Brislin, 1980). This questionnaire was intended to be completed by the company's CEO and MMTs. Random sampling was used to interview 170 small and medium-sized enterprises (SMEs) based on the National Bureau of Statistics of China's proprietary SME database from March to December 2019. During the data gathering procedure, we conducted additional tests and implemented a variety of checks to ensure that the questionnaire data accurately represent the measurement findings. A total of 128 SMEs participated in the survey; after 11 items were removed due to missing data, 117 cases were analysed. This questionnaire's overall recovery rate was 68.88%. These companies' average length of existence is 19 years. Among the 117 SMEs, 53 are manufacturing firms, 64 are high-tech firms, and 65 are service firms. There were 101 males among the 117 CEOs interviewed, with an average age of 46–50 years old and a tenure of 98 months, while 56 of the 117 mid-level managers interviewed were men, with a tenure of 55 months.

Overview of Fuzzy-Set Qualitative Comparative Analysis

Fuzzy-set qualitative comparative analysis (fsQCA) is both a research method and a collection of analysis tools. It is a novel research method that combines the advantages of qualitative and quantitative methods (Ragin, 2000). On the one hand, fsQCA leverages the capabilities of qualitative research to elicit information directly from research subjects, hence minimising measurement error associated with survey research (Dana and Dana, 2005). On the other hand, fsQCA combines the benefits of quantitative analysis, resulting in reproducible study results (Douglas et al., 2020). In terms of methodology, it employs both configuration comparison and set theory (Ragin, 2000). fsQCA is beneficial for analysing asymmetric relationships between dependent and independent variables (Woodside, 2011, 2013).

Consequently, fsQCA is engaged in the complexity of developing things and finding and identifying the causal path that leads to the same result in different situations to evaluate multiple concurrent causalities (Rihoux and Ragin, 2012). Scholars call for researchers to use of the fsQCA approach to a variety of micro and macro business concerns, such as innovation and entrepreneurship studies (Douglas et al., 2020). This is because fsQCA eliminates the assumption of independence between influencing factors, is compatible with cross-layer factor embedding (Greckhamer, 2011; Kraus et al., 2018), and does not require special cross-layer variable processing, making it particularly suitable for management research involving multi-layer variables (Morgan, 2010; Kraus et al., 2018). System theory suggests that because of imitation, coercion, and regulation, an organisation's configuration tends to condense and cannot be infinitely varied (DiMaggio and Powell, 1983). Furthermore, the theory of social construction suggests that because people's actions, motives, and behaviours are constantly repeated, some configurations will be selected and continually strengthened (Berger, 1967). Therefore, we employed fsQCA 3.0 for our analysis.

Measures

The survey questionnaire contained an outcome variable regarding MMT innovativeness, as well as causal conditions from the external environment to the organisational characters and middle manager levels. We used a scale validated by previous research to assess MMT innovativeness with seven items (Atuahene-Gima et al., 2005; Chen et al., 2009). MMT innovativeness measurement primarily includes (1) the team's innovative ideas and plans; (2) the team's innovative work results; (3) the team's innovative use of existing resources and information; and (4) the team's current product or service improvement.

The external context was chosen based on the business trend and industry background. First, the business environment was chosen to be the mainstream trend of the digital economy. Based on the various China provinces panel data from China Statistical Yearbook, Shuaitao and Qiubi (2021) build a spatial measurement model to measure the provincial digital economy development index for China's inter-provincial digital economy from four dimensions of digital foundation, application, innovation, and transformation. We use this indicator to determine the digital development trend in each province. Second, the dynamic competitive environment of the industry was chosen to evaluate the company's industry background, which is measured with eight items (Zollo and Winter, 2002; Barrales-Molina et al., 2010).

In terms of firm-level organisational factors, CEO EO is used to capture corporate management's innovation and entrepreneurial intentions, including innovativeness, proactivity, and risk-taking with nine items (Liu and Xi, 2021). The organisational structure is captures with seven items about the organisation's freedom of information exchange, decision-making, and cooperation. Higher scores denote a more dynamic structure, whereas lower scores indicate a more mechanistic structure.

About manager-level causal conditions, four items are used to evaluate confidence in the organisation's prospects (Liu and Xi, 2021). For example, one of the items is "I am confident that the company will develop better in the future." Moreover, four items address achievement orientation motivation or a person's desire and psychological proclivity to overcome difficulties, achieve success, and pursue perfection (Lang and Fries, 2006). Finally, four items from Charbonnier-Voirin and Roussel (2012) measure performance pressure. Scales are in the **Supplementary Appendix A**.

Calibration

For configurational analysis, each variable should be calibrated for set membership (Ragin, 2013). Owing to the variation in the kurtosis and skewness each factor's data set, this study employs percentages to directly establish the qualitative anchor point (Morgan, 2010). As part of this investigation, percentiles were utilised to calibrate the data. A threshold above 95% indicates that observations are "fully in" the set membership; a crossover point of 50% indicates that observations are "neither in nor out," and a threshold below 5% indicates that observations are "fully out" of the set membership. Following recommended practices, we recalibrated each set with an exact membership score of crossover point, by introducing a tiny constant (0.001). Details in **Table 1**.

RESULTS

The fsQCA method includes two critical steps: a necessity test and a sufficiency test. These two steps determine the configuration of the necessary and sufficient conditions to promote the result in the presence of causal complexity.

Analysis of Necessary Conditions

Whether each variable is a necessary condition for the outcome variable must be checked before constructing a sufficiency

TABLE 1 | Sets, calibrations, and descriptive statistics.

Sets	Fuzzy-set calibrations			Descriptive statistics					
	Full in	Crossover	Full out	Mean	SD	Min	Max	*N* cases	Missing
DCE	7	4.667	2.667	4.789	1.141	2.111	7	117	0
DEL	18.530	18.448	18.365	0.952	0.010	0.95	1	117	0
OS	6.857	4.714	2.571	4.779	1.213	1.429	7	117	0
Inn	7	6	3.6	5.707	1.128	2	7	117	0
Pro	7	6	4	5.934	0.999	2.333	7	117	0
RT	7	5.667	4	5.658	1.037	2.333	7	117	0
COP	7	6.125	4.463	6.033	0.996	0	7	117	0
AO	7	6	4	5.884	1.077	2	7	117	0
PP	6.525	5	2.250	4.788	1.339	0	7	117	0
TI	7	5.429	3.7	5.337	0.993	0	7	117	0

DCE, Dynamic Competitive Environment; DEL, Digital Economy Level; OS, Organisational Structure; Inn, Innovativeness; Pro, Proactiveness; RT, Risk-taking; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure; TI, Middle Management Team Innovativeness.

analysis. Conditions that should exist for results to occur are referred to as "necessary conditions." As a standard fsQCA practice, fuzzy set analysis is performed on the necessary conditions, with a consistency benchmark of 0.90. Based on the necessary condition analysis in **Table 2**, the province digital economy level where the company located in is a necessary condition for MMT innovativeness.

Sufficiency Conditions Analysis

The outcome of the adequacy test on the innovation stimulation of MMTs and fsQCA standard notation were used to report this investigation's findings (Fiss, 2011). **Table 3** shows that there are four first-level configurations and two second-level configurations in each group. **Figure 2** shows that an ellipse with a black border indicates a condition is present, an ellipse with a dashed border indicates that the condition is absent, and no border indicates that EO cannot fully manifest (in S3a). The ellipse is not displayed if the condition is unrelated to the configuration. Grey represents the common conditions in second-level configurations, lattice marks alone represent Solution Xa (SXa), and white only represents Solution Xb (SXb). The raw consistency benchmark is set to greater than or equal to 0.8, and the inconsistency ratio reduction (PRI) is set to greater than or equal to 0.70, based on fsQCA operational requirements (Greckhamer et al., 2018). There are two sets of results, including configurations for high MMT innovativeness and for the absence of MMT innovativeness.

TABLE 2 | Analysis of necessary conditions for middle management team innovativeness in fuzzy-set qualitative comparative analysis.

	Outcomes: MMT innovativeness	
Sets of conditions	**Consistency**	**Coverage**
DCE	0.676	0.654
∼DCE	0.676	0.689
DEL	0.999	0.521
∼DEL	0.094	0.975
OS	0.698	0.672
∼OS	0.653	0.669
Inn	0.717	0.698
∼Inn	0.604	0.611
Pro	0.729	0.652
∼Pro	0.576	0.642
RT	0.703	0.658
∼RT	0.610	0.644
COP	0.824	0.727
∼COP	0.507	0.574
AO	0.703	0.636
∼AO	0.578	0.636
PP	0.684	0.648
∼PP	0.645	0.671

DCE, Dynamic Competitive Environment; DEL, Digital Economy Level; OS, Organisational Structure; Inn, Innovativeness; Pro, Proactiveness; RT, Risk-taking; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure. ∼ means the absence of. For example: ∼ Organisational Structure, absence of high OS.

Configurations for High Middle Management Team Innovation

The solution coverage and consistency of MMT innovativeness were 0.536 and 0.906, respectively. Solution 1 (including S1a and S1b) and Solution 2 (including S2a and S2b) are configurations that stimulate MMT innovation in a dynamic competitive environment, whereas S3 (including S3a and S3b) and S4 (including S4a and S4b) provide pathways for encouraging MMT innovation in SMEs in a non-dynamic competitive environment. Moreover, because the level of the digital economy is a necessary condition, it exists in all configurations.

The dynamic competitive environment is an important causal factor in MMT innovativeness, as demonstrated by solutions 1 (S1) and 2 (S2). When companies with mechanised organisational structures operate in a dynamic competitive environment, the CEO's innovation strategy is influenced by external competitive pressure (Covin and Slevin, 1989). A mechanised organisational structure is not conducive to the vertical penetration of CEO EO within an organisation and impacts the full display of CEO EO as an information source within the organisation (Wales et al., 2011). On the one hand, middle managers may be unable to perceive and transmit superior innovation strategy information due to a lack of accurate information sources (CEO EO) (Wales, 2016). On the other hand, a rigid organisational structure limits middle managers' rights, which affects communication and information sharing between middle managers and subordinate employees (Rhee et al., 2017), which makes it difficult for middle managers to input, process, and share information. Hinder efficient information transmission and sharing put middle managers at disadvantage when it comes

TABLE 3 | Configurations for high middle management team innovativeness (fuzzy-set qualitative comparative analysis).

Configuration	**Solutions**							
	S1a	**S1b**	**S2a**	**S2b**	**S3a**	**S3b**	**S4a**	**S4b**
DCE	●	●	●	●	⊗	⊗	⊗	⊗
DEL	●	●	●	●	●	●	●	●
OS	⊗	⊗	●	●	⊗	⊗		●
Inn	⊗	⊗	⊗	●	●	●	●	⊗
Pro	⊗	⊗	⊗	●	⊗	●	●	⊗
RT	⊗	⊗	⊗	●	⊗	●	●	⊗
COP	●	●	●	●	●	●	●	●
AO		●	⊗	⊗	●		●	⊗
PP	⊗		●	⊗	●	⊗	⊗	⊗
Raw coverage	0.248	0.231	0.236	0.221	0.181	0.283	0.317	0.212
Unique Coverage	0.007	0.009	0.031	0.016	0.012	0.006	0.050	0.018
Consistency	0.957	0.947	0.926	0.972	0.966	0.963	0.915	0.952
Solution Coverage: 0.536								
Solution Consistency: 0.906								

●, *presence core conditions;* ⊗, *absence core conditions;* ●, *present contributing conditions;* ⊗, *absence contributing conditions; blank, do not care; DCE, Dynamic Competitive Environment; DEL, Digital Economy Level; OS, Organisational Structure; Inn, Innovativeness; Pro, Proactiveness; RT, Risk-taking; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure.*

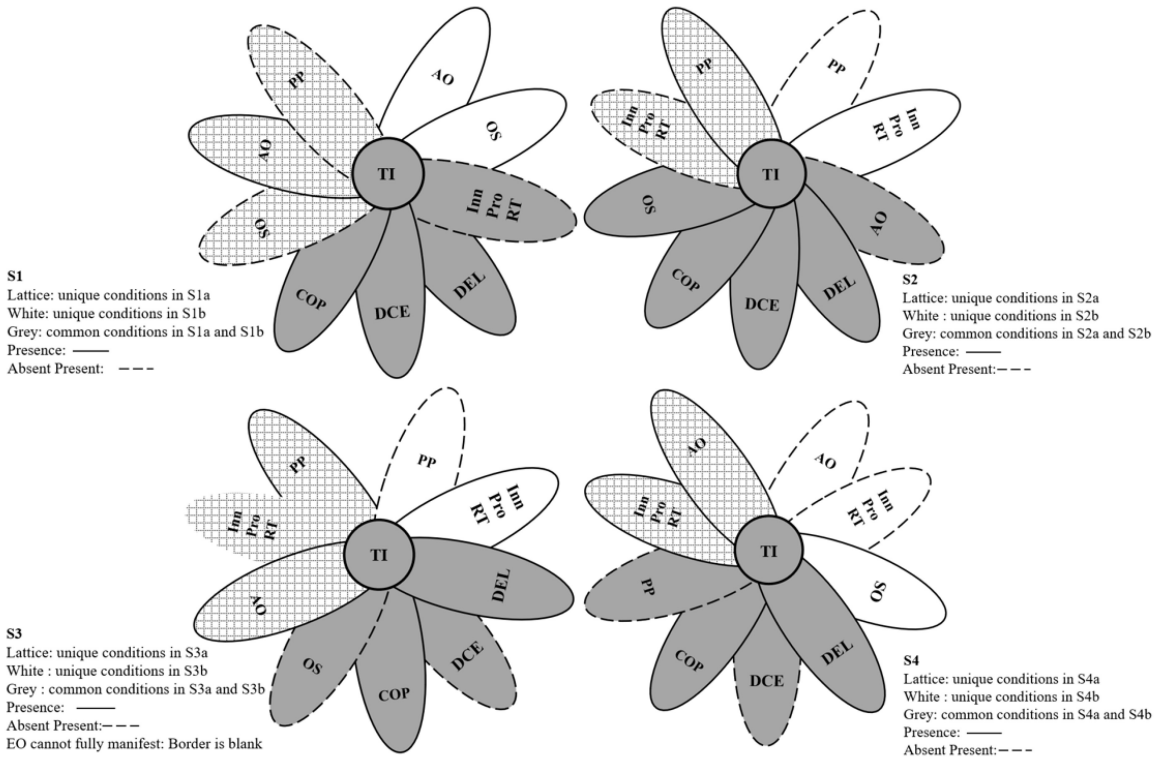

FIGURE 2 | Configurations for high middle management team innovativeness (fuzzy-set qualitative comparative analysis). CEO EO, CEO Entrepreneurship Orientation (including Innovativeness, Proactiveness, and Risk-taking); OS, Organisational Structure; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure; TI, Middle Management Team Innovativeness.

to achieving team member coordination and unity of cognition. On the one hand, CEOs can stimulate MMT innovativeness by reducing middle management's perception of performance pressure as a threat (Mitchell et al., 2018) and cultivating middle management's confidence in the organisation's development (S1a). On the other hand, CEOs can foster innovativeness by encouraging the confidence in the organisation's development and the achievement-oriented motivation of team members (S1b). The coverage of S1a and S1b is 0.248 and 0.231, respectively; and S1a and S1b's consistency is 0.957 and 0.947, respectively.

When companies have autonomous organisational structures in a dynamic competitive environment, external competitive pressure affects the CEO's entrepreneurship cognition and behaviour (Covin and Slevin, 1988), but an autonomous organisational structure may facilitate the vertical penetration of CEO EO (Wales et al., 2011). The CEO is an important source of information within an organisation, owing to the trend of digital innovation. If the CEO lacks entrepreneurial orientation, MMTs lack information sources about the organisation's internal innovation and entrepreneurship. However, autonomous organisations have established that MMTs have decision-making power, which enables them to realise information sharing and communication among members (Rhee et al., 2017). Thus, MMT enthusiasm for innovation is critical to the team's innovativeness model and atmosphere. Chief executive officers can clarify mission goals by improving MMT challenging perceptions of performance pressure, while also cultivating their confidence in the organisation's development prospects, which is critical for stimulating their innovativeness (S2a, coverage is 0.236, consistency is 0.926). Furthermore, if there is the vertical pervasiveness of CEO EO, it will help MMTs obtain clear digital innovation strategy information, achieve top-down information sharing and transmission, and effectively supervise and control employee behaviour in subordinate departments (Liu and Xi, 2021). Thus, if the MMTs are full of confidence and enthusiasm for the organisation's development prospects, it will stimulate MMT innovativeness (S2b, coverage is 0.221, consistency is 0.972).

Solutions 3 and 4 are strategies for promoting MMT innovation when the dynamic competitive environment has no significant influence. When the external environment is non-dynamic and non-competitive and the organisational structure lacks autonomy, the competitive pressure of the external environment has little impact on CEO entrepreneurship cognition and behaviour (Covin and Slevin, 1988). CEOs' cognition and decision-making regarding the digital innovation trend are important in mechanical organisational structures. MMTs may not perceive superior innovation strategy information if CEO EO does not manifest sufficient vertical penetration in mechanical organisational structures. It is necessary to improve middle managers' perceptions of

performance pressure while also cultivating their confidence in the organisation's prospects and stimulating MMT achievement orientation to boost their innovativeness (S3a). However, if CEO EO is fully manifested and achieves vertical penetration within an organisation (Wales et al., 2011), middle managers will be able to obtain clear goal-oriented directions regarding digital innovation and entrepreneurship. In the solution, if the MMTs are optimistic and confident about the organisation's development prospects, it will stimulate MMT innovativeness (S3b). S3a (0.966) and S3b (0.963) have higher consistency than the accepted threshold of 0.80. The coverage of S3a and S3b is 0.181 and 0.283, respectively.

External environmental pressure has less impact on the CEO's entrepreneurship when the external environment is non-dynamic and non-competitive. Regardless of organisational structure, CEOs should reduce the threat MMTs perceive from performance pressure to achieve innovativeness. Furthermore, if CEO EO can penetrate vertically within an organisation and encourage the use of digital equipment for innovative behaviours, MMTs will have high achievement orientation and be confident in the organisation's development, which is essential for inspiring team innovativeness (S4a coverage is 0.317, consistency is 0.915). However, although CEO EO cannot be fully manifested in an organisation with an autonomic organisational structure, middle managers have some autonomy and participation rights in developing innovation and entrepreneurship, and internal organisational information can be shared and innovated. Thus, MMTs must capture information on the trends in digital innovation and entrepreneurship by themselves; when MMTs have full confidence in the organisation's development prospects, it helps stimulate the team's innovativeness (S4b coverage is 0.212, consistency is 0.952).

Configurations for the Absence of Middle Management Team Innovativeness

According to the asymmetry principle in fsQCA, we consider that a configuration that promotes teams' innovativeness may differ from configurations that are absent of MMT innovation. Thus, we conducted a separate analysis of pathways where the MMT innovation is absent (**Table 4**). If the results are accurate, they mean that the pathways that promote innovation in MMTs are distinct from the cause of the absence of innovation in MMTs (e.g., Du and Kim, 2021). The results highlight the importance of confidence in organisational development. Regardless of the situation, if middle leaders lack confidence in the organisation's development prospects, it may lead to insufficient or lack of innovativeness in a team.

When the dynamic competitive environment has no significant impact on companies and CEO EO can be manifested in a mechanical organisation, MMTs are under performance pressure and achievement orientation but lack confidence in the company's development, resulting in low or no MMT innovation (AS1a). The absence of MMT innovation in 1b (AS1b) and 1c (AS1c) demonstrate that, regardless of organisational structure, if there is no CEO EO and the necessary personal characteristics of MMTs are lacking, the MMT innovativeness cannot be stimulated.

In a dynamic competitive environment, the absence of MMT innovation in 2a (AS2a) demonstrates that when CEO EO is fully manifested, MMTs lack of confidence in the organisation's prospects, lack of achievement orientation, and lack of performance pressure causes their innovation to vanish. Furthermore, even in the presence of performance pressure and achievement orientation, the solution in the absence of MMT innovation in 2b (AS2b) indicates that when CEO EO cannot fully manifest and incorporate vertical penetration, MMTs lack of confidence in the organisation's prospects causes MMT innovativeness to disappear.

Robustness Checks

The results of stimulating MMT innovativeness were subjected to a robustness test. The study was repeated after modifying the calibration points in all cases to 10 (full out), 50 (crossover), and 90 (full in) percentage points using the direct calibration method. The outcomes were similar. Details are in **Supplementary Appendix B**.

DISCUSSION, IMPLICATIONS, LIMITATIONS, AND FUTURE RESEARCH

Discussion

The following conclusions were drawn based on the fsQCA configuration analysis. First, the complexity and variability of the market environment has a profound impact on the innovative cognition and behaviours of organisational members in the digital economy era (Wang et al., 2021). Second, with the growing

TABLE 4 | Configurations for the absence of middle management team innovativeness (fuzzy-set qualitative comparative analysis).

Configuration	Solutions				
	AS1a	AS1b	AS1c	AS2a	AS2b
DCE	⊗	⊗	⊗	●	●
DEL	•	•	•	•	•
OS	⊗	⊗	•	●	●
Inn	•	⊗	⊗	•	
Pro	•	⊗	⊗	●	●
RT	•	⊗	⊗	●	●
COP	⊗	⊗	⊗	⊗	⊗
AO	●	⊗		⊗	•
PP	●		⊗	⊗	•
Raw coverage	0.192	0.263	0.244	0.273	0.251
Unique Coverage	0.017	0.056	0.015	0.039	0.030
Consistency	0.961	0.946	0.968	0.973	0.965
Solution Coverage: 0.478					
Solution Consistency: 0.945					

●, *presence core conditions;* ⊗, *absence core conditions;* •, *present contributing conditions;* ⊗, *absence contributing conditions; blank, do not care; DCE, Dynamic Competitive Environment; DEL, Digital Economy Level; OS, Organisational Structure; Inn, Innovativeness; Pro, Proactiveness; RT, Risk-taking; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure.*

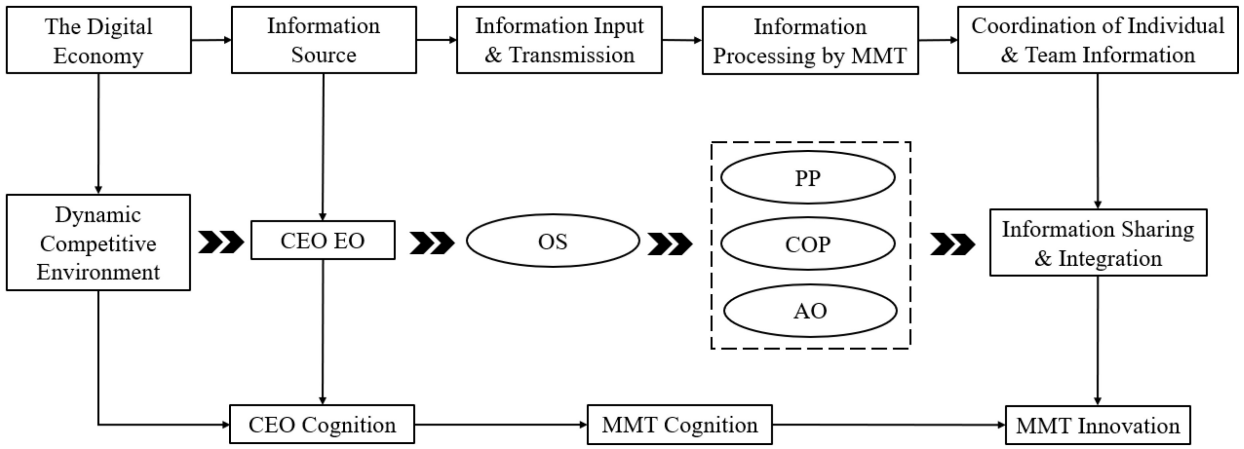

FIGURE 3 | Chief executive officer entrepreneurial orientation vertical penetration and middle management team innovativeness. CEO EO, CEO Entrepreneurship Orientation; OS, Organisational Structure; COP, Confidence in the Organisation's Prospects; AO, Achievement Orientation; PP, Performance Pressure.

diversity and complexity of external information, organisational members' work becomes more difficult, and the importance of teamwork among members has begun to be emphasised. When confronted with complex digital information, middle managers should strengthen teamwork and cultivate the unity of innovativeness among team members. Third, according to social information processing theory, CEOs act as an important information channel, and CEO EO has a top-down impact on members' innovativeness. This mode of influence is essentially CEO EO vertical penetration within the organisation. In addition, to achieve consistency in individual and team cognition, MMTs input, process, and share the information received (CEO EO) among team members based on the specific characteristics of the organisation's internal situation and their perceptions. In turn, CEO EO can stimulate MMT innovativeness. **Figure 3** shows the relationship between CEO EO vertical penetration and MMT innovativeness.

Theoretical Implications

First, the external environment's complexity and variability significantly impact enterprises' internal innovation activities. This study investigates the relationship between CEO EO and MMT innovativeness and provides a new perspective for research on internal entrepreneurship during the digital innovation period. Second, based on social information processing theory, this study proposes that CEO EO, as organisations' internal information source, has a significant impact on organisational members' innovativeness (Wales et al., 2020; Liu and Xi, 2021). Moreover, this study provides the first in-depth interpretation of the internal mechanism of the top-down influence of CEO EO on MMT innovativeness and opens the black box of the vertical penetration of CEO EO to the recognition of MMT innovativeness. This adds to research on the role of EO penetration at various enterprise levels. Third, MMTs are important for organisational communication and information-sharing (Liu and Xi, 2021). This study investigates the internal reasons for MMTs' information interpretation heterogeneity, which is critical for realising the coordination and unity of entrepreneurial cognition and behaviours. Finally, unlike previous single and fragmented research findings (Covin and Lumpkin, 2011), using the causal conditions in a dynamically competitive market, organisational structure, and middle manager cognition, this study is the first to employ fsQCA to investigate the path configuration of the innovativeness relationship between CEO EO and MMTs, which provides a better understanding of the internal mechanism of CEO EO vertical penetration. Furthermore, fsQCA uses Boolean algebra laws to collect the factors that drive the results and truly explain how CEO EO vertical penetration within an organisation impacts MMT innovation in a complex real-world environment. This contributes to the derivation and theoretical innovation of information processing theory and CEO EO in real business.

Managerial Implications

This study's findings have significant managerial implications. First, given the importance of CEOs' continuous attention to entrepreneurial activities, companies should include the characteristics of CEO EO in the scope of investigation when selecting CEOs. Second, the results indicate that teamwork is an important way for organisations to respond to the complex and dynamic environment in the age of digital innovation. Therefore, it is critical to understand the unity of information sharing, cognition, and behavioural patterns among team members. Third, considering the importance of the external market environment for a company's development, corporate decision-makers such as CEOs should pay attention to the external environment and take steps to address the challenges it poses. Finally, this study reveals that MMTs with different cognitive models have different innovativeness based on their perceived performance pressure, degree of organisational development confidence, and achievement-oriented behaviours. Thus, regarding entrepreneurship, organisations should pay more attention to how to motivate MMTs innovativeness.

Limitations and Future Research

First, we encourage scholars to research the content of an organisation's internal entrepreneurial activities. With the onset of the digital innovation era, organisational innovation efforts face new challenges. Whether in the organisational innovation development process or form, or in the innovativeness of organisational members, there is greater complexity and uncertainty. Thus, conducting in-depth study on a company's internal entrepreneurial activities can help it adapt to the difficulties posed by digital innovation. Second, this study focuses on the vertical penetration of CEO EO within organisations; the findings show that CEO EO can achieve vertical, horizontal, and cross-time penetration in organisations (Wales et al., 2011). Therefore, we hope that scholars can research the role of CEO EO in the entrepreneurial process within organisations from a variety of perspectives. Furthermore, investigating how to fully manifest CEO EO within organisations aids in expanding the theoretical research framework of EO in the digital innovation era. Third, as CEOs' cognitive model, CEO EO can influence the cognitive models and behaviours of employees at all levels of organisations (Liu and Xi, 2021). However, this study is the first to look at the impact of CEO EO on MMT innovativeness only. Some studies show that CEO EO influences the cognition and behaviour patterns of operations managers and front-line employees (Wales et al., 2011). Scholars can dig deeper into CEO EO vertical penetration and discuss it in more depth. Finally, this study employs fsQCA to examine how the vertical penetration of CEO EO promotes MMTs innovativeness. This study, however, is based on a static state, whereas dynamic studies that incorporate the time dimension represent another fsQCA trend. Therefore, scholars can attempt to investigate the vertical penetration of dynamic CEO EO within an organisation during the life cycle of different organisations and how it impacts the members' innovativeness.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

XZ wrote the manuscript and understood data processing. YL built the study structure framework, guided study writing, and gave theoretical guidance. XG provided scientific research funding support. DW provided research data. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.775558/full#supplementary-material

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How Does Perceived Support for Innovation Lead to Deviant Innovation Behavior of Knowledge Workers? A Moderated Mediation Framework

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Many studies concerning deviant innovation behavior mainly focus on the influence of personality differences or leadership styles, and there is a lack of attention given to internal cognitive factors related to actors. Therefore, the purpose of this paper is to examine the internal mechanism of perceived support for innovation on deviant innovation behavior. A two-wave study was conducted among 393 knowledge workers from 10 knowledge-intensive enterprises in the People's Republic of China. Model 4 and Model 14 from SPSS macro PROCESS are used to test the mediating effect of innovation commitment and the moderating effect of threatened self-identity, respectively. The findings suggest that perceived support for innovation can significantly predict deviant innovation behavior; innovation commitment fully mediates the relationship between perceived support for innovation and deviant innovation behavior; public threat to self-identity plays a moderating role in the relationship between innovation commitment and deviant innovation behavior; and public threat to self-identity moderates the mediating effect of innovation commitment on perceived support for innovation and deviant innovation behavior. This study enriches the research on antecedent variables of deviant innovation behavior, and highlights the important role of situational factors on the whole mechanism.

Keywords: perceived support for innovation, deviant innovation, innovation commitment, threatened self-identity, relationship

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INTRODUCTION

The dynamic competition market and trade frictions of large countries have posed a great challenge to the adaptability of local enterprises. An increasing number of entrepreneurs realize that the key to enterprises enhancing their core competitiveness is to stimulate employee innovation. In knowledge-intensive enterprises that value innovation, knowledge workers have now become the object of strong organizational support, but compared to the methods and process of innovation, the enterprise attaches more importance to the results of innovation (Neumeyer et al., 2019). The common inference is that "innovation should be under the direct control of management" (Augsdorfer, 1996). However, resources are sometimes limited in the process of realistic innovation

practice (Mainemelis, 2010), and employees cannot achieve their own innovation goals through formal channels and may turn to informal way-deviant behavior (Zhang and Tu, 2022), which is called "deviant innovation behavior". It is characterized by bootlegging or underground innovation (Knight, 1967). Different from deviant employee behaviors such as lying, stealing, corruption, etc., which are generally considered to be avoidable due to losses caused, deviant innovation behavior often has altruistic motives and functional roles (Cheng, 2019). In the workplace, when a conflict between an employee's creativity and organizational authority or system will or may occur, if the individual insists that his or her creativity is conducive to the organization, he or she should choose to continue to practice this idea through unconventional means (Wang et al., 2018). Some studies have shown that individual variables such as overqualification, job characteristics such as remote position, and relationship status such as supervisor-subordinate task conflicts are closely related to deviant innovation behavior (Wang et al., 2018; Wang, 2019; Xiao, 2020). However, the psychological conflicts and cognitive changes in employees themselves were ignored (Helene and Philip, 2019). When employees receive much support for innovation from the organization, what are the characteristics of internal psychological changes and why would they want to disregard the rules to be observed and bootleg?

According to social exchange theory, there may be reciprocity and commitment between individuals and organizations when they gain value recognition and high trust (Eisenberger et al., 2001). Commitment often leads to target behavior and to deviant innovation behavior (Yuan and Liu, 2021). Perhaps perceived support for innovation influences deviant innovation behavior via innovation commitment. Meanwhile, when the idea for an innovation and the conventional mode are quite different or high responsibility requirements lead to innovation anxiety (Anwar and Niode, 2017), employees feel threatened by their self-identity. Threatened self-identity mainly refers to the immediate negative self-perception formed by an individual in a specific situation (Murtagh et al., 2012). Influenced by the psychological conflict of threats to self-identity, employees are more likely to behave in their prescribed roles to keep self-congruity. Therefore, threatened self-identity should be regarded as a conditional variable when exploring the influencing mechanism of the effect of perceived support for innovation on deviant innovation behavior.

Given the above, this study has an objective to analyze the internal mechanism of perceived support for innovation on deviant innovation behavior via the mediating effect of innovation commitment and the moderating effect of threatened self-identity. To conduct the study, we used Wenjuanxing, an online crowdsourcing platform in mainland China that provides functions equivalent to Amazon Mechanical Turk, to collect knowledge workers' perceptions about the studied variables. After this current introduction, the theoretical framework is developed. Then, the 6 hypotheses to be tested are presented and justified, followed by an explanation of the research model. Next, the analysis of the collected data is presented, followed by a discussion of the results and the main conclusions of the study.

THEORY AND HYPOTHESES

Eisenberger et al. (2001) proposed the concept of perceived organizational support and regarded it as a comprehensive perception of how organizations evaluate employees' contributions and whether organizations are concerned about their wellbeing during the work process. This perceived support was proven to play an important role in stimulating social exchange between employees and organizations and enhancing the sense of obligation to achieve organizational goals (Rhoades and Eisenberger, 2002). Compared with perceived organizational support, perceived support for innovation refers to the subjective perception of organizational support for employees' pursuit and implementation of new ideas at work, which is more closely related to the target, i.e., creative behavior (Xu et al., 2021). Perceived support for innovation has an impact on employees' creative behavior, which, in turn, indirectly impacts their creative execution behavior (Gu et al., 2014a). A strong sense of support for innovation can create an advantageous psychological atmosphere for individuals who mobilize them to produce more positive emotions (Ding et al., 2018). In such an environment, knowledge workers often feel more confident about their innovative ideas and can become more creative as they experience positive emotions. Supportive external resources can be transformed into internal psychological advantages through cognitive evaluation, which can increase the sense of self-efficacy and even lead to self-expansion and the neglect of work boundaries, which can facilitate deviant innovation behavior (Gao et al., 2020; Ma and Guo, 2020). In addition, perceived support for innovation can stimulate employees' achievement motivation and positively impact their autonomous behavior (Lin, 2020). When knowledge workers perceive encouragement and support for innovation from their organization, they tend to increase their internal psychological resources, challenge conventions, and show high levels of creativity (Gu et al., 2014b). Thus, considering that deviant innovation behavior may be influenced by perceived support for innovation, we propose the first hypothesis:

H_1: Perceived support for innovation has a positive effect on deviant innovation behavior.

Perceived support for innovation refers to employees' positive awareness of the openness of the organization. Based on the principle of reciprocity in social exchange, employees tend to engage in active thinking and have a strong sense of innovation. According to social exchange theory, employees are willing to make commitments and act in more ways that are beneficial to the organization because of the need to be recognized for their values (Settoon et al., 1996). Innovation commitment is a subordinate concept of commitment that emphasizes that the content of individual commitment is innovation rather than other types (Yuan and Liu, 2021). Highly committed employees tend to be more innovative than other employees because they consider their work to be self-fulfilling and are willing to show more talent and innovation in their work (Chen and Francesco, 2003). As a form of individual inner attachment to innovation, innovation commitment reflects not only employees'

own behavior of giving back to the organization but also their high expectations for the realization of innovation goals or innovation performance (Yuan and Liu, 2021). The supportive and caring behavior of organizations and superiors makes it easier for employees to generate or pursue novel ideas, activities or relationships; helps them actively build lasting personal resources, such as problem-solving skills, and acquire new knowledge; and further enhances their beliefs about expectations for the success of innovation (Yang et al., 2008). Commitment reflects the degree to which an individual identifies with and participates in an organization (Yuan and Liu, 2021). Individuals have a sense of obligation to work, and in terms of job innovation, they also appreciate innovative behaviors through innovative self-efficacy (Xu and Zhao, 2020). Innovation commitment can influence the choice of innovation mode and plays a mediating role in the relationship between innovation climate and innovation performance (Wang and Ge, 2016). Overall, employees' perceived support for innovation should promote innovative behaviors through an inner sense of commitment and increase the probability of deviant innovation behavior. Thus, the second, third and fourth hypotheses to be tested are as follows:

H_2: Perceived support for innovation has a positive effect on innovation commitment.

H_3: Innovation commitment has a positive effect on deviant innovation behavior.

H_4: Innovation commitment mediates the relationship between perceived support for innovation and deviant innovation behavior.

Deviant innovation behavior is regarded as an extrarole behavior of employees when their innovative ideas conflict with the rules of the organization and their superiors. Such a conflict may be caused by individuals' high sense of being overqualified in the workplace, which leads to paradoxical thinking and ultimately to these behaviors (Wang, 2019). This paradoxical thinking involves self-concept (Nanyangwe et al., 2021). Self-threat is a psychological state that measures the destruction of self-concept (Franzoi, 1982). This system of internal and external balance can be divided into the private self and public self. Private self-concepts are aspects of self-identity or self-concern that are difficult for others to understand, while public self-reflections are aspects of social identity or public display that are easy for others to discern (Franzoi, 1982). Knowledge workers have individualistic tendencies and a strong sense of freedom, do no follow authority, have high expectations and high goals and are willing to invest more resources to meet challenges (Parry and Urwin, 2011). In China, people are sometimes constrained by the ideology of "being superior to others and being inferior to others", so they dare not go against the organization's requirements in public (Liu, 2019). When individuals fail in some innovation tasks, their innovative views are not supported and recognized by superiors and others, and the self-information that the individual usually receives from the outside world is negative. This sense of self-uncertainty often brings an experience of conflict for individuals, thus leading to psychological pressure. Such experience reduces the possibility of extrarole behavior to reduce the sense of self-threat. Individuals with a high sense of self-uncertainty are more willing to categorize and deindividuate (Hogg, 2014). In this way, conflict experiences lead to uncertainty in self-concept, and individuals increase in-role behavior while decreasing extrarole behavior. The level of threatened self-identity should influence the relationship between innovation commitment and deviant innovation behavior. Hence, we propose the fifth hypothesis to be tested in this study:

H_5: Public threat to self-identity has a negative moderating effect on the relationship between innovation commitment and deviant innovation behavior. Private threat to self-identity has a negative moderating effect on the relationship between innovation commitment and deviant innovation behavior.

As mentioned above, the mediating effect of innovation commitment on the relationship between perceived support for innovation and deviant innovation behavior may also be moderated by threatened self-identity. In other words, when the level of public or private threat to self-identity is high, the indirect effect of perceived innovation support on deviant innovation behavior through the mediating role of innovation commitment is relatively weak. In contrast, when the level of public or private threat to self-identity is low, the indirect effect of perceived innovation support through innovation commitment on deviant innovation behavior is correspondingly enhanced. Thus, we consider it interesting to formulate the following hypothesis:

H_6: Public threat to self-identity has a negative moderating effect on the mediating effect of innovation commitment. Private threat to self-identity has a negative moderating effect on the mediating effect of innovation commitment.

Assuming that threatened self-identity moderates the relationship between innovation commitment and deviant innovation behavior, threatened self-identity is also likely to conditionally influence the strength of the indirect effect of perceived support for innovation on deviant innovation behavior through innovation commitment. This pattern of moderated mediation between the variables is depicted in **Figure 1**.

DATA ANALYSIS

Sample and Procedures

This study was a two-wave design conducted in 10 knowledge-intensive companies in the Yangtze River Delta of China from March through April 2021. These companies are mainly involved in software development, information technology and manufacturing. All workers were informed of the study via a WeChat working group and then received an invitation that described the aims, risks, benefits and process of the study, emphasized confidentiality, pointed out requirements for participating, and provided a link to the survey. A total of 456 knowledge workers consented to participate in the first survey. At time 1, the data of perceived support for innovation, threatened self-identity, and innovation commitment were collected. We received 432 valid responses for a 94.74% response rate. One month later, at time 2, a deviant innovation behavior scale was administered, and the second survey was answered by 393 out of

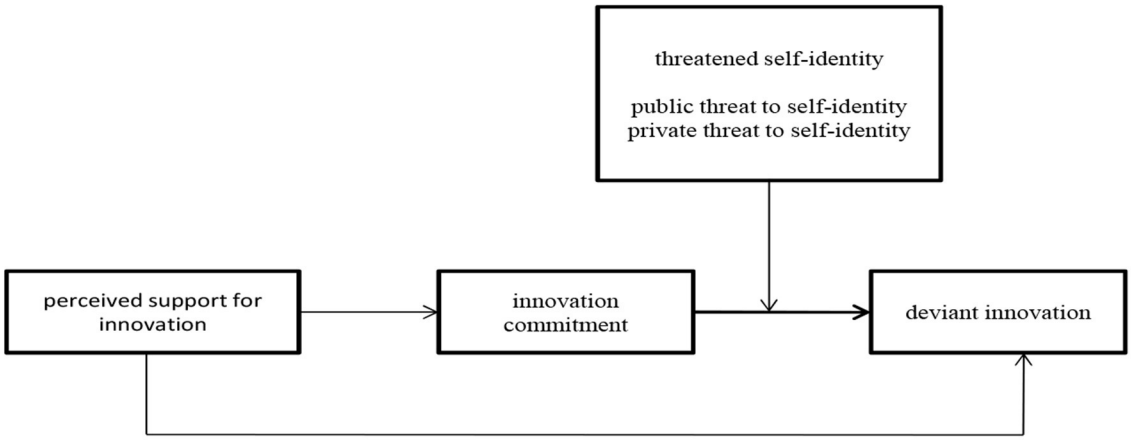

FIGURE 1 | Proposed research model. Source: own elaboration.

the 432 initial respondents, for a 90.97% response rate. Among them, 55% were male, while 45% were female. In addition, 58.21% had bachelor's degrees, 28.1% had master's degrees, 7.6% had doctoral degrees, and 6.09% had an education below the bachelor's level. Given the nature of their job, 43.3% were core, and 56.7% were general. Regarding their positions, 69% were in intermediate positions or lower, and 31% were at associate senior positions or higher. The average age was 37.96 years (SD = 8.68).

Measures

A Chinese version of all the measures based on the original English language scales was created using the translation and back-translation procedure (Brislin, 1986). The subjects were asked to respond to the survey using a five-point Likert scale (*1 = strongly disagree, 5 = strongly agree*). We measured deviant innovation behavior with nine items adopted from Lin et al. (2016). A sample item was "Although my superiors do not agree with my new plan, I will still go ahead with it". Cronbach's α for this scale was 0.949. We assessed perceived support for innovation with eight items adopted from Siegel and Kaemmerer (1978). A sample item was "Our ability to work creatively is valued by our leader". Cronbach's α for this scale was 0.944. According to the innovation theme, we adopted a five-item scale from Klein et al. (2001) that was adjusted appropriately for innovation commitment. A sample item was "I care a lot about whether I can achieve my innovation goals". Cronbach's α for this scale was 0.918. We adopted a nine-item scale for threatened self-identity from Campbell and Sedikides (1999). There were four items for private threats to self-identity, such as "After rejecting my proposal or idea, I would feel a kind of inexplicable depression in my heart". There were five items for public threats to self-identity, such as "Rejecting my proposal or idea will affect my image in front of other colleagues". Cronbach's α was 0.887 for the former and 0.912 for the latter. Similar to previous research (Dewett, 2007; Jiang, 2018), we controlled for the employees' gender, education level, age, position and job nature.

ANALYSIS OF THE RESULTS

To assess the potential influence of common method bias, we used Harman's one-factor test (Podsakoff et al., 2003). Four factors that accounted for 74.62% of the variance were extracted, and the first factor accounted for 31.57%. These findings demonstrate that common method bias is unlikely to be a significant problem in this study. Moreover, we tested for common method bias with a single-factor measurement model by combining all items into a single factor (Dedahanov et al., 2016). The findings indicate a poor model fit: comparative fit index *(CFI)* = 0.282; Tucker–Lewis index *(TLI)* = 0.220; standardized residual mean root *(SRMR)* = 0.262; χ^2/df = 22.868; and root mean square error of approximation *(RMSEA)* = 0.236. These findings also demonstrate that common method bias is unlikely to be a significant issue in our study.

The discriminative validity of each scale was tested, and we found that the five-factor model was superior to the other models ($\chi^2 = 731.813$, $df = 289$, $\chi^2/df = 2.532$, $RMSEA = 0.062$, $CFI = 0.951$, $TLI = 0.945$, $SRMR = 0.053$). These findings demonstrate that there is good discriminative validity among the factors (Wen et al., 2018). In addition, the *CR* values of innovation commitment, private threat to self-identity, public threat to self-identity, perceived support for innovation and deviant innovation behavior were 0.920, 0.890, 0.914, 0.944 and 0.951, respectively (all > 0.7). The average variance extracted *(AVE)* values were 0.698, 0.731, 0.780, 0.740 and 0.686, respectively (all > 0.5 and all greater than the squared value of the correlation coefficient between the factors). Therefore, each factor had good construct reliability and convergence validity. **Table 1** reports the means, standard deviations and bivariate correlations of all variables. As shown in **Table 1**, our results showed significant correlations between the dependent and independent variables and limited collinearity between our independent variables.

Following Preacher et al. (2010), we tested a path model specifying the indirect effects of perceived support for innovation on deviant innovation behavior through innovation commitment (X→ M→ Y). In addition, gender, age, education level, position

TABLE 1 | Descriptive statistics and correlations ($N = 393$).

Variables	Means	SD	1	2	3	4	5	6	7	8	9
1. Perceived support for innovation	3.56	0.68									
2. Innovation commitment	3.69	0.64	0.35**								
3. Deviant innovation behavior	3.05	0.76	0.16**	0.40**							
4. Private threat to self-identity	2.60	0.77	−0.27**	−0.08	0.02						
5. Public threat to self-identity	2.46	0.85	−0.28**	−0.13**	0.04	0.71**					
6. Gender	0.55	0.50	−0.07	−0.08	−0.21**	−0.04	−0.09				
7. Age	37.91	8.67	−0.03	0.11*	0.16**	0.12**	0.15**	−0.14**			
8. Education	2.39	0.83	0.05	0.18**	−0.02	0.05	0.00	0.00	−0.03		
9. Position	2.55	1.23	−0.08	0.21**	0.20**	0.15**	0.14**	−0.13**	0.54**	0.31**	
10. Job nature	1.43	0.50	−0.02	0.01	0.08	0.17**	0.14**	−0.02	0.24**	0.09	0.10

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 2 | Results of the path analysis of the mediating effect.

Path	Estimate	SE	Lower and upper 95% CI limits
Test of direct relationships			
Perceived support for innovation → deviant innovation behavior	0.18***	0.06	(0.06, 0.31)
Perceived support for innovation → innovation commitment	0.32***	0.04	(0.22, 0.43)
Innovation commitment → deviant innovation behavior	0.47***	0.06	(0.34, 0.60)
Test of indirect relationships			
Perceived support for innovation → innovation commitment → deviant innovation behavior (bootstrap)	0.15***	0.03	(0.09, 0.22)

$N = 393$, ***$p < 0.001$.

and job nature were included as control variables. The purpose of this analysis was to test the significance of the direct and indirect effects from X to Y through M.

As shown in **Table 2**, the path model results showed that perceived support for innovation was positively related to deviant innovation ($\gamma = 0.18$, $p < 0.01$); thus, H1 was supported. Furthermore, as H2 proposed, perceived support for innovation was proven to be positively related to innovation commitment ($\gamma = 0.32$, $p < 0.001$) and thus supported H2. Similarly, the results showed that innovation commitment was positively related to deviant innovation behavior ($\gamma = 0.47$, $p < 0.001$), which supported H3. To test the mediating effect proposed by H4, we used a parametric bootstrap procedure with 20,000 Monte Carlo replications to estimate a confidence interval (*CI*) around the indirect effects (Preacher et al., 2010). The results showed a positive indirect effect of perceived support for innovation on deviant innovation behavior via innovation commitment (estimate = 0.15, 95% $CI = 0.09, 0.22$), which provided support for H4.

Furthermore, we suggest that possible moderators should be considered to explain deviant innovation behavior. Thus, we proceeded to test for moderated mediation. H5 predicted that the effect of innovation commitment and deviant innovation behavior was moderated by threatened self-identity. The modeling results indicated a negative moderation effect of public threat to self-identity on the random slope between innovation commitment and deviant innovation behavior ($\gamma = -0.13$, $p < 0.01$). However, we found that the negative moderation effect of private threat to self-identity on the random slope between innovation commitment and deviant innovation behavior was not significant ($\gamma = -0.08$, $p>0.05$). Therefore, the form of the interaction was partially in the hypothesized direction. Additionally, to better comprehend the moderation of public threat to self-identity, we plotted the effect in **Figure 2** (Aiken et al., 1991).

The results indicated that the indirect effect of perceived support for innovation on deviant innovation behavior via innovation commitment differed as a function of public threat to self-identity. That is, the negative indirect effect was weaker when there was a greater public threat to self-identity (estimate = 0.10, $SE = 0.04$, $p < 0.05$) and stronger when this threat was lower (estimate = 0.21, $SE = 0.04$, $p < 0.05$). Additionally, the difference in the indirect effects between the function of high and low levels of public threats to self-identity was significant (estimate = −0.13, $SE = 0.05$, $p < 0.01$). According to Hayes (2015), the index of moderated mediation was significant (estimate = −0.05, $SE = 0.02$, 95% $CI = -0.10, -0.01$), providing partial support for H6. In summary, the results from our path analysis provided strong support for our hypothesized process of the moderating effect of public threat to self-identity.

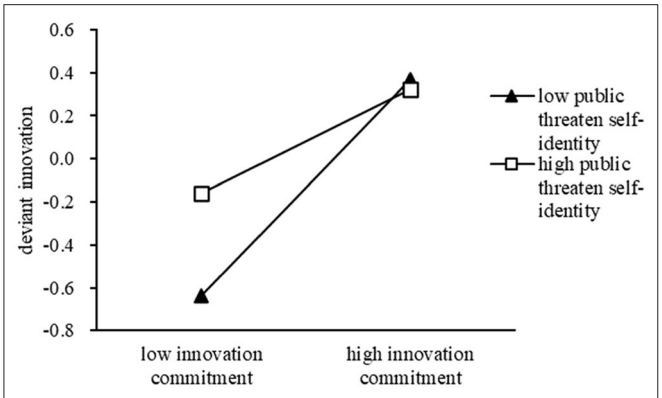

FIGURE 2 | Moderating effect of public threat to self-identity on the relationship between innovation commitment and deviant innovation behavior.

CONCLUSION

The purpose of this study is to understand whether and how perceived support for innovation as an important individual difference affects deviant innovation behavior. Our results demonstrate that perceived support for innovation fosters deviant innovation behavior fully through innovation commitment and that public threat to self-identity buffers the positive effects of innovation commitment. The results of the analysis of data from 393 knowledge workers by SEM supported the hypotheses.

First, the results showed that perceived support for innovation has a positive direct effect on deviant innovation behavior. Because of the strong support for innovation from enterprises, knowledge workers satisfy their needs for efficacy, sense of power, and belonging and stimulate their rewards and reciprocal motives to the organization (Pierce et al., 2020; Wang and Yu, 2022; Xue, 2022). Possessions are often seen as extensions of self-awareness (Belk, 1988). Knowledge workers make the organization better by making more efforts to devise all types of creative solutions. Second, we also proved the mediation effect of innovation commitment. In China, people adopt the principles of both fairness and renqing when engaging in social exchanges (Ma et al., 2017; Ling et al., 2019). Perceived support for innovation is internalized as the motivation to reward the organization, leading to job involvement and more and higher-quality creative behavior (Gu et al., 2014a). Finally, we found that public threat to self-identity buffered the positive relationship between innovation commitment and deviant innovation behavior, as well as the indirect relationship between perceived support for innovation and deviant innovation behavior through innovation commitment. The bootlegging behavior is essentially about self-initiative (Nanyangwe et al., 2021). When knowledge workers take an active and self-starting approach to work and go beyond what is formally required in the given job, identification has been recognized as important for their deviant innovation behavior (Blader et al., 2017). And consciousness of social face is an important personal factor in China (Oetzel, 2008; Zhao and Bao, 2011). It is negatively correlated with interpersonal satisfaction and collaboration strategy (Liang and Duan, 2018). Public threat to self-identity can influence employees' in-role behavior in a safe direction.

Taking into account the results of the study, this research has theoretical and practical implications. In the case of theoretical implications, this study takes knowledge workers as the research object to explore the antecedent variables of deviant innovation behavior. It reveals the influential mechanism of perceived support for innovation on the deviant innovation behavior under the background of Chinese culture and verifies the mediating role of innovation commitment. This study also proves the moderating effect of public threat to self-identity, exposes the boundary conditions under which the perceived support for innovation influences the deviant innovation behavior of knowledge workers, and highlights the important role of situational factors on the whole mechanism. Previous studies have mostly examined the moderating or mediating effects of perceived support for innovation (Huang et al., 2016; Bosselut et al., 2020). Our findings highlight the influence of such perceived support on how knowledge workers treat their roles and the choice of innovation mode. Because knowledge workers often face complex and uncertain work conditions (Pearce, 2004), support from the organization can provide a sense of security. In addition, because of knowledge workers' work contains high creativity and autonomy, they often encounter problems of identity conflict and balance in terms of self-worth and self-efficacy under the influence of emotional events. Our findings are important for research because relationships with and comments by other people are more valued and play a particularly critical role in deviant innovation behavior in China (Fujiwara et al., 2016).

In the case of practical implications, managers should be fully aware of approaches to stimulating employee creative behavior. According to the findings of this paper, organizations should pay close attention to how employees perceive support for innovation. In line with previous studies (Gu et al., 2014b; Xu et al., 2021), we believe that perceptions of strong support for innovation can lead to positive outcomes. Although deviant innovation behavior has some risk and uncertainty, it is a spontaneous behavior and is good for organizations in essence (Wang, 2019). Managers should increase the confidence of knowledge workers and provide clear goals in various ways to fulfill their commitment to innovation. Organizations should optimize the institutional design to ensure full freedom and security. Furthermore, the psychological demands of these employees should be considered because feedback from the surroundings influences the motivation of the behavior. Organizations must alleviate employees' pressure at work, listen to their opinions and ideas, encourage them to view the value of innovation and properly address suggestions from others. In this way, organizations should improve the mechanisms of creative communication to successfully promote creative behavior. Moreover, managers should expand greater efforts to assist in the development of innovation commitment, which is helpful for achieving higher levels of innovation. Emotional events experienced by employees should also be given close attention in the workplace (Broekhuizen et al.,

2017). When there is innovation failure or high pressure for innovation, entrepreneurs should create a strong democratic atmosphere and encourage employees to express their inner thoughts or dissatisfaction to promote a harmonious relationship and self- congruity.

The present research also has several limitations. First, although the data were collected at two stages, it would be better to measure perceived support for innovation and innovation commitment at two different times rather than at the same time. Second, we proposed only threats to self-identity, one of which, public threat to self-identity, buffers the positive indirect effect of perceived support for innovation on deviant innovation behavior through innovation commitment. Future studies should explore the buffering effects, which are not only from individual factors but also from organizational culture or situational characteristics such as person-job fit. Finally, the conclusion that public threat to self-identity buffered the positive indirect effect of perceived support for innovation on deviant innovation behavior through innovation commitment needs to be further tested in other populations and countries.

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

SY and XL designed the research and carried the investigation. XL analyzed the research data. SY wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Support or Suppress? Research on the Mechanism of Employee's GNS on Innovation Performance: From the Perspective of Status Competition

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The purpose of this paper is to investigate how supervisor's mental state and behavior choice affect the relationship between employees' strong growth need (GNS) and their innovation performance. Using 210 sets of supervisor-subordinate dyads data from two-wave survey, this research reveals that GNS has a significant positive effect on innovation performance, and leader–member exchange (LMX) mediates the effect of GNS on innovation performance. Supervisor perceived status threat moderates the relationship between GNS and LMX, such that this relationship gets weaker for supervisors with higher perceived status threat. Furthermore, supervisor perceived status threat moderates the relationship between GNS and innovation performance, such that this relationship becomes weaker for supervisors with higher perceived status threat. The study concludes with theoretical and practical implications, as well as future research avenues.

Keywords: growth need strength, leader–member exchange, perceived status threat, status competition, innovation performance

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INTRODUCTION

Employees differ in their level of growth need strength, which is a personality trait that refers to the needs and willingness of individuals to learn, grow, accept challenges, and achieve career development from work (Hackman and Oldham, 1976, 1980; Shalley et al., 2009). The higher the strong growth need (GNS), the more employees will pay attention to personal growth and achievement, exercise their independent thoughts, enjoy challenging work, and get more internal motivation and happiness from it (Bottger and Chew, 1986; Shalley et al., 2009; Lin et al., 2016). A secret behind a successful organization is to attract high-GNS employees and help them achieve success (Strubler and Redekop, 2010). Besides, the intensification of the global market competition and the turbulence of the organizational environment urge organizations to actively seek good development strategies. Employee innovation, under this circumstance, is the engine of organization development (Kim et al., 2013; Nieto et al., 2015). Therefore, how to improve employees' innovation performance has become an important issue in the management field (Guo and Hu, 2022). Indeed, employees who can make intensive efforts and breakthrough attempts have good innovation performance. Obviously, employees

with high GNS have the strong motivation of learning new knowledge and pursuing excellent work performance (Shalley et al., 2009) and, thus, incline to invest more energy into innovation. Thus, there should be a positive relationship between employees' GNS and innovation performance. However, the reality is that numerous extant literature discussed the relationship between GNS and individual behaviors and attitudes (Lin et al., 2016), such as GNS and employees' openness to experience (Graen et al., 1986), knowledge sharing behavior (Li and Ma, 2014), creativity (Shalley et al., 2009; Volmer et al., 2012), leader–member exchange (LMX) relationship quality (Phillips and Bedeian, 1994), job performance and affective commitment (Lin et al., 2016), and attitude to organizational change (Elias, 2009); little literature has verified the relationship between GNS and innovation performance. In other words, despite the natural association between GNS and innovation performance, existing studies do not explicitly validate the relationship. Hence, this paper will first discuss this research gap.

The extant literature on employee innovation mainly focuses on the internal characteristics of employees (Shalley et al., 2009), Some scholars propose that external influence of stakeholders in the organization play on employees' innovation performance cannot be ignored either (Seibert et al., 2001; Tang and Mao, 2020). A variety of social and resource supports from stakeholders create fertile land for employees' innovation performance. Leader, undoubtedly, is an important stakeholder. According to the leader–member dependency hypothesis, leaders need to achieve team goals through employees' efforts, and, in turn, the feedback, guidance, and innovation resource support from leaders provide a guarantee for employees with GNS to achieve innovation performance. Consequently, there is a natural cooperative relationship between leaders and subordinates (Huang and Iun, 2006; Liu et al., 2018). We take an cooperative perspective in this study to argue that LMX has an important mediating effect on the relationship between GNS and innovation performance.

However, some contradictory phenomena cannot be explained by the leader–employee cooperation perspective. For example, a leader sometimes expresses very weak support toward subordinates with high GNS who can help him achieve team goals, and even destroy or suppress innovative behavior of subordinates with high GNS. However, the existing literature rarely discusses the phenomenon. We argue that supervisor perceived status threat can explain leaders' "suppression" behavior possibly. As the spokesperson of the organization, a leader wants to lead team members to achieve team goals and realize personal goals. Furthermore, as rational egoists, leader's personal goals usually are superior to team goals (Hoyos, 2013). Among the numerous personal goals of leaders, status demand is the deepest and most fundamental demand. Neuroeconomics and ecology show that people's demand for status is overwhelming (Charness et al., 2014; Liu et al., 2015). Therefore, there is also a dynamic co-opetition relationship between leader and member from the perspective of status competition. On the one hand, leaders need to rely on the employees' GNS to achieve team tasks (Griffin et al., 2007). On the other hand, leaders face challenges and threats brought by employees with high GNS. According to status characteristics theory (Berger et al., 1972) and social dominance theory (SDT; Sidanius et al., 2004), the leaders regard the individuals with high GNS as potential status competitors with necessary capability to obtain high status and participate in status competition. Due to the scarcity and competitiveness of organizational status resources, leaders naturally tend to protect the existing status. Leaders who perceive status threat probably make a poor response to employees' GNS, for example, taking non-political measures to destroy the LMX relationship, and hindering the positive effect of employees' GNS on their innovation performance. Hence, the cooperation perspective cannot effectively explain the leaders' influence on the relationship between employees' GNS and their innovation performance. Accordingly, this paper introduces the supervisor perceived status threat as a leadership characteristic variable to explore whether it will exert a contingency effect on the influence of employees' GNS on LMX and innovation performance.

This study seeks to offer some contributions to the existing research literature. First, although previous studies have verified that the employees' GNS positively affects various routine work outcomes, few studies examine the relationship between GNS and innovation performance. Our examination of whether GNS has a positive effect on innovation performance, contributes to GNS literature by providing evidence of the relationship between personality trait and innovation performance. Second, this study reveals the mediating role of LMX in the influence process of employees' GNS on innovation performance from leader–member cooperative perspective. Our mediating approach contributes to the literature on GNS and innovation performance by revealing why and how employees' GNS is a strong booster for their innovation performance. Third, this study provides a possible answer to an important question: under what circumstances will supervisors not promote but hinder LMX and the innovation performance of subordinates with high GNS? From the perspective of status competition, we identify supervisor perceived status threat as an important boundary condition when exploring the effects of GNS on LMX and innovation performance. Finally, the integration of leader–member cooperative perspective and the perspective of status competition in the same model is helpful to comprehensively understand the influence mechanism and boundary conditions of GNS on employees' positive outcomes.

THEORY AND HYPOTHESIS

Status Characteristic Theory and Social Dominance Theory

According to status characteristic theory (SCT), some dominant characteristics such as demographic variables (e.g., gender, age, seniority, race) and individual characteristics which reflect the employees' work performance are regarded as symbols that have the potential to obtain high social hierarchy (Berger et al., 1972). SDT focuses on how culture, ideology, politics, social structure, individual psychology, and social psychology interact at different levels (Sidanius et al., 2004); the dominant

high-status group suppresses the low-status group to maintain their dominance or high status (Khan et al., 2016). Grant (2013) argued that when evaluating employees' performance, leaders should consider not only whether the employees' behavior is needed by the organization, but also the influence of employees' way of putting forward ideas and behavior on their status. Leaders will adopt ideas that could protect their status, identity, and honor in the organization, while ignoring or belittling suggestions that threaten their status (Hogan and Holland, 2003; Morrison and Ybarra, 2008).

On the one hand, a natural cooperative relationship exists between leaders and members (Liang et al., 2022). The subordinates with high GNS need leaders to provide resources and support for their innovative work. Leaders often rely on employees with high GNS to exert high-level innovation and initiative on work tasks to achieve team goals and performance (Volmer et al., 2012).

On the other hand, GNS as an individual characteristic variable that can improve employees' innovation performance may be regarded by leaders as a symbol that has the potential to obtain high status and participate in the status competition (Liu et al., 2015). As a result, leaders face constant status threats and challenge from the employees with high GNS; then as conflicts and contradictions were provoked, they take defensive or non-constructive measures to resist or suppress subordinates to maintain their status (Grant et al., 2011; Chen et al., 2017; Liu et al., 2021). Therefore, supervisor perceived status threat will affect the relationship between GNS and innovation performance.

GNS and Innovation Performance

GNS is an important variable highly related to job setting in the work characteristic model (Hackman and Oldham, 1976), reflecting the strong willingness of individuals to accept challenges, continue to learn and achieve professional development. With the widespread use of information and communication technologies (ICT) and the global popularity of COVID-19, crises and technological advances have influenced each other to bring about changes in the ways of working such as telecommuting and virtual work strategies (Abarca et al., 2020; Low et al., 2020; Garro-Abarca et al., 2021; Martínez-Navalón et al., 2021). Therefore, this also brings profound changes to the working characteristic model, such as diversity, communication, virtuality, innovation, challenge, and so on. Compared with employees with low GNS, employees with high GNS are more sensitive to new changes in work characteristics and more positively respond to them. Meanwhile, employees with high GNS take a series of proactive behaviors to seize all opportunities and even change the working environment to complete work tasks (Huselid and Day, 1991). They can be regarded as the pioneer to convey the mission of an organization, identify and solve problems. However, employees with low GNS react passively to the environment, and it is difficult for them to aware that working characteristics have changed, respond less positively, or even negatively to enriched work and challenging tasks (Lin et al., 2016). Thus, it is conjectured that employees' GNS can positively influence their innovation performance through the following paths.

First, the generation of innovation performance encompassed various uncertainties and risks (Zhou et al., 2012). Therefore, innovation requires high concentration and initiative (Lin et al., 2016). While achieving innovation performance, employees need to have internal and continuous motivation to firmly promote themselves to face difficulties, challenges, and performance pressure. Research shows that employees with high GNS often regard complex work tasks as ideal challenges or growth opportunities, from which they can get intrinsic incentive (Hackman and Oldham, 1976) to perform more proactively in innovative work (Johnson et al., 2010). In addition, employees with high GNS generally will not passively wait for and accept everything that the environment gives. Instead, they will proactively seek and create opportunities to meet their growth needs (Shalley et al., 2009) and even modify the working environment to meet their strong demand for success (Huselid and Day, 1991). This provides motivation and opportunity basis for employees to innovate and accumulate creative output.

Second, turning creative ideas into real work results is a complex and challenging task, requiring employees to have in-depth professional knowledge and even develop and apply some new knowledge beyond their work field. Hackman and Oldham (1980) argued that employees with high GNS are more inclined to update their professional knowledge and working skills, concentrated on in-depth processing of professional knowledge, thereby further deepening their understanding of work (Wang et al., 2018). Abundant task experience and diversified knowledge improve employees' cognitive flexibility, formulating the knowledge and ability foundation for improving innovation performance (Arias-Pére and Vélez-Jaramillo, 2022).

Third, innovation is a social activity that requires interpersonal and resource supports from the organization. Employees with high GNS actively establish relationship networks in the organization. Employees with high GNS had more knowledge-sharing behaviors on social networking sites, through which they interact with others, set up relationships and obtain social capital (Li and Ma, 2014). In addition, to promote individual growth and development, employees with high GNS build strong trust relationships with colleagues and leaders through active communication and cooperation with organization members, frequently seeking performance feedback from their supervisors. Sufficient social capital and interpersonal network form a resource base for innovation performance (Sarkawi et al., 2016). Therefore, hypothesis 1 is proposed:

H1: GNS is positively related to innovation performance.

The Mediating Role of LMX

According to LMX theory, resource scarcity and subordinates' individual differences will lead a leader to adopt different exchange strategies to establish the exchange relationship from low to high quality with member (Wilson et al., 2010). A high-quality LMX relationship is characterized by the subordinates being marked as "in-group members," accessible to more trust, support, and preferential treatment. On the contrary, a low-quality LMX relationship equals a pure working relationship based on the power system, and subordinates, as

the "out-group members" of leaders, are difficult to get extra care and rewards (Maslyn and Uhl-Bien, 2001).

As mentioned above, GNS refers to the degree to which individuals attach importance to personal growth and development opportunities at work (Oldham and hackman, 2010). Employees with high GNS focus on personal development and are willing to undertake challenging jobs (Bottger and Chew, 1986; Sarkawi et al., 2016). They are more likely to proactively seek leaders' feedback to improve work quality continuously. During this process, employees with high GNS demonstrate the traits of a sense of responsibility, affinity, and extroversion. These characteristics incur leaders' love, trust, and dependence, conducive to establishing a high-quality LMX relationship (Wilson et al., 2010). Moreover, employees with high GNS can provide valuable resources for leaders by imposing higher levels of innovation and initiative on tasks (Wilson et al., 2010), thus helping leaders become more effective and flexible. Previous studies have also shown that members with higher GNS are often more likely to establish a high-quality LMX relationship with their leaders (Phillips and Bedeian, 1994). Graen et al. (1986) found that the GNS of subordinates was positively correlated with the quality of LMX. Employees with high GNS have a clearer understanding of the necessity of establishing a strong network with resource controllers and better political knowledge and skills to deal with the relationship with colleagues and leaders. Therefore, it can be predicted that the higher the GNS of employees, the better they will establish high-quality exchange relationships with their leaders.

A high-quality LMX relationship provides employees with greater freedom of decision-making, broader innovation space, more innovation resource support (Zhang et al., 2012), and sufficient respect and trust (Newman et al., 2017). In addition, recognized as an "in-group member" by leaders, leaders will better understand the expectations of employees with high GNS, allocates more important organizational roles and offers more growth opportunities to them, such as more challenging work and constructive feedback and support when necessary. For subordinates, applying innovative ideas to practice encompassed a certain extent of risk and uncertainty (Yu et al., 2020). Meanwhile, subordinates will have instinctive fear and anxiety about unknown new things. However, the "in-group member" identity endowed by high-quality LMX reinforces subordinates' sense of belonging, self-affirmation and psychological security, thus strengthening their courage to face innovation risks. They hence have more resources and motivation to carry out innovative behaviors and increase innovation performance. Therefore, the following hypothesis is proposed:

H2: LMX mediates the relationship between GNS and innovation performance.

Buffering Effect of Perceived Status Threat

The status threat is defined as an individual's perceived disrespect and denial, or an individual' status characteristics such as official status, reputation and influence within the organization are threatened or weakened (Kramer, 1998). Due to the distinct characteristics of status resources, such as high demand, high value and strong competition (Pearce et al., 2001), position hierarchy is dynamic and unstable in specific organizational situations. Therefore, organization members always try to change or enhance their status by improving their ability, performance, and other status symbols (Berger et al., 1972).

Employees with high GNS usually focus on developing their skills and talents, possessing a strong sense of responsibility and affinity, putting forward constructive suggestions and innovative methods. Therefore, high GNS can be regarded as the potential factor and precondition for acquiring status symbols such as capability, reputation, influence, and high-performance level, making leaders often perceive status threats from subordinates (Khan et al., 2016). Furthermore, employees with high GNS are probably seen as a threat to their leaders because the employees can introduce unwelcome changes which make leaders feel embarrassed, weak and vulnerable by exposing their shortcomings and weaknesses, further doubt their incompetence (Grant and Parker, 2009). According to SDT (Sidanius et al., 2004), people with high status have a high level of social dominance. After perceiving a threat to the status in the group, leaders will amplify power and stratus differences to consolidate and maintain their own status. From the perspective of status competition, when leaders evaluate employees' behaviors, leaders consider whether employees' GNS is needed by the organization and whether employees' GNS will pose a threat to his status (Ames and Flynn, 2007; Grant et al., 2011; Grant, 2013). Leaders who perceive status threats probably destroy the relationship with employees with high GNS through counterproductive political operations and adopt defensive or even exclusive communication modes toward employees, for example isolating subordinates, silent treatment, indifference, "wearing little shoes" for subordinates or deliberately concealing work information (Tang and Mao, 2020), even undertake destructive negative behaviors to deliberately provoke interpersonal conflicts in the team and viciously resist subordinates' GNS to maintain their status. Thus LMX relationship quality is reduced. Therefore, we propose:

H3: Supervisor perceived status threat weakens the positive relationship between GNS and LMX.

Although the employees with high GNS can bring more innovation performance, the degree of the supervisor perceived status threat probably determines whether he is willing to provide employees with innovation support and resources. A leader with high-status threat perception will intensify his control (Liu et al., 2021) and influence to maintain his status rather than provide resources to promote employees' innovation performance (Galinsky et al., 2010). Conversely, employees probably fail to be recognized and appreciated by the leaders because of their GNS, but they are ignored and alienated, further weakening innovation performance. Thus, we propose the following hypothesis:

H4: Supervisor perceived status threat weakens the positive relationship between GNS and innovation performance.

The theoretical model of this study is shown in **Figure 1**: Theoretical model of the study.

MATERIALS AND METHODS

Sample and Procedure

For data collection, we developed a questionnaire based on scales have been well established in relevant previous studies. High-tech enterprises have high requirements for employees' innovation performance, and employees' GNS can also highly explain their performance. Due to the nature of work and the short half-life of knowledge, the cooperation and competition between supervisors and subordinates are more prominent than in other industries. According to the above considerations, this study focuses on high-tech enterprises. Because of time, energy, and human resources restrictions, it was not possible to send the questionnaire to all high-tech enterprises, drawing on previous studies (e.g., Gelashvili et al., 2021), a convenience sampling approach was used and survey questionnaires were disseminated online in the Design and R&D departments of 13 high-tech enterprises from Guangzhou, Shanghai, Wuhan, and Suzhou in China. We contacted the human resources managers and arranged a formal training before their monthly meeting to briefly introduce our academic purpose and highlight the anonymity in our survey.

In order to avoid the influence of homologous bias on the research validity, the questionnaire was filled out by the supervisor and the subordinates in pairs. The employee's direct supervisor evaluated the employee's innovation performance and GNS, and self-reported perceived status threat and GNS. The subordinate self-reported GNS, LMX. Employees' GNS was reported by supervisors and subordinates at the same time, the samples with great variation in the results reported by both parties were eliminated [the difference (absolute value) of the results was greater than or equal to 3] to minimize the possible error caused by social approval, subordinates' self-evaluation of GNS data was retained. The supervisor and subordinate questionnaire adopt a ratio of 1:3, meaning that one supervisor only randomly evaluates three subordinates in the team. The data were collected in two stages with the consideration of the lag of employees' innovation performance. In the first stage (Time 1), GNS, LMX, and perceived status threats were collected. The second stage (Time 2) survey was conducted to assess employees' innovation performance 2 months later. This study carried out anonymous processing to protect the privacy of participants. Each participant was given a serial number, through which the data collected in the two stages were combined into complete data. A total of 239 sets of questionnaires were distributed to nearly 90 different teams in 13 companies. In the end, we received 210 sets of valid questionnaire, for an effective rate of 87.9%.

Among 210 supervisor questionnaires, 49.05% were female. The average age was 38.8 years old and mainly distributed between 28 and 45 years old. Most had advanced degree: 56.12% had a bachelor's degree and 22.31% had a master's degree or above. The average organizational tenure was 8.18 years, and the average work time with subordinate was 4.24 years. Among 630 subordinate questionnaires, 46.51% were females. The average age was 25.16 years old and mainly distributed between 22 and 35 years old. 64.11% had a bachelor's degree and 26.62% had a master's degree or above. The average organizational tenure was 4.17 years, and the work time with the supervisor was 3.1 years.

Measures

All scales used in this research have been well established in the literature to ensure rigor and credibility and have been revised according to the actual situation in China. Back translation was performed to avoid semantic confusion affecting the quality of the questionnaire (Brislin, 1970). First, two doctoral students who majored in human resource management translated the English version of the survey into Chinese. Second, the two students exchanged the Chinese version and translated it back into English. Third, they discussed and modified the Chinese version according to the back translation. Finally, two professors

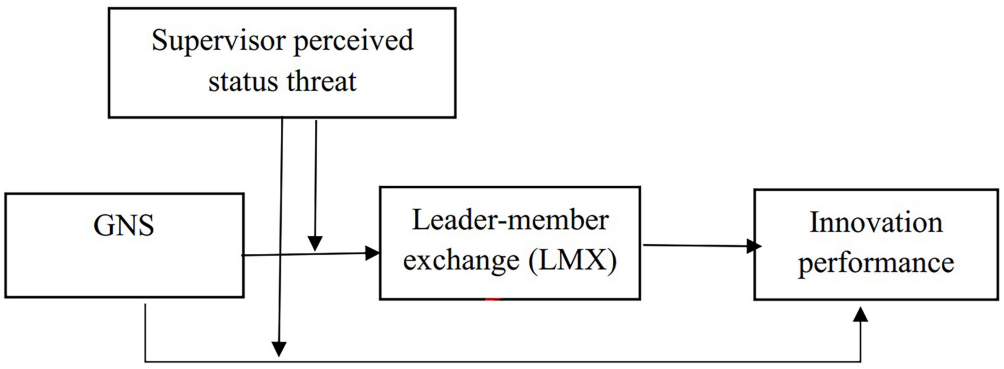

FIGURE 1 | Theoretical model of the study.

verified the surveys using their professional experience to ensure that the final Chinese version was clear to understand. All scales in this study were measured on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

GNS(Time 1) GNS was measured using seven-item scale developed by Hackman and Oldham (1980). By referring to the practice of Heckler (1996), finally, 5 items were retained after eliminating 2 items with a factor load less than 0.5. Some of the items used were, "I will exert my imagination and creativity in my work," "I will look for opportunities for personal growth and development." The Cronbach's alpha of the GNS scale was 0.838.

Innovation performance(Time 2) The scale of innovation performance was adapted from a scale with 5 items developed by Zhou and George (2001). The employee's innovation performance was measured by the direct supervisor because previous study showed that supervisor evaluation was more reliable than the subordinate evaluation (George and Zhou, 2001). Some of the items used were, "I often put forward some new methods and suggestions to improve the work results or product quality," "I often adopt new methods to solve problems in work." The Cronbach's alpha for the innovation performance scale was 0.901.

LMX(Time 1) LMX was measured using the one-dimensional scale proposed by Graen and Uhl-Bien (1995), including 7 items, Some of the items used were, "I think the relationship between me and my supervisors is harmonious," "When I encounter difficulties in work, I believe my supervisors can help me solve the problem together." The Cronbach's alpha for the LMX scale was 0.891.

Supervisor perceived Status Threat (Time 1) The supervisor perceived status threat scale was adapted from the scale used to measure the perceived status threat of team members from Okimoto and Wenzel (2011). There are 3 items in total. "Some of the subordinate's work practices weaken your status in the organization," "Some of the subordinate's work practices make you feel disrespected in the organization," and "Some of the subordinate's work practices make you feel you are being questioned in the organization." The Cronbach's alpha for this scale was 0.837.

Control Variable(Time 1) We controlled the four demographic variables of age, education level, organizational tenure and working years with supervisor. Because employees' age and education level were closely related to employees' GNS and innovation performance (Hackman and Oldham, 1980; Lin et al., 2016), the organizational tenure and working years with supervisors would affect the LMX (Zhang et al., 2012), further affecting employees' GNS and innovation performance.

Analytical Strategy

We first examine the distinctiveness of the research variables, and we conducted a confirmatory factor analysis (CFA) using Amos 23.0 to compare the fit of our hypothesized four-factor model to the fit of alternative models.

Moreover, as we proposed direct effect (i.e., Hypothesis 1), indirect effect (i.e., Hypothesis 2) and moderating effect (i.e., Hypothesis 3 and Hypothesis 4), we employed the hierarchical regressions to examine the proposed direct effect, indirect effect and interactive effects. Specially, we required the following conditions for mediation: (a) the independent variable must be related to the mediator; (b) the mediator must be related to the dependent variable; and (c) the independent variable must have no effect on the dependent variable when the mediator is held constant (full mediation), or the effect should become significantly smaller (partial mediation) (Kenny et al., 1998). To further assess the mediating hypothesis, we assessed the indirect effects with the bootstrapping technique using SPSS 24.0.

Besides, we followed Aiken et al. (1991) recommendation for plotting the interactions.

RESULTS

Confirmatory Factor Analysis

CFA was used to test the discriminant validity of the four key variables: GNS, LMX, supervisor perceived status threat, and innovation performance. All variables were analyzed directly in the items (Netemeyer et al., 1990). Against the baseline model of four factors, five alternative models were examined. **Table 1** presents the results of CFA. The proposed fit indices of four-factor model ($\chi^2 = 526.38$, df = 203, NFI = 0.93, TLI = 0.91, CFI = 0.92, GFI = 0.94, RMSEA = 0.06) is significantly better than the three-factor model, two-factor model, and one-factor model, The results indicate that the four-factor model was better than any of the alternatives, indicating good discriminant validity between each variable.

Descriptive Analysis

Table 2 presents the descriptive statistics and zero-order correlations of the variables and includes GNS, LMX, supervisor perceived status threat, and innovation performance. As expected, GNS are significantly positively correlated with innovation performance ($r = 0.45$, $p < 0.01$), LMX ($r = 0.24$, $p < 0.01$), and supervisor perceived status threat ($r = 0.19$, $p < 0.01$). LMX are significantly positively correlated with innovation performance ($r = 0.34$, $p < 0.01$). The correlation coefficients confirm our hypotheses. Additionally, education level is positively related to GNS ($r = 0.20$, $p < 0.01$), and innovation performance ($r = 0.09$, $p < 0.05$), is negatively related to LMX ($r = -0.09$, $p < 0.05$). Organizational tenure is positively related to innovation performance ($r = 0.02$, $p < 0.05$). Years of working with supervisors was negatively related to GNS ($r = -0.08$, $p < 0.05$) and was positively related to innovation performance ($r = 0.02$, $p < 0.05$).

Hypotheses Testing

The hypotheses were tested using Mplus 7.0. The coefficient results are shown in **Table 3**.

First, the direct effect of employees' GNS on innovation performance was tested. The analysis results show that GNS has a significant positive effect on innovation performance (M3, $\beta = 0.44$, $p < 0.001$), and Hypothesis 1 is supported.

Second, the mediating effect of LMX was tested. According to the regression results of M1 and M4, GNS has a significant positive effect on LMX (M1, $\beta = 0.39$, $p < 0.001$), and LMX

TABLE 1 | Results of confirmatory factor analysis (CFA).

Models	Factor structures	χ^2	χ^2/df	NFI	TLI	GFI	CFI	RMSEA
Four-factor	GNS; LMX; innovation performance; perceived status threat	526.38	203	0.93	0.91	0.94	0.92	0.06
Three-factor 01	GNS and LMX combined	965.17	206	0.83	0.79	0.68	0.78	0.14
Three-factor 02	LMX and innovation performance combined	1134.67	206	0.68	0.70	0.62	0.76	0.16
Two-factor 01	GNS and LMX combined; innovation performance and perceived status threat combined	1300.55	208	0.65	0.67	0.59	0.69	0.15
Two-factor 02	GNS and innovation performance combined; LMX and perceived status threat combined	1247.65	208	0.68	0.72	0.68	0.72	0.15
One-factor	All factors combined into one factor	1701.29	209	0.53	0.5	0.57	0.60	0.19

n = 210; TLI is the Tucker–Lewis index; GFI is the goodness-of-fit index; CFI is the comparative fit index; NFI is thenormed fit index; and RMSEA is the root mean square error of approximation.

TABLE 2 | Descriptive statistics and zero-order correlations.

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Age	29	5.51							
2. Education	2.78	0.79	−0.01						
3. Organizational tenure	5.91	0.94	0.05**	−0.01*					
4. Years of working with supervisors	2.66	1.24	0.09	0.03	0.06*				
5. GNS	3.62	1.04	0.04	0.20**	−0.03	−0.08*			
6. LMX	3.39	0.94	0.04	−0.09*	−0.05	0.07	0.24**		
7. Innovation performance	3.58	1.04	0.08	0.09*	0.02*	0.02*	0.45**	0.34**	
8. Perceived status threat	2.81	1.06	−0.03	0.06	−0.03	0.02	0.19**	−0.19**	−0.27**

*n = 210. LMX, Leader–Member Exchange; GNS, Growth Need Strength. *p < 0.05 and **p < 0.01.*

TABLE 3 | Results of the hypothesis test.

	LMX			Innovation performance		
	M1	M2	M3	M4	M5	M6
Age	−0.06	−0.05	0.05	0.08	0.07	0.07
Education	0.07	0.09	0.09*	0.10*	0.08*	0.02*
Organizational tenure	0.05	0.20	0.05	−0.06	−0.03	0.07
Years of working with supervisors	0.09	0.09*	0.02*	0.07	0.07	0.05
GNS	0.39***	0.29***	0.44***		0.36***	0.40***
LMX				0.48***	0.33***	
Perceived status threat		−0.22***				−0.22**
GNS*Perceived status threat		−0.34***				−0.25**
R^2	0.29	0.41	0.23	0.32	0.33	0.31
R^2 Change	0.24	0.12	0.18	0.27	0.10	0.08
F	44.15***	21.56***	39.15***	40.60***	49.12***	16.68***

*n = 210. LMX, Leader–Member Exchange; GNS, Growth Need Strength. *p < 0.05, **p < 0.01, and ***p < 0.001.*

has a positive effect on innovation performance (M4, $\beta = 0.48$, $p < 0.001$). The GNS and LMX are entered into the regression model, the LMX positively correlates with innovation performance (M5, $\beta = 0.33$, $p < 0.001$), but the positive effect of GNS on innovation performance is reduced (M5, $\beta = 0.36$, $p < 0.001$). The results show that the LMX plays a partial mediating role between GNS and innovation performance (Kenny et al., 1998), and Hypothesis 2 is supported. Hypothesis 2 was also tested using bootstrap resampling (5,000 times), which allows us to see the algebraic sign, the magnitude and the significance of the hypotheses put forward (Martínez-Navalón et al., 2021). If the confidence intervals of the results exclude 0, the mediation effect is supported (Preacher et al., 2010). The result shows that the mediation effect is 0.246 with a 95% confidence interval of [LLCT = 0.1713, ULCI = 0.2845], not including 0. Therefore, GNS had a positive effect on innovation performance indirectly through LMX. Besides, after controlling the mediating variable LMX, the independent variable GNS has a significant effect on the dependent variable innovation performance with a 95% confidence interval of [LLCT = 0.4137, ULCI = 0.5864]. Therefore, LMX plays a partial mediating role between employees' GNS on their innovation performance, supporting Hypothesis 2.

Finally, hierarchical regression analyses to test our hypotheses regarding the moderating effect of supervisor perceived status threat on the relationship between GNS and LMX and the relationship between GNS and innovation performance. To minimize any potential problems with multicollinearity, we centered the predictor variables before calculating the interaction terms (Aiken et al., 1991). As shown in **Table 3**, the interaction between GNS and supervisor perceived status threat on LMX is significant (M2, $\beta = -0.34$, $p < 0.001$), indicating that supervisor perceived status threat has a significant moderating effect on the relationship between GNS and LMX. Hypothesis H3 is supported. Besides, a simple slope test suggests that the relationship between GNS and LMX is significantly positive when the supervisor perceived status threat is low (see **Figure 2**). When the supervisor perceived status threat is high, the relationship between GNS and LMX is weak. As shown in **Table 3**, the interaction between GNS and supervisor perceived status threat on innovation performance was significant (M6, $\beta = -0.25$, $p < 0.01$), indicating that supervisor perceived status threat had a negative moderating effect on the relationship between GNS and innovation performance. Thus, Hypothesis 4 was supported. The interaction effect of GNS and perceived status threat on innovation performance is shown in **Figure 3**. Compared with low supervisor perceived status threat, the positive relationship between NGS and innovation performance decreases when the supervisor perceived status threat is high.

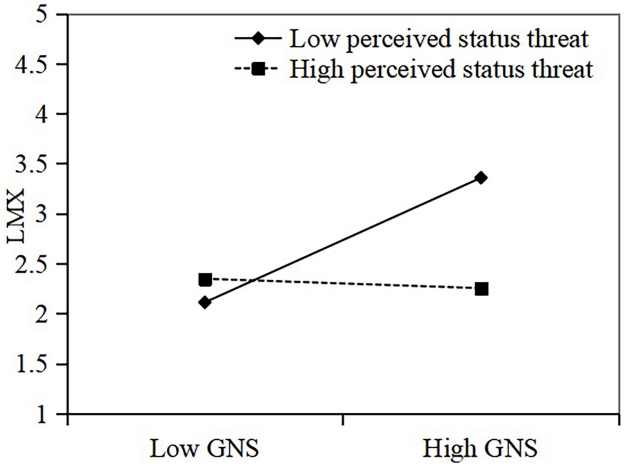

FIGURE 2 | Interaction impacts of GNS and perceived status threat on LMX.

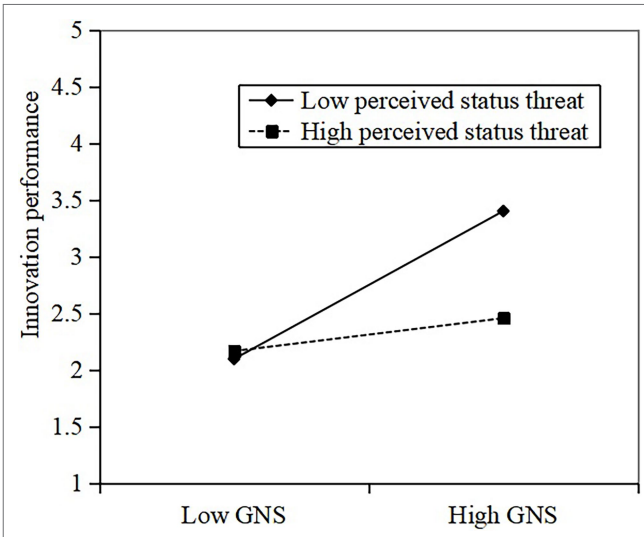

FIGURE 3 | Interaction impacts of GNS and perceived status threat on innovation performance.

DISCUSSION

This study constructed a new theoretical model from the perspective of status competition to explore the significant positive effect of employees' GNS on innovation performance *via* LMX, and the boundary conditions of supervisor perceived status threat. This study found that employees' GNS significantly affects their innovation performance. This result coincides with other previous findings that confirm that GNS can lead to positive working outcomes such as knowledge sharing behavior (Li and Ma, 2014), job performance and organizational affective commitment (Lin et al., 2016), and organizational identification (Wang and Yang, 2015), which has increased our knowledge about the outcomes of GNS by explicitly validate the positive relationship between GNS and innovation performance.

Furthermore, the results confirmed that LMX plays a mediating role between GNS and innovation performance, that is, employees' GNS affects their innovation performance by influencing LMX. This is consistent with leader–member dependency hypothesis and leader–member cooperative perspective (Huang and Iun, 2006; Liu et al., 2018; Li and Huang, 2021). Although research has explored the mediating role of personal emotions and attitudes in the relationship between GNS and employee outcomes, little research has specifically examined how GNS affects innovation performance from the leader–member cooperative perspective. For example, Lin et al. (2016) showed hope mediates the effect of growth need strength on job performance and affective commitment based on hope theory. Li and Huang (2021) stated implicitly that LMX may play a mediating role in predicting the relationship between personality trait and innovation performance. Thus, consistent with past research, we have found that GNS causes reciprocity and cooperation between supervisors and subordinates, leading to high-quality LMX and resulting in innovation performance. We thus contribute to GNS literature by providing evidence that facilitates the understanding of the relationship between GNS and positive employee outcomes through LMX.

Different from previous studies, our research has proposed and found that supervisor perceived status threat played a consistent negative moderating role on the relationship between employees' GNS and innovation performance and between employees' GNS and LMX. From the perspective of status

competition, this paper explained how leaders' psychological state and behavior choice affect the relationship between GNS and its positive results. This contributes to GNS literature by enhancing our understanding of the boundary conditions of GNS on employees positive outcomes. Existing researches have mainly focused on supportive or cooperative perspective to emphasize that the leadership style (Gu et al., 2015), LMX (Pan et al., 2012) promoted employees' innovative behavior or innovation performance. There is no denying that these studies do make a significant contribution in exploring how leadership characteristics or behavior affect innovation performance. However, the existing studies cannot explain some special phenomena in reality, for example, why do the supervisors weakly support their subordinates with high GNS who can obviously help them achieve goals? What is the deep mechanism of action? In the present study, we argued that status competition between supervisors and subordinates can answer these questions, our research has proposed and found that that supervisor perceived status threat buffers the positive effect of GNS on LMX and innovation performance. On the one hand, according to status characteristics theory and SDT, supervisors who perceived status threat may destroy the LMX relationship with employees with high GNS through counterproductive political operations. On the other hand, in order to maintain the existing status or to reduce the status threat, those supervisors who perceived status threat from the employees with high GNS will take undermining behavior such as hiding the information that needed by employees with high GNS or reduce the support or help to them, finally reduce their innovation performance (Duffy et al., 2002; Chen et al., 2017; Liu et al., 2021). Thus, our research enhances the current knowledge about how leaders' psychological state and behavior responses affect the relationship between GNS and innovation performance.

CONCLUSION

The findings of our study reveal that employees' GNS is positively related to their innovation performance. In addition, LMX plays a significant mediation role in transmitting the effect of GNS to innovation performance. Finally, we found that supervisor perceived status threat moderated the relationship between GNS and LMX, such that this relationship got weaker for supervisors with higher perceived status threat. Furthermore, supervisor perceived status threat moderated the relationship between GNS and innovation performance, as such, it became weaker for supervisors with higher perceived status threat. By examining the joint effect of GNS and supervisor perceived status threat on GNS and innovation performance, we have enhanced the understanding of how leaders' psychological state and behavior choice affect the relationship between GNS and its positive results. Therefore, we recommend that organizations and supervisors identify employees' growth need strength and help them develop LMX by adopting appropriate leadership styles and reducing supervisor perceived status threat. As a result, employees will generate more innovation performance to the organization and become better performers.

Theoretical Contributions

First, our study explored the significant positive effect of employees' GNS on their innovation performance from the perspective of employees' needs level and expanded the research on the antecedent variables of innovation performance.

Second, our paper identified LMX as an interpersonal relationship mechanism effectively mediating the relationship between GNS and innovation performance. The employees' GNS can significantly promote their exchange relationship with leaders, while LMX promotes employees' innovation performance. Although scholar stated that LMX may play a mediating role in the relationship between personality trait and innovation performance from leader–member cooperative perspective (e.g., Li and Huang, 2021), there is still a lack of relevant empirical support for this view. Our study provides early empirical evidence to echo calls for examining the mediating role of LMX. Thus, our study clarifies the influence mechanism of GNS on innovation performance.

Finally, we incorporate SCT and SDT, into organizational management research and propose supervisor perceived status threat play a consistent negative moderating role on the relationship between employees' GNS and innovation performance and between employees' GNS and LMX. Our study, from the perspective of status competition, clarifies that supervisor perceived status threat was an important boundary condition between GNS and innovation performance, answers the question that why supervisors sometimes expresses very weak support toward subordinates with high GNS. Our study goes one step further and takes a new theoretical research perspective of the roles of growth need strength in employees' positive outcomes.

Managerial Implications

This study helps to understand GNS from the perspective of status competition deeply and puts forward a new perspective on how management practices can improve employees' innovation performance.

First, our study emphasizes that employees with high initiative (e.g., growth need strength) are the key resources for personal innovation and organizational success. Therefore, the cornerstones of human resource activities are to getting, keeping, and growing such employees for organizations. Further, we suggest that human resource management practices should prioritize finding each employee's GNS and focus on enhancing and developing employees' capabilities, wellness, and prosperity. To assess an employee's level of growth need strength, organizations could use a survey questionnaire developed by organizational studies (e.g., Hackman and Oldham, 1980) or a clinical classification developed by positive psychology research. More importantly, we suggest that human resource managers and supervisors should communicate with individual employees and observe their behavior and attitude to identify the employees with high internal expectations and desires for accomplishment, learning, and personal development within their jobs, and then, to provide them with support and resources to improve their innovation performance.

Second, our finding suggests that employees fulfill their growth need and achieve innovation performance *via* LMX. Organizations should help employees develop high-LMX by adopting appropriate leadership styles and considering each employee's personality characteristics. On the one hand, we suggest employees should actively seek feedback and guidance from leaders. When the organization encounters difficulties or challenges, employees should show initiative in solving problems independently and unconventionally, or communicate with the leader and make suggestions when necessary. On the other hand, supervisor should pay more attention to the requirements and expectations of their employees, and also be sensitive to employees' emotional states and innovative needs, if they find that an employee with high GNS is suffering from innovation risk and uncertainty, an additional management action, such as timely communication and work lightening, may help to reinforce subordinates' sense of belonging, self-affirmation and psychological security, thus strengthening their courage to face innovation risks. Thus, a LMX with high-quality will be establish to improve employees' innovation performance.

Third, our finding regarding a negative moderating effect of supervisor perceived status threat shows that the status competition have significant influences on the impact of GNS. The findings of this study sounded an alarm for managers. Although employees' GNS can bring high innovation performance, those employees who have high GNS but lack accurate judgment over the supervisor perceived status threat will not be loved and supported by their leaders. Therefore, the organization should design a scientific and reasonable incentive mechanism to reduce the psychological defense and negative behavior of leaders. Besides, the organization should attach importance to the selection and training of grassroots leaders and implement the recruitment standards of "integrity and ability" for leading cadres.

Limitations and Future Research Directions

Despite its contributions, this study does have its share of limitations. First, the supervisor completes the evaluation of employees' innovation performance with some intentional or unintentional subjective deviations. In the future, objective indicators such as the number of patents, innovation awards, and the number of innovative proposals adopted can be considered for measurement. Second, from the perspective of status competition, this study verifies that the supervisor perceived status threat is an important boundary condition for the effect of GNS on innovation performance. The uncertainty of leadership power and status is probably another important boundary condition. When leaders have high "reference power" and high achievement or status, no matter how much status threat employee with high GNS brings to them, leaders will be open to employees with high GNS because leaders feel that their strong status and authority will not be threatened. Third, although our research examined the relationship between GNS, LMX, supervisor perceived status threat, and innovation performance in a non-Western culture (i.e., China), we did not provide much information about whether this relationship would be different across varying cultures. For example, since employees with high power distance obey supervisors' expectation unconditionally, it may be possible that this relationship will be weaker in low power distance culture. Thus, it is worthwhile for future researchers to conduct cross-culture comparison study to examine whether there is a culture difference.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The dataset involves personal privacy. Requests to access these datasets should be directed to 25690401@qq.com.

AUTHOR CONTRIBUTIONS

YT and ZD designed and adopted the study, and wrote the paper. XH and RT wrote the paper. All authors contributed to the article and approved the submitted version.

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Relative team-member exchange, affective organizational commitment and innovative behavior: The moderating role of team-member exchange differentiation

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Based upon social comparison theory, a multilevel moderated-mediation theoretical model was built up to explore the influence mechanism of relative team-member exchange (RTMX) on innovative behavior. We tested the proposed hypotheses using a sample of 260 individual members within 51 teams in a two-wave survey study. Controlling for team-member exchange (TMX), results showed that RTMX was positively related to innovative behavior, and the relationship above was mediated by affective organizational commitment. Moreover, team-level TMX differentiation played a moderating role in the mediated relationship between RTMX and innovative behavior through affective organizational commitment. This study also emphasizes the significance of conceptualizing TMX as concurrently implementing at multiple levels.

KEYWORDS

relative team-member exchange, team-member exchange differentiation, affective organizational commitment, innovative behavior, social comparison theory

Introduction

Innovative behavior (i.e., "A multi-stage process of problem recognition, generation of ideas or solutions, building support for ideas, and idea implementation"; see Pieterse et al., 2010, p. 610) has been theorized to be highly critical for the development of both individuals and teams (Ali et al., 2019; Imam et al., 2020). Especially in today's fiercely competitive surroundings it is more significant to achieve advantage by engaging in innovative behavior. More scholars also call for more attention to innovative behavior due to its importance. Thus, it is important and necessary to explore the antecedents of innovative behavior. Social exchange relationships embedding in the whole innovative process have been robustly

examined to make a significant influence on employees' behaviors including innovative behavior (Saeed et al., 2018). However, compared to several vertical social exchange relationships (e.g., LMX; perceived organizational support), very few prior studies have attempted to cast light on horizontal social exchange relationships (Farmer et al., 2015). Because individual members have to cooperate with each other to fulfill the challenging and various team tasks (Bakar and Omilion-Hodges, 2018), the horizontal social exchange relationships, such as team member exchange (TMX) in particular, may exert a more direct influence on innovative behavior. More importantly, even though the positive effects of individual-level TMX have been argued in most research (Shih and Wijaya, 2017; Lee, 2020), largely ignoring the fact that TMX is actually embedded within the broader social context of teams (Kim et al., 2021). This omission is not conducive to fully understand the effectiveness of TMX in the majority of enterprises using teams to accomplish complex jobs. Indeed, this deficiency prompted more scholars (Liao et al., 2010; Liu et al., 2011; Farmer et al., 2015) to call for much more studies on TMX within the context of teams.

To answer the appeal above about considering TMX within the team context, We focused on an extension of the TMX concept, relative team-member exchange (RTMX), as a key instantiation of horizontal social exchange relationship, which represents the actual level of one's own TMX relationships compared to the average TMX within teams (Farmer et al., 2015). Individuals working in a team not only have a sense of belonging to the team but also see themselves as positively unique within the team (Dierdorff et al., 2018). The differentiated nature of social exchanges including TMX has attracted much more attention (Vidyarthi et al., 2010; Tse et al., 2012; Farmer et al., 2015). However, the knowledge of the effectiveness of RTMX is still far from sufficient. To be more specific, we can conclude from the related research that RTMX may have an impact on individuals' affection. For example, Wu et al. (2018) suggested that what is being exchanged by TMX is mostly socioemotional support, whereas little is learned about the underlying affective mechanisms of RTMX's influence on innovative behavior. Therefore, this research firstly tried to uncover the mechanisms by employing affective organizational commitment to explain the effects of RTMX on innovative behavior. Our argument is guided by social comparison theory (Festinger, 1954), which suggests that individuals are inclined to use social comparison information to form a self-assessment of their own abilities and guide their work attitudes and behaviors (Wood, 1989). In consequence, we propose that RTMX standing serves to shape individuals' affective organizational commitment, which, in turn, has a positive impact on innovative behavior.

Another part of our incomplete understanding of RTMX involves how the contexts in which TMX relationships are embedded affect the outputs related to RLMX. Some scholars (e.g., Liu et al., 2011; Kim et al., 2021) have pointed out that TMX may operate at the team level of theory, as TMX differentiation (i.e., "the degree to which the quality of a team member's exchange relationships with other team members varies"; see Liao et al., 2010, p. 1091), a critical contextual variable surrounding the social comparison process of TMX (Chen and Liu, 2020), creates a team-level context that is important and meaningful to the experience of all team members. Specifically, in each executive team, TMX relationships within teams may be more or less different due to the difference in personality, strengths and majors of members. In teams with low-level TMX differentiation, individuals who are relatively closer to their colleagues may not enjoy the same relative advantages that they might if they were in a team with a higher-level TMX differentiation (Liao et al., 2010). Thus, from a social comparison perspective, we further put forward that the effectiveness of RTMX noted above may be contingent on TMX differentiation at the team level.

Figure 1 depicts our proposed theoretical model. Specifically, in line with recent efforts to expand the taxonomy of TMX research (e.g., TMX differentiation, Liu et al., 2011), we aim to push forward the new field of RTMX in TMX literature in four ways. First of all, we fill the void by employing social comparison theory as an overarching theory for building up a multilevel theoretical framework to examine the impact of RTMX on individual innovative behavior within the context of teams. Second, this study responds to a call by Farmer et al. (2015) to find out underlying mediating processes in associating RTMX with individual outputs. We verify affective organizational commitment as a key psychological mechanism that plays a mediating role in the link between RTMX and innovative behavior. Third, by building up a cross-level moderated mediation model, this study tries to explain the moderating role of TMX differentiation, attempting to probe into why and when RTMX is able to have an impact on affective organizational commitment and, in turn, innovative behavior. The attempt above deepens the understanding of the potential boundary conditions related to the association between RTMX and innovative behavior. Last, the findings of this research provide some useful suggestions for both teams and individuals to deal with the differentiation of TMX relationships within teams.

Theory and hypotheses

RTMX and innovative behavior

Relative team-member exchange focuses on differences within teams. Specifically, high and low RTMX offers individuals a reference point to identify their own status relative to other colleagues' TMX standings. Relative team-member exchange not only can help individuals understand how they define themselves within the teams (Vignoles et al., 2000) but also can bring them some other more valuable resources (e.g., respect, confidence, and trust) through comparisons. We thus believe comparison processes could offer a theoretical framework for explaining the effect of RTMX on individual innovative behavior.

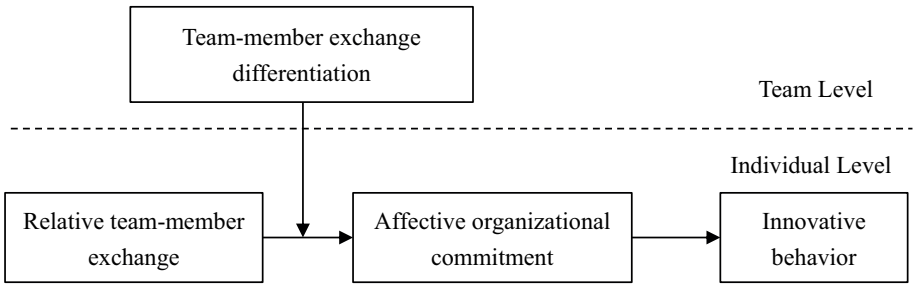

FIGURE 1
Theoretical model.

In line with the reasoning above, we contend further that when a member has a high-level RTMX, s/he can be thought to have a positive self-concept (Vignoles et al., 2000; Farmer et al., 2015) and engage in innovative behaviors proactively. Specifically, first, drawing on social comparison theory, members with high RTMX relationships stand at the upper level within the team in terms of their TMX relationships and tend to believe that they can gain much more respect and attention from other members in their teams through downward comparisons (Liao et al., 2010). Thus, these high RTMX members are inclined to perform innovative behaviors so as to maintain a domain position in the team. Second, RTMX provides evaluating information for individuals to understand their outstanding competence (Forsyth, 2000; Farmer et al., 2015). Each member wants to cooperate with capable colleagues to accomplish tasks. High RTMX means that the target individual has a much higher ranking than others within the teams in terms of their TMX score and helps to confirm the abilities of individual members. Therefore, high RTMX members who hold high self-efficacy believe that they have the competence to engage in innovative behavior. Third, when individual members have high-level RTMX, they can gain much more trust from their coworkers (Lau et al., 2021), and then they are likely to enjoy the advantages of collecting much more different and useful information from their colleagues within their teams, thereby behaving innovatively through integrating their own and others' knowledge and information when they deal with daily tasks (Du et al., 2021).

However, low RTMX individuals may not be as inclined to behave innovatively. Specifically, on the one hand, individual members with low RTMX standings realize that they are at the edge of the group in terms of their TMX rankings through upward comparisons. As they compare their social exchanges with colleagues (i.e., TMX) with other members who hold relatively high TMX, low RTMX members come to realize that they do not get much say within teams and may feel much more uncertain and unworthy when challenging status and thus experience a negative self-concept and decrease the motivation to engage in innovative behaviors. On the other hand, those members with low RTMX become more aware of being detached from their colleagues and getting little assistance and support from others within their teams by making upward comparisons (Farmer et al., 2015). Therefore, they may take action to accomplish the regular work discreetly instead of performing innovative behaviors venturesomely.

Building on the preceding discussion, we believe RTMX could be positively related to individuals' innovative behavior within their team beyond TMX. Accordingly, we present the following hypothesis:

> *Hypothesis 1*: RTMX is positively related to innovative behavior, controlling for individual-level TMX.

The mediating role of affective organizational commitment

Comparison processes provide a framework for learning how RTMX may have an impact on individuals' attitudes, including affective organizational commitment. Specifically, on one hand, high RTMX signals the focal member to have closer exchange relationships with other members and facilitates a sense of uniqueness (Farmer et al., 2015). As such, those individuals may realize that others treat them with respect and dignity due to their high-status position within teams, which may contribute to a strong sense of affective organizational commitment. On the other hand, some research has confirmed that individuals may experience more positive feelings when making downward comparisons (Fleischmann et al., 2021), so we tend to contend that individuals who hold high-level RTMX can understand their higher capability and feel more confidence in solving difficulties over others (Stamper and Masterson, 2002), and then generate high-level organizational affective commitment. On the contrary, individuals with relatively lower-level exchange relationships with their colleagues (i.e., low RTMX) are more likely to review themselves as out-group members and then may be affected by negative reciprocity beliefs, so they tend to have weak affective organizational commitment. It is also consistent with those studies showing that perceived outsider status may negatively influence organization commitment (Farmer et al., 2015).

Drawing on social comparison theory, we further emphasize the mediating variable (i.e., affective organizational commitment)

that can play in accounting for the effect of RTMX on innovative behavior. Specifically, RTMX serves as salient social comparison information that urges all the members to participate in comparatively estimating their own abilities. This, in turn, helps to form their high-level affective organizational commitment. These affective organizational commitment perceptions that make members much more goal-oriented and proactive directly influence their efforts to engage in innovative behaviors (Yang et al., 2020). Besides, because when individuals have high RTMX, they can gain more trust and respect from their colleagues. This helps to form high affective organizational commitment. These affective organizational commitment perceptions then directly influence innovative behavior. We therefore propose the following hypotheses:

> *Hypothesis 2*: RTMX is positively related to affective organizational commitment, controlling for individual-level TMX.

> *Hypothesis 3*: Affective organizational commitment mediates the relationship between RTMX and innovative behavior, controlling for individual-level TMX.

The moderating role of TMX differentiation

As discussed earlier, in a team, a member can form different exchange relationships with peers. Teams with high-level TMX differentiation consist of members who keep social exchange relationships with coworkers that vary widely (Chen and Liu, 2020). Liao et al. (2010) argue further that the degree of TMX differentiation may offer valuable and accurate information to an employee engaging in comparative social evaluation, the reason is that TMX differentiation can be explained as "an indicator of a member's status in a team." In consequence, the experience of comparing with colleagues can further influence how an individual reacts to RTMX. In this study, we postulate that TMX differentiation will augment the inflation influence of RTMX in affective organizational commitment from a social comparison perspective.

Specifically, on one hand, high TMX differentiation means team members keep exchange relationship with their coworkers very various (Liao et al., 2010), which signals to members about rich and obvious comparative information. With such high TMX differentiation, as the quality of a member's social exchanges with colleagues increasing, the member may become increasingly aware that he or she maintains much closer work relationships than do teammates through making downward comparisons (Liao et al., 2010). As a result, the member who enjoys a relatively high TMX relationship within teams tends to realize that he/she is at the center of the team and may be more likely to view him−/herself as more respected and more valued. Then he/she may have a high-level affective organizational commitment and prefer to stay within the organization. On the other hand, TMX differentiation sharpens contrasting perceptions (Ford and Seers, 2006). When TMX differentiation levels are high, some members who keep close exchange relationships with most other colleagues may consider others as "free riders," while those others may think the former as political operators (Ford and Seers, 2006). In this context, those members who keep high RTMX relationships can clearly realize that they are much more capable and better off than other teammates, it is because they believe that they have taken on more tasks than others. Thus, they hold high affective organizational commitment. On the contrary, as TMX differentiation is at a low level, members may perceive themselves as having a comparable quality of TMX relationships with their teammates (Liao et al., 2010; Liu et al., 2011). In this case, when individual members keep high-level RTMX, they may still regard this relationship to be universal rather than particularly unique or advantageous to themselves and may not think of themselves as in-group members with a higher social position as compared to their colleagues in the team. Thus, the positive effects of RTMX on affective organizational commitment may dwindle. In sum, we postulate that TMX differentiation amplifies the impact of RTMX on affective organizational commitment. Thus, we propose the following hypothesis:

> *Hypothesis 4*: TMX differentiation moderates the relationship between RTMX and affective organizational commitment such that RTMX will have a stronger positive effect on affective organizational commitment when TMX differentiation is high rather than TMX differentiation is low.

Integrated model

To integrate these relationships above, in line with social comparison theory, we propose a multilevel moderated-mediation theoretical model in which TMX differentiation plays a moderating role in the indirect relationship between RTMX and innovative behavior *via* affective organizational commitment. Specifically, when TMX differentiation is high, that is, the quality of exchange relationships between members and colleagues varies greatly (Liao et al., 2010). In this time, individuals with high RTMX who hold a high-status position within teams are inclined to be respected and trusted by more coworkers and feel confident about being better than others by making downward comparisons, so generating high-level affective organizational commitment and, subsequently, innovative behavior. In contrast, when TMX differentiation is low, individuals who have high RTMX cannot feel distinct advantage over others. In this time, RTMX will have a weaker influence on affective organizational commitment and indirectly on innovative behavior. Therefore, we put forward the following hypothesis:

> *Hypothesis 5*: TMX differentiation moderates the indirect effect of RTMX on innovative behavior via affective organizational commitment, such that the effects are stronger when TMX differentiation is high rather than TMX differentiation is low.

Materials and methods

Sample and procedure

To test the proposed hypotheses, we used a survey-based design to collect data in different organizations located in China. These employees worked in teams and were from different departments, including engineer designing, educational product designing, and software designing. To minimize the potential common method biases, data were collected in a time-lagged design at two-time points. At Time 1 (T1), team members must first report their team-member exchange relationship and affective organizational commitment. At Time 2 (T2), they rated their innovative behavior.

Although the research team made a few attempts to increase the response rate (e.g., sending e-mail reminders and controlling the length of the questionnaires), a few teams and employees did not return their questionnaires. In order to avoid potential random and systematic biases (Allen et al., 2007), teams with within-team response rates higher than 80% were chose for the final sample. The final sample was composed of 51 teams, including 260 team members. 89% response rate for teams and 84% response rate for team members. Among these participants, 54% of the members were female. The average age (in years) was 29.72 for team members. 93% of team members had a bachelor's degree or higher. The average team tenure (in months) was 35.90, and the average team size was 5.10.

Measures

According to a back- translation process, our survey questionnaires are translated from English to Chinese. Unless otherwise noted, the measures that the study mentioned were rated employing a 7-point Likert-type scale (1 = *strongly disagree*; 7 = *strongly agree*).

Team-member exchange

The 10-item scale that Seers et al. (1995) developed was adopted to measure TMX. A sample item is "I often make suggestions about better work methods to other team members." Cronbach's α for this value was 0.89.

Relative team-member exchange

Following Farmer et al. (2015), we subtracted the average TMX score of individuals in a team from each team member's TMX score to evaluate RTMX.

TMX differentiation

In line with Liao et al. (2010), we employed the within-team variance in individual-level TMX scores to operationalize TMX differentiation for each team. Much higher within-team variance represents higher-level TMX differentiation (Chen and Liu, 2020).

Affective organizational commitment

Consistent with Pundt and Venz (2017), this variable (i.e., affective organizational commitment) was measured using a five-item scale. A sample item is "I would be happy to spend the rest of my career with this organization." Cronbach's α was 0.89.

Innovative behavior

Following Janssen (2000), we captured innovative behavior by using a nine-item measure. A sample item is "transforming innovative ideas into useful applications." It is worth mentioning that the reasons why we asked individual members instead of team leaders to assess innovative behaviors in this study are as follows. First, employees know more about their own work backgrounds indeed (*cf.* Jones and Nisbett, 1971), so their assessment of the innovative behaviors may be more subtle than those of their leaders. Second, the reporting of innovative behavior is one of the discretionary work behaviors, and very similar to other forms of subjective performance appraisal, raters may vary widely in their assessment of innovative behavior due to their different characteristics (Organ and Konovsky, 1989). Third, leaders are likely to miss genuine employee innovative activities since individual members could only perceive those behaviors intended to impress the leaders (Organ and Konovsky, 1989). Cronbach's α was 0.96.

Control variables

In an effort to be consistent with past TMX and innovative behavior research, and to control for the potential influence of individual and group characteristics on the findings of this study, we included several variables as controls. Specifically, at the team level, team tenure was also included as a control variable because it may potentially explain innovative behaviors (Vidyarthi et al., 2010). Accordingly, we also controlled for team size to rule out potential confounds. At the individual level, we controlled for each member's gender (0 = female, 1 = male) and age (in years) as these variables have been verified to make an impact on the outcome variables in past studies (Wang et al., 2017). Besides, we controlled individuals' organizational tenure as a control variable. Finally, we included individual-level perceptions of TMX as a control because of its potential influence on both affective organizational commitment and innovative behavior.

Results

Descriptive statistics

Before examining the proposed hypotheses, a confirmatory factor analysis of our key individual variables, including TMX, affective organizational commitment, and innovative behavior, was conducted to examine the reliability, convergent validity, and discriminant validity. Both Cronbach's α and composite reliability could be used to assess reliability. All of the Cronbach's α and composite reliability values were greater than the threshold of 0.70, suggesting the reliability of all constructs. To examine the

TABLE 1 Results of confirmatory factor analysis.

Model	χ^2	χ^2/df	$\Delta\chi^2$	CFI	TLI	RMSEA	SRMR
3-factor	370.74	1.63	–	0.97	0.96	0.05	0.06
2-factor (TMX + AOC; IB)	740.84	3.10	370.10**	0.89	0.88	0.09	0.07
2-factor(AOC + IB; TMX)	1049.17	4.38	678.43**	0.83	0.80	0.11	0.13
2-factor(TMX + IB; AOC)	1169.28	4.75	798.54**	0.81	0.78	0.12	0.14
1-factor(TMX + AOC + IB)	1817.83	7.24	1447.09**	0.67	0.64	0.16	0.15

$N = 260$ for individuals; $N = 51$ for teams. $\Delta\chi^2$ tests relative to three factors; TMX, team-member exchange; AOC, affective organizational commitment; IB, innovative behavior; CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual.
$^{**}p < 0.01$.

TABLE 2 Variable correlations, means, and standard deviations.

Variables	*M*	SD	1	2	3	4	5	6	7
Individual-level variables									
1. Gender	0.46	0.50							
2. Age	29.72	4.94	0.03						
3. Organizational tenure	3.96	3.15	−0.02	0.55**					
4. TMX	5.41	0.73	−0.10	0.02	−0.07	**0.71**			
5. RTMX	0.00	0.63	−0.10	0.07	−0.04	0.86**			
6. AOC	4.94	1.02	−0.12	0.02	−0.09	0.65**	0.64**	**0.84**	
7. Innovative behavior	4.81	0.99	0.03	0.01	−0.09	0.52**	0.54**	0.58**	**0.86**
Team-level variables									
1. Team size	5.10	1.79							
2. Team tenure	35.90	34.73	0.35*						
3. TMX differentiation	0.62	0.31	0.14	−0.02					

$N = 260$ for individuals; $N = 51$ for teams. *M*, mean; SD, standard deviation; TMX, team-member exchange; RTMX, relative team-member exchange; AOC, affective organizational commitment. The square root values of the average variances extracted are in the main diagonal.
$^{*}p < 0.05$; $^{**}p < 0.01$.

discriminant and convergent validity (Hair et al., 2017), this research conduct a series of confirmatory factor analyses (CFAs). The χ^2, Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR) were employed to test the fit of all models. As shown in Table 1, the three-factor model fits the data better than other models, indicating that our respondents could distinguish the focal constructs clearly. Moreover, the square roots of all of the average variances extracted were larger than the correlations with corresponding other constructs, also indicating an adequate discriminant validity. Besides, all of the average variances extracted were greater than the suggested 0.50, confirming a satisfactory convergent validity.

Table 2 showed the means, standard deviations, and correlations among all of the variables. Variables at the individual level are shown in the upper portion of Table 2, and variables at the team level are shown in the lower portion.

Hypotheses testing

Hierarchical linear modeling (HLM) was adopted to test the proposed hypotheses, considering the nested structure of our data and the multilevel nature of these hypotheses.

We first examined null models employing the software HLM 7.0 without any specified predictors to test the significance of between-group variance in the outcomes by examining the significance level of the level-2 residual variance of the intercept (τ_{00}) and ICC1. The significant results of between-team variance in affective organizational commitment ($\tau_{00} = 0.12$, $\chi^2(50) = 84.16$, $p < 0.01$, ICC1 = 0.12), and innovative behavior ($\tau_{00} = 0.13$, $\chi^2(50) = 91.88$, $p < 0.001$, ICC1 = 0.14), confirming HLM as the appropriate analytic technique.

We then conducted hierarchical regression analyses with HLM 7.0 by entering control variables and the study variables into different equation steps. Table 3 shows the regression results.

Hypothesis 1 predicted that RTMX is positively related to innovative behavior, controlling for individual-level TMX. As shown in Model 2 of Table 3, the result indicated that RTMX affected innovative behavior significantly ($\beta = 0.49$, $p < 0.05$). Therefore, Hypothesis 1 was supported.

Hypothesis 2 proposed that RTMX influences affective organizational commitment positively, controlling for individual-level TMX. The results in Table 3 demonstrated the positive relationship between RTMX and affective organizational commitment ($\beta = 0.51$, $p < 0.05$). Thus, Hypothesis 2 was supported.

Hypothesis 3 posited that affective organizational commitment plays a mediating role in the relationship between

TABLE 3 Results of hierarchical linear modeling analysis for the hypothesized relationships.

	Innovative behavior						Affective organizational commitment			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Gender	0.11	0.11	0.12	0.11	0.12	0.12	−0.04	−0.03	−0.03	−0.02
Age	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.01	0.01	0.01	0.00
Organizational tenure	−0.02	−0.02	−0.02	−0.02	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01
Team tenure	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.00	0.00*	0.00	0.00
Team size	0.02	0.02	0.02	0.02	0.02	0.03	−0.02	−0.02	−0.01	−0.01
TMX	0.79**	0.35	0.35	0.29	0.29	0.29	0.98**	0.52**	0.40	0.40
RTMX		0.49*	0.24	0.55*	0.43	0.26		0.51*	0.62*	0.41
TMXD				−0.28	−0.28	−0.28			−0.53**	−0.53**
RTMX * TMXD					0.40*	0.25				0.72**
AOC			0.24*			0.21*				
Deviance	610.35	605.46	595.99	604.25	600.17	593.24	555.72	549.77	545.00	528.12
ΔDeviance		4.89*	9.47*	1.21	4.08*	6.93*		5.95*	4.77	16.88**

$N = 260$ for individuals; $N = 51$ for teams. M, model; RTMX, relative team-member exchange; TMXD, team-member exchange differentiation; AOC, affective organizational commitment. The table shows unstandardized coefficients.
*$p < 0.05$; **$p < 0.01$.

RTMX and innovative behavior, controlling for individual-level TMX. As shown in Model 3 of Table 3, when the mediator (i.e., affective organizational commitment) was entered into the regression model, the positive and significant effect of RTMX on innovative behavior decreased to an insignificant level ($\beta = 0.24$, $p > 0.05$). Further, we used a parametric bootstrap procedure that employed 20,000 Monte Carlo replications to estimate a confidence interval (CI) around the indirect effect. Results showed that 95% CI was [0.01, 0.26], with zero outside the 95% bias-corrected CI. Therefore, Hypothesis 3 was supported.

Hypothesis 4 proposed TMX differentiation moderates the relationship between RTMX and affective organizational commitment such that RTMX will have a stronger positive effect on affective organizational commitment when TMX differentiation is high rather than TMX differentiation is low. Results in Model 10 showed that the interaction term of RTMX and TMX differentiation influenced affective organizational commitment positively ($\beta = 0.72$, $p < 0.01$). Following Aiken and West's (1991) procedures, we further plotted the interaction at higher and lower levels of TMX differentiation (1SD above and below the mean). As shown in Figure 2, RTMX was more positively related to affective organizational commitment when TMX differentiation was higher rather than when TMX differentiation was lower. Thus, Hypothesis 4 was supported. Moreover, as can be seen from Figure 2, because TMX differentiation may disrupt interpersonal harmony by creating a relational imbalance among team members, which leads to emotional hostility among them (Chen and Liu, 2020), the average level of affective organizational commitment for the group with low TMX differentiation is higher than that of the group with high TMX differentiation. This means that it is necessary to beware of the potential negative effect of TMX differentiation in workgroups.

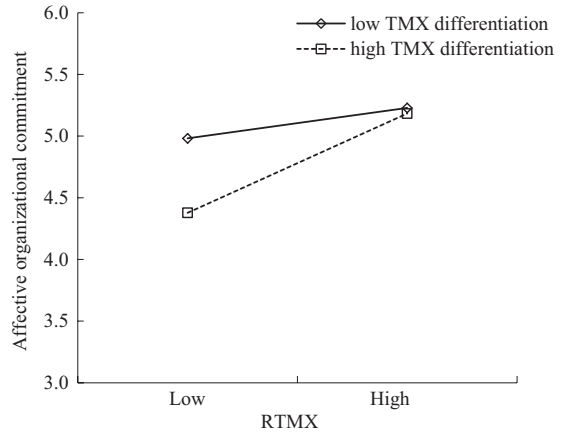

FIGURE 2
Simple slope of the moderating effect of TMX differentiation on the relationship between relative team-member exchange (RTMX) and affective organizational commitment.

Hypothesis 5 proposed TMX differentiation moderates the indirect effect of RTMX on innovative behavior *via* affective organizational commitment, such that the effects are stronger when TMX differentiation is high rather than TMX differentiation is low. As shown in Model 6, when the mediator (i.e., affective organizational commitment) was entered into the regression model, the positive and significant influence of the interaction of RTMX and TMX differentiation on innovative behavior decreased to an insignificant level ($\beta = 0.25$, $p > 0.05$). Further, a Monte Carlo simulation method was applied to obtain 95 percent confidence intervals (CI). Our analysis showed that 95% CI was [0.03, 0.28], with zero outside the 95% bias-corrected CI. Thus, the result proved the moderated mediation models of Hypothesis 5.

Discussion

In this study, by building up a cross-level moderated mediation model, we tested TMX processes at both the individual and team levels of theory and analysis. Our results examine and support all the hypothesized relationships in the theoretical model. First, we found that RTMX (i.e., TMX relative to a within-group average) has a positive effect on innovative behavior after controlling for individual-level TMX. Moreover, the results showed that affective organizational commitment mediates RTMX and innovative behavior, controlling for individual-level TMX. Finally, we found that TMX differentiation plays a moderating role in the strength of the mediated relationship between RTMX and innovative behavior through affective organizational commitment. These conclusions above offer some significant theoretical contributions to TMX, innovative behavior, and social comparison theory literature and also provide several valuable practical implications for managers and individual members.

Theoretical implications

The theoretical contributions of this research are threefold. First and foremost, most scholars (e.g., Schermuly and Meyer, 2016; Farh et al., 2017; Lee, 2020) have focused on the effectiveness of TMX at the individual level until now. Considering individual embeds within the broader social context of teams, this research found out the positive linkage between RTMX and innovative behavior. This finding is very consistent with social comparison theory (Festinger, 1954), emphasizing that individuals have self-evaluations and then affect their behaviors by comparing themselves with others. To be specific, RTMX represents the actual level of one's TMX standing in groups, which offers employees a reference point and context to gain their comparative social evaluations, in turning, leading to individual behavior reactions (i.e., innovative behavior; Greenberg et al., 2007). This finding responds to a call for theoretically and empirically exploring the influence of RTMX (Farmer et al., 2015). Besides, this research deepens the understanding of the impact of RTMX on innovative behavior and further enriches the literature on the construct of RTMX.

Second, even though some scholars have called for more studies to explore mediating processes that might uncover the relationship between RTMX and its outputs, empirical research investigating the indirect influence is still relatively limited. Our paper theoretically and empirically suggested that affective organizational commitment mediates the positive link between RTMX and innovative behavior based upon social comparison theory. In such a case, our findings extend the research of RTMX-innovative behavior linkage by raising a reasonable mediator to understand how RTMX influences innovative behavior.

Third, although individual members inevitably develop different social exchange relationships with their colleagues within the same team (Liao et al., 2010), a very critical limitation so far is the failure to fully realize the moderating role of this horizontal social exchange (i.e., TMX differentiation). Taking a social comparison perspective, we found that TMX differentiation, as a critical boundary condition, moderates the strength of link between RTMX and affective organizational commitment. Furthermore, this research deepens our understanding of the impact of RTMX on innovative behavior using a multilevel moderated-mediation theoretical model. The result showed that TMX differentiation played a moderating role in the strength of the mediated the link between RTMX and innovative behavior through affective organizational commitment. These findings above indicate that TMX relationships do occur at multiple theoretical levels and further emphasize the importance and necessity of taking how the social context created through TMX differentiation affects both individuals' affection and behaviors into consideration.

Practical implications

Our study provides the following vital implications to managerial practice. First, our findings suggest that employees with high-level RTMX are more likely to participate in innovative behavior. Thus, to further encourage all members to perform innovative behaviors, it is necessary for managers to help those members with high RTMX realize that they are in a higher insider position and make others also learn about the possibility to develop high RTMX by offering them some opportunities (e.g., training, studying abroad, meetings) to improve their abilities at the same time.

Second, the result shows that RTMX alone is positive for affective organizational commitment, and affective organizational commitment can mediate the direct influence of RTMX on innovative behavior. It is therefore essential for managers to keep all members willing to stay within organizations. For example, one effective way for team leaders is to set clear expectations that members have differentiated strengths that make them unique and valuable contributors to the teams so that they can maintain high-level affective organizational commitment and then do more for the development of their teams (i.e., making an effort in exerting innovative activities).

Last but not least, managers should take the impact of TMX differentiation into consideration, as suggested by the moderating influence that this study identified. Moreover, to further exert the effectiveness of TMX differentiation, team leaders should follow two general guidelines. On the one hand, leaders not only ought to tolerant the existence of TMX differentiation but also should distribute the limited resources fairly, and then make TMX differentiation developed be based upon both ability difference and task allocation. On the other hand, they should take action (e.g., setting up regulations; communicating with subordinates frequently) to avoid potential conflicts and vicious competition caused by TMX differentiation.

Limitations and directions for future research

Although this research makes several theoretical and applied contributions, some potential limitations still exist. First, the data used to examine our hypotheses came from one

cultural background (i.e., China). Therefore, the results may be affected by different cultures and values including power distance, Confucianism, and collectivism (Zhao, 2014). To further determine the generalizability of these new findings, maybe it is necessary for much more scholars to carry out and examine our study again in other cultures. Besides, using survey-based measure to evaluate LMX and TMX may not capture the actual construct of the quality of relationships, thus, we encourage more scholars to measure LMX and TMX adopting different approaches when retesting the proposed hypotheses of our study in future research.

Second, even though this research adopted a time-lagged design and assured the respondents of anonymity to minimize the risks of self-report, it was still very hard to avoid common method biases. It is worth mentioning that some empirical evidence (e.g., Janssen, 2000; Ding and Quan, 2021) supports self-reported innovative behavior, suggesting that self-report may be more subtle than leader-scores. Despite this optimistic observation, we still encourage more scholars to test the proposed hypotheses by employing a multiple-source research design. Specifically, employees can be required to complete measure of TMX, affective organizational commitment, while leaders can rate innovative behavior of each member.

Third, based upon social comparison theory, we explore *how* and *when* RTMX influences innovative behavior only concerning the mediating role of affective organizational commitment and the moderating role of TMX differentiation. Further research can explore other mediating mechanisms (e.g., self-efficacy, network centrality, and psychological ownership) to explore the influence mechanism of RTMX on innovative behavior. Furthermore, other potential moderators (e.g., power distance, team identification, and task complexity) can also be employed from other perspectives. For example, when task complexity is high, instead of paying attention to the intra-group differentiation of TMX, members tend to see RTMX as the result of rational division and then cooperate with each other to accomplish their common jobs, which in turn benefits individual outcomes.

Conclusion

As noted by Farmer et al. (2015, p. 592), it is necessary to further explore the influence of RTMX. The present study tries to link RTMX to innovative behavior based upon social comparison theory. Specifically, this research indicated that individuals' within-group TMX (i.e., RTMX) affected innovative behavior positively, and the link above was uncovered to be mediated by affective organizational commitment. Furthermore, TMX differentiation plays a moderating role in the strength of the relationship between RTMX and innovative behavior through affective organizational commitment. All in all, the findings above point out that TMX processes can simultaneously manipulate at multiple theoretical levels to affect innovative behavior within employment relationships.

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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Author contributions

CC and XL contributed to conception and design of the study. CC 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.

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.

Publisher's note

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How does venture capital cross-border syndication spur corporate innovation? Evidence from China

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In recent years, venture capital (VC) cross-border syndication has shown an obvious growth trend. Based on the existing studies, this paper explores the impact of VC cross-border syndication on corporate innovation. We also examine the mediating roles of cross-border quadratic relationship closure (CBQRC) formed by the strategic cooperation relationship between the respective portfolio companies of domestic and foreign VCs. This paper conducted an empirical analysis to test our hypotheses using a sample of first-round investments in domestic firms by domestic VC firms from 2014 to 2016. Results show that the more investment events of VC cross-border syndication or the more partners of VC cross-border syndication, the more likely it is to have a significant positive impact on the innovation of domestic portfolio companies. CBQRC plays a mediating role between VC cross-border syndication on corporate innovation. Results remain robust after removing endogeneity using the instrumental variables approach and removing sample selection bias using Heckman two-stage regression. Results deepen the understanding of the relationship between VC cross-border syndication and corporate innovation and provide essential guidance to domestic VC firms promoting corporate innovation in open partnerships.

KEYWORDS

venture capital, cross-border syndication, corporate innovation, cross-border quadratic relationship closure, strategic cooperation relationship

Introduction

Technological innovation is an activity of high cost, uncertainty, and risk, because of the information asymmetry between the owners of startups and external investors (Binks and Ennew, 1996), which makes it difficult for startups to obtain the capital of banks and other financial intermediaries for corporate innovation. In addition, startups can only generate limited cash flow (Arvanitis and Stucki, 2012) and can hardly afford the high R&D costs. As a result, capital constraints become the biggest problem that prevents startups from crossing the "valley of death" period when they intend to carry out innovative activities. At this stage, startups have minimal access to capital, and venture capital (VC) is a critical force in helping startups across the "valley of death"

and then grow quickly. VC invests in unlisted and high-growth startups through equity investments (Han, 2021), and successfully exits startups by means of mergers and acquisitions (M&A) or initial public offerings (IPO) to obtain considerable returns (Zheng, 2022). VC is widely credited with supporting the development of global high-tech industries because of its ability to provide critical support for startups' early survival and growth (Hirukawa and Ueda, 2011). Many world-class innovative companies, such as Apple, Facebook, and Alibaba, have received VC support in the early stage of development. Therefore, VC plays a considerable role in promoting innovation and entrepreneurial activities.

Take China's VC market as an example. Since the Chinese government proposed the development policy of mass entrepreneurship and innovation, the enthusiasm for innovation and entrepreneurship in China has never been higher, and with the emergence of a large number of high-quality entrepreneurs, more and more investment institutions and investors have started to pay more attention to and support the development of innovation. Lin (2017) shows that China's VC market provides a case worth studying due to the fact that China has become the second-largest VC market in the world, showing a rapid growth in terms of fundraising, financing amount, and exit channels for capital. In addition, according to a recent report by PitchBook, China's total VC investment reached $113.8 billion in 2021, ranking second in PitchBook's data records and near an all-time high.[1] Therefore, China's VC market becomes an ideal context to study the impact of VC on entrepreneurial and innovative activities.

The VC industry has long been a local industry (Cumming and Dai, 2010) because geographical proximity to portfolio companies allows for effective monitoring and value-added services (Mäkelä and Maula, 2006). However, with the increased competition in the domestic VC market, more and more VC firms are moving out of the country to look for investment opportunities abroad (Chemmanur et al., 2016). In the operational practice of domestic VC, cross-border syndication with foreign VC is a frequent investment approach adopted by domestic VC. VC firms in syndication have different skills, and they can comprehensively supervise, constrain, and evaluate the development of startups by complementing each other's advantages (Bayar et al., 2020). Therefore, cross-border syndication with foreign VC has become the primary form for domestic VC to actively integrate into the global innovation network. According to the statistics provided by Crunchbase database, domestic VC cross-border syndication has developed rapidly in recent years. The number of investment events of domestic VC cross-border syndication was only 317 before 2013, while it reached 1,985 from 2014 to 2019. Although the rise of domestic VC cross-border syndication brings the advantages of risk diversification and opinion assistance, the impact of domestic VC cross-border syndication on corporate innovation is still under-revealed due to the agency problem caused by information asymmetry and development uncertainty of startups. Therefore, it is necessary to study the impact of VC cross-border syndication on corporate innovation.

Based on the related research of VC post-investment management (Wang et al., 2012; Ozmel et al., 2013a,b), VC syndication (Sorenson and Stuart, 2001, 2008; Meuleman et al., 2017; Zhelyazkov, 2018) and corporate cooperative innovation (Luo, 2002; Belderbos et al., 2004; Fitjar and Rodríguez-Pose, 2013; Hsieh et al., 2018; Yang et al., 2018), this study proposes a new mechanism, namely, cross-border quadratic relationship closure (CBQRC), to reveal the role of domestic VC in promoting domestic corporate innovation through cross-border syndication. The core idea of CBQRC is summarized: Domestic VC cross-border syndication can help their portfolio companies establish strategic cooperation relationships with cross-border partners' foreign portfolio companies, thus promoting innovation of domestic portfolio companies. By empirically analyzing a sample of first-round investments in domestic companies by domestic VC firms from 2014 to 2016, we obtained the following conclusions: (1) The proactive integration of domestic VC into global innovation networks through cross-border syndication can significantly enhance corporate innovation. (2) CBQRC plays a mediating effect in the impact of domestic VC cross-border syndication on corporate innovation.

Literature review

Venture capital cross-border syndication

Venture capital cross-border syndication refers to multiple VC firms collaborating across geographical boundaries to participate in the same investment activity, providing the required resources and sharing the investment results (Lerner, 2000; Mäkelä and Maula, 2006). More and more VC firms have started to go abroad for cross-border syndication in recent years, which has aroused great interest among scholars. Many scholars have examined VC cross-border syndication from multiple perspectives, and basically, these existing studies can be summarized in two aspects: risk sharing and value-added.

On the one hand, VC is a high-risk investment activity, especially in cross-border investment. The geographical distance, institutional distance, and cultural distance between VC firms and their portfolio companies make the information asymmetry dilemma more obvious (Chemmanur et al., 2016). Although foreign VCs have advantages in resources and expertise, they also have disadvantages in terms of local knowledge and networks that affect investment performance

1 PitchBook News & Analysis, 18 March 2022. Available at https://pitchbook.com/

(Mäkelä and Maula, 2008). Therefore, when domestic VC firms go abroad to invest in overseas markets, cooperation with local VC firms in foreign countries can help domestic VC firms gain access to local knowledge and resources and help reduce information asymmetry. In addition, when multiple investors participate in an investment activity together, each VC firm can use less capital to invest in more areas of interest and achieve the purpose of risk diversification (Khavul and Deeds, 2016).

On the other hand, in their role as value-added service providers, VC firms have access to detailed information about the strategies and development dynamics of the company. They can use this information to identify profitable collaborations between companies (Lindsey, 2008). Different VC firms may have different strengths in terms of connections, capital, and social networks (Brander et al., 2002), so that they can guide companies in their innovation activities more comprehensively and provide resources in various areas of expertise to their portfolio companies, thus avoiding abortive innovation activities due to lack of industry experience and expertise. In addition, VC firms can also learn from other partners through cross-border syndication to make up for their internal knowledge deficiencies and improve investment performance (Khurshed et al., 2020). Therefore, from the perspectives of risk sharing and value addition, it can be found that VC cross-border syndication is beneficial to reducing risk and integrating entrepreneurial resources to help startups grow.

Cross-border quadratic relationship closure

Factors influencing partner selection have long focused on organizational theorists studying partnerships, including strategic alliances (Mitsuhashi and Greve, 2009) and VC syndication (Sorenson and Stuart, 2008; Plagmann and Lutz, 2019). Granovetter (1973) described the phenomenon of two strangers creating strong and weak ties through some common medium as a closed triad. Based on this idea, Kossinets and Watts (2006) described the process of two strangers getting to know each other through a third person as triadic closure, and their study showed that the role and status of the third person had a strong influence on the strength of the relationship between the other two. Lindsey (2008) explores the phenomenon of triadic closure in VC syndication, where they find that the likelihood of two startups forming an alliance increases if the two startups have a common VC firm. Thus, triadic closure has been documented in many empirical settings, particularly in clusters of relationships that tend to develop intensive, interconnected relationships (Gulati et al., 2012; Zhelyazkov, 2018).

To date, however, limited attention has been paid to the downstream relationship between VC firms and their portfolio companies. Although existing literature has focused on how ties to a shared third party can affect the outcome of the relationship between two organizations, scholars have overlooked the importance of closure in a partnership in facilitating or inhibiting direct collaboration between indirectly linked actors of two organizations. For example, On 23 May 2017, a China company—Realtime Technology announced a strategic partnership with a US company-Immersion, planning to apply Immersion's technology in Realtime Technology's products. Before these two companies formed a strategic partnership, Realtime Technology had received a Series A investment from Tencent Capital on 11 April 2016, and Immersion had received a Series A investment from Intel Capital on 24 March 2011. In addition, Tencent Capital and Intel Capital had jointly invested in Ark, a US-based search engine company, on 25 April 2012. Combining this VC investment event case, we can find interconnection among Realtime Technology (Domestic firm)—Tencent Capital (Domestic VC firm)—Intel Capital (US VC firm)—Immersion (US firm) form a CBQRC, as shown in **Figure 1**. Before Tencent Capital and Intel Capital co-invested, perhaps Realtime Technology and Immersion did not know each other, but after the two VC firms co-invested across the border, it is possible to increase the possibility of their acquaintance and cooperation.

The formation of CBQRC creates opportunities for domestic and foreign VC firms' respective portfolio companies to be more likely to establish direct collaboration with each other (Rogan and Sorenson, 2014). In addition, the involvement of domestic and foreign VCs in startups also releases relevant signals about the quality of the startups to the market to some extent, helping to alleviate any concerns of the partners about the capabilities and motivations of the startups themselves (Zhelyazkov, 2018), making the stability, trust, and benefits of this pluralistic relationship more likely to arise (Li and Piezunka, 2020). However, as with most partnerships, the stability of collaborative relationships between portfolio firms can be challenged by some uncertainty. For example, Pahnke et al. (2015b), by investigating the impact of early relationships on innovation in entrepreneurial firms, find that competitive information leakage occurs when firms are indirectly linked to competitors through shared intermediary organizations, which can hinder young firms' innovation efforts and reduce the effectiveness of collaboration. Related studies have also shown that achieving successful collaboration between different organizations means facing the challenge of coordination and communication among multiple parties (Gulati et al., 2012), such challenges change even more in the context of cross-national collaboration. These challenges include poor language communication, institutional and cultural differences, disagreements, and conflicts, all of which can undermine interorganizational collaborative efforts and make collective

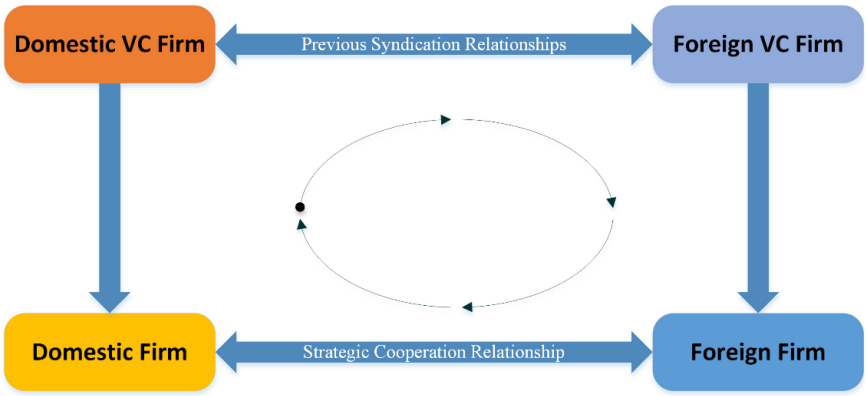

FIGURE 1
Structure of the cross-border quadratic relationship closure.

success difficult to achieve (Gulati et al., 2008; Wang et al., 2022). Therefore, the successes and challenges in strategic cooperation among portfolio companies in the context of VC internationalization prompt further academic research on the evolution and outcomes of cooperation among relationship subjects.

The impact of venture capital cross-border syndication on corporate innovation

Previous research has shown that VC firms' involvement in startups helps portfolio companies find strategic partners (Lindsey, 2008). Similarly, the more VC firms invest in a given firm or the more rounds of financing, the more strategic partners the firm is likely to acquire (Wang et al., 2012; Ozmel et al., 2013a). In particular, when startups have multiple investors, the more prominent the VC firm is in that network of relationships, the more likely the portfolio company is to form R&D partnerships with established firms (Ozmel et al., 2013b). Therefore, VC involvement can have a profound impact on the subsequent development of a startup.

Innovation, as an important part of a company's core competence, is an essential indicator for investors to assess the value of a company and reflects its market value. According to previous research, Lemley (2001) observed that venture capitalists use client patents (or more likely patent applications) as evidence that the firm is well-managed, at a particular stage of development, and has identified and developed a market niche. Similarly, Hsu and Ziedonis (2013), using a sample of 370 VC-involved startups, find that firms with more patents can receive more dramatic valuation adjustments when they go public. These quotes imply that VCs focus on the patenting activities of startups to monitor the firms' innovation process and promote the firms' use of innovation advantages to improve their market position. Based on the above analysis, we believe that VCs will pay attention to firms' patent activities when participating in startups.

Based on the existing literature on the relationship between VC and corporate innovation and the inconsistency of existing research findings on the relationship between the two, we argue that the relationship between VC cross-border syndication and corporate innovation deserves further study, especially in the absence of existing research on the Chinese VC ecosystem. In fact, startups' high degree of uncertainty makes it very difficult to obtain funds from external investors. However, VC investment in startups can help promote innovation by providing more funds for R&D activities and solving the dilemma of difficult and expensive financing for startups. Moreover, VCs' participation in startups can signal to the market that the startups are of high quality, reduce the information asymmetry between startups and external investors, and help moderate the subsequent financing costs. In addition, the ultimate goal of VC is to successfully exit the portfolio companies through IPO and M&A after the value of the startups has increased, in order to earn excess investment income. Therefore, as a professional investment institution, VCs are motivated to pay attention to and participate in the R&D decisions of their portfolio companies to improve their innovation capabilities for their own investment returns.

In the context of cross-border syndication, it has been shown that domestic and foreign VC firms that have experienced cross-border syndication are more likely to repeat the syndication in the future (Zhelyazkov, 2018). Furthermore, classical literature also shows that cooperation with other firms is beneficial for firm innovation (Luo, 2002), especially with non-local firms (Belderbos et al., 2004). Similarly, some scholars further found that cooperation with foreign firms helps domestic firms to innovate (Fitjar and Rodríguez-Pose, 2013; Hsieh et al., 2018), especially when there is mutual trust between the two partners

(Yang et al., 2018). Taken together, we argue that the VC cross-border syndication will improve the innovation of domestic portfolio companies. Based on the above analysis, the following hypotheses are proposed in this paper.

> **Hypothesis 1:** VC cross-border syndication will have a positive impact on the innovation of domestic portfolio companies.

Mediating role of cross-border quadratic relationship closure

Related studies have shown that interorganizational cooperation tends to produce achievements beyond what any single organization can achieve (Wang et al., 2022). Factors such as complementary capabilities, similarity in domain specialization, etc. can predispose two organizations to cooperate (Sorenson and Stuart, 2008; Shipilov and Li, 2012). Applied to the research context of this paper, we argue that the strategic partnerships formed in the process of cross-border cooperation between domestic and foreign firms will create long-term and sustainable value for both parties by leveraging their expertise and industry resources. In addition, cooperation between domestic and foreign firms linked through domestic and foreign VC firms also has the potential to reduce costs, secure supply chains, reduce competition, increase resources (Chang, 2004), and create other synergistic effects.

Therefore, the CBQRC formed by the strategic cooperation relationship between the respective portfolio companies of domestic and foreign VCs creates a bridge between VC cross-border syndication and the innovation of their portfolio companies. The formation or not of strategic partnership determines the relationship closure between the four innovation agents (domestic firm—domestic VC firm—foreign VC firm—foreign firm). When domestic and foreign firms are linked by having cooperated with domestic and foreign VCs, the formation of CBQRC helps provide legitimacy to their portfolio companies, reduces search costs for resource-poor new ventures, and reduces expropriation problems by monitoring and penalizing non-cooperation (Wang et al., 2012). In addition, from the perspective of alliance formation, VC firms use their expertise to manage information flows and identify profitable alliance opportunities (Lindsey, 2008). After forming an alliance, VC firms in a syndicate provide a broader range of value-added services to their respective portfolios through complementary management skills and shared social capital (Brander et al., 2002). Thus, domestic and foreign portfolio companies are more likely to benefit from the different information, expertise, and network relationships that different VC firms have through prior collaboration, which in turn affects the portfolio companies' innovation. Based on the above analysis, we argue that VC cross-border syndication helps domestic portfolio companies establish strategic cooperation partnerships with foreign portfolio companies invested by foreign VC firms by forming a CBQRC, thus influencing the innovation of domestic portfolio companies. The following hypotheses are proposed in this paper.

> **Hypothesis 2:** Cross-border quadratic relationship (CBQRC) plays a mediating role in the impact of VC cross-border syndication on the innovation of domestic portfolio companies.

Research design

Data sources and sample selection

The data sources used in this paper are shown as follows. First, the data on domestic VC investment events and the characteristics of domestic VC comes from the Private Equity Database. Second, the number of cross-border syndication events and cross-border syndication partners of domestic VC comes from Crunchbase Database. Third, the data on corporate innovation are collected through the China Intellectual Property Right Net. Fourth, the data on strategic cooperation between domestic firms and foreign firms is collected through their official websites and the Baidu search engine. Finally, the data on the director assignment and CEO replacement of firms are collected through the Tianyancha Database. It is remarkably, however, that although the Private Equity Database is widely used in China's VC research, it is a domestic commercial database with poor coverage of domestic VCs cross-border syndication events and their cross-border syndication partners' investment events. In contrast, Crunchbase database, as a global international database, covers foreign VCs investment data worldwide, which can solve the data shortage problem of Private Equity database. Combining those two databases can interoperate and improve data coverage and data quality.

This paper obtained a sample of domestic VC firms' first-round investments in domestic companies from 2014 to 2016 through the Private Equity Database. The starting point of the sample is 2014 because there were few domestic VC cross-border investment events before that, and the data become quite comprehensive after that year in time. We use 2016 as the sample termination point is required to retain the first post-investment year as the observation period for VC post-investment management, including the director assignment, CEO replacement, and the establishment of strategic cooperation partnerships between domestic firms and foreign firms, and the second and third post-investment years as the observation period for the innovation of

domestic portfolio companies. For example, Legend Capital invested in Lanchai, a Beijing-based Fintech company, on 1 January 2015. Then the period for observing Legend Capital's post-investment management is from 2 January 2015 to 1 January 2016 (the first year after VC investment), and the period for observing Lanchai's innovation activities is from 2 January 2016 to 1 January 2018 (the second and third years after VC investment). After excluding companies with undisclosed key information, we finally obtained a final sample of 1,311 VC first-round investments with complete information.

Variables

Explained variable

The types of patents are regulated differently in different countries. China's patent law classifies patents as invention, utility model, and design patents. Zhou et al. (2017) argue that invention patents are a better indicator of corporate innovation than utility model patents and design patents. Therefore, following the common practice in the international literature, this paper uses the number of granted invention patents to measure corporate innovation.

Explanatory variable

This paper observes the active integration of domestic VC into global innovation networks through cross-border syndication from two perspectives: (1) Number of investment events of domestic VC cross-border syndication; (2) Number of partners of domestic VC cross-border syndication. When counting these two indicators, there are two points to note. First, the domestic VC cross-border syndication here refers specifically to domestic VC firms co-investing in foreign companies with foreign VC firms in the same round, and the sample of purely domestic VC firms co-investing in foreign companies with other domestic VC firms in the same round is not included. Second, the cross-border syndication partners of domestic VC firms include both current and previous cross-border syndication partners.

Mediation variable

Most previous studies have relied on sizeable strategic alliance databases to observe strategic partnerships among firms. For example, Wang et al. (2012) used the SDC Alliances database, Ozmel et al. (2013a) used Recombinant Capital's Strategic Alliance database, and Ozmel et al. (2013b) used the Deloitte Recombinant LLC database. It is reliable to use large commercial databases to observe strategic cooperation partnerships between enterprises, but unfortunately, there is no similar database in China, and these foreign databases mentioned have a poor coverage of strategic cooperation partnerships between Chinese companies. Therefore, we developed a multistage procedure to observe whether the domestic portfolio companies invested by domestic VCs and the foreign portfolio companies invested by foreign VCs established a strategic cooperation partnership. First, we searched the names of all the foreign strategic cooperation partners of the domestic portfolio companies invested by domestic VCs through their official websites. Second, we identified the timing of the formation of the strategic partnership through the Baidu search engine. Finally, we use the Crunchbase database to determine the investors of the foreign strategic cooperation partners. If the investors of those foreign strategic cooperation partners include domestic VC firms' cross-border syndication partners, it is defined as a CBQRC and takes the value of 1. If the investors do not include domestic VC firms' cross-border syndication partners or domestic portfolio companies do not establish strategic partnerships with foreign portfolio companies, it is defined as non-CBQRC and takes the value of 0.

Control variables

Drawing on existing research and data availability, this paper selects a series of control variables regarding VC level and firm level, respectively. The specific definitions of the control variables are shown in **Table 1**.

Model building

To examine the impact of VC cross-border syndication on corporate innovation, we applied negative binomial regression to test hypotheses. Equation (1) formed the econometric model to test hypothesis 1. Equation (2) and (3) are used to test hypothesis 2. Under the circumstance of β_1, β_3, and β_6 are statistically significant, the mediation effects exist. Furthermore, perfect mediation occurs if estimated value of β_5 is not statistically significant. Formally, the equations are expressed as follows:

$$CI_{i,t} = \beta_1 X_{i,t} + \beta_2 Controls_{i,t} + \mu_t + \lambda_i + \varepsilon_{i,t} \quad (1)$$

$$CBQRC_{i,t} = \beta_3 X_{i,t} + \beta_4 Controls_{i,t} + \mu_t + \lambda_i + \varepsilon_{i,t} \quad (2)$$

$$CI_{i,t} = \beta_5 X_{i,t} + \beta_6 CBQRC_{i,t} + \beta_7 Controls_{i,t} + \mu_t + \lambda_i + \varepsilon_{i,t} \quad (3)$$

In both Equations (1) and (3), the explained variables are corporate innovation ($CI_{i,t}$) measured by the number of granted invention patents, which are count variables, so this paper uses a negative binomial distribution regression model to test those two equations. In addition, since the CBQRC is a binary dummy variable, a binary discrete choice model is used when this variable is the explained variable in Equation (2). In the context of this paper, the most widely used logit and probit models of the binary discrete choice model are not applicable

TABLE 1 Variable descriptions.

	Variables	Index	Definition
Explained variable	*CI*	Corporate innovation	The number of invention patents granted by domestic portfolio companies in the second and third years after receiving VC investment.
Explanatory variable	*Ne*	Number of investment events of domestic VC cross-border syndication	Cumulative number of investment events in which domestic VC cross-border syndication prior to investing in domestic companies.
	Np	Number of partners of domestic VC cross-border syndication	Cumulative number of partners of domestic VC cross-border syndication prior to investing in domestic companies.
Mediation variable	*CBQRC*	Cross-border quadratic relationship closure	The value is 1 if the domestic VC's domestic portfolio company establishes a strategic cooperation partnership with a foreign company invested by foreign VC, who are cross-border syndication partners of domestic VC within the first year after receiving the investment, 0 otherwise.
Control variable	*Se*	Successful exits	The cumulative number of domestic VC successful exits through M&A and IPO prior to investing in domestic companies.
	IPO	IPO on foreign stock exchanges	The cumulative number of domestic VC exits through IPOs on foreign stock exchanges prior to investing in domestic companies.
	Rep	VC reputation	In the year of VC investment in domestic companies, 1 if the VC is listed in the annual ranking list of China equity investment published by Zero2IPO Group, 0 otherwise.
	Sob	State-owned background	1 if the VC has a state-owned background, 0 otherwise.
	Syn	VC syndication size	When VC invests in domestic companies, 1 if the number of investors is greater than or equal to 2, 0 otherwise.
	Da	Director assignment	Within the first year after the domestic portfolio company receives investment from domestic VC, 1 if domestic VC assigns directors to the domestic portfolio company, 0 otherwise.
	CEO	CEO replacement	Within the first year after the domestic portfolio company receives investment from domestic VC, 1 if domestic VC replaces the CEO of the domestic portfolio company with an experienced external CEO, 0 otherwise.
	Pci	Previous corporate Innovation	The total number of invention patents, utility model patents, and design patents applied for by domestic portfolio companies in the five years prior to receiving domestic VC investment.
	Tech	Hi-tech dummy	1 if domestic portfolio company belongs to the high-tech industry, 0 otherwise.
	Early	Early dummy	1 if development stage of the domestic portfolio company is in the seed stage or start-up stage, 0 otherwise.
	Age	Company age	The difference in years between the year the domestic portfolio company is founded and the deal year.

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because the value of CBQRC is 0 in most cases and 1 in only a few cases in the entire sample of this paper. Therefore, in the binary discrete choice model, this distribution belongs to the extreme value distribution, and the model we selected to apply is the complementary log-log model.

In the above equation, $X_{i,t}$ refers to the explanatory variable that is the number of investment events of domestic VC cross-border syndication (*Ne*) and number of partners of domestic VC cross-border syndication (*Np*), respectively. $Controls_{i,t}$ refers to a set of control variables at the VC level and firm level including the Successful exits (*Se*), IPO on foreign stock exchanges (*IPO*), VC reputation (*Rep*), State-owned background (*Sob*), VC Syndication size (*Syn*) at the VC level; and Director assignment (*Da*), CEO replacement (*CEO*), Previous corporate Innovation (*Pci*), Hi-tech dummy (*Tech*), Early dummy (*Early*), Company age (*Age*) at the firm level.

Results

Descriptive statistics

The descriptive statistics of each variable are shown in **Table 2**. According to the statistical results, the maximum and minimum values of CI are 237 and 0, respectively, indicating significant differences in the innovation capability of domestic firms. The maximum and minimum values of Ne are 163 and 0, and the maximum and minimum values of Np are 634 and 0, showing that there are significant differences in the ability of domestic VC firms to integrate into the global VC market by way of cross-border syndication. The mean value of CBQRC is 0.046, indicating that 4.6% of domestic firms will form strategic cooperation partnerships with foreign firms. The control variables are distributed in reasonable ranges.

Baseline results

After controlling for a series of VC level and firm level control variables, this paper empirically tests the impact of VC cross-border syndication on corporate innovation and the mediating role of CBQRC in this impact, respectively. The regression results obtained are shown in **Table 3**. From the regression results of Models (1) and (2), it can be found that both Ne and Np are significantly and positively associated with CI, indicating that the more cross-border syndication events of domestic VC firms, or the more cross-border syndication partners of domestic VC firms, the more beneficial to the corporate innovation. Therefore, the regression results obtained support hypothesis 1.

In addition to the main findings, we also observed some regression coefficients of the control variables in Models (1) and (2). First, in terms of control variables at the VC level: The coefficients of Se are not significant, indicating that the impact of prior successful exits of domestic VC firms on corporate innovation is not significant. The coefficients of IPO are not significant, indicating that the impact of domestic VC firms' prior experience with IPOs on foreign exchanges on corporate innovation is not significant. The coefficients of Rep are negative, indicating that highly reputable VC firms do not better drive corporate innovation, and this result is inconsistent with the findings of Hua et al. (2016). The coefficients of Sob are not significant, indicating that there is no significant difference between state-owned background VC firms and non-state-owned background VC firms in driving corporate innovation, which is inconsistent with the findings of Bertoni and Tykvová (2015) and Pahnke et al. (2015a). The coefficients of Syn are positive and significant, indicating that VC syndication size drives corporate innovation, which is consistent with the findings of Hua et al. (2016). Second, in terms of control variables at firm level: The coefficients of Da are positive and significant, indicating that VC firms assigning directors to portfolio companies drives corporate innovation, consistent with the findings of Amornsiripanitch et al. (2019). The coefficients of CEO are insignificant, indicating that the positive effect of whether VC firms replace the CEOs of their portfolio companies with experienced external CEOs on the corporate innovation is insignificant, and this result is different from the findings of Conti and Graham (2020). The coefficients of Pci are positive and significant, indicating that the previous innovation capacity of enterprises contributes to subsequent innovation.

The mediating effect of cross-border quadratic relationship closure

The regression results of Models (3) and (4) in **Table 3** show that both Ne and Np are significantly and positively associated with CBQRC, indicating that the more cross-border syndication events of domestic VCs or the more cross-border syndication partners of domestic VCs, the greater the likelihood of establishing strategic cooperation partnership between domestic firms and foreign firms. Both Ne and Np in Models (5) and (6) are insignificantly and positively associated with CI, whereas the coefficients of CBQRC have a significant positive effect on CI at the 1% significance level, indicating that CBQRC plays a perfect mediating effect in the impact of Ne and Np on the corporate innovation, respectively. Therefore, the regression results support hypothesis 2.

To sum up, the regression results in **Table 3** indicates that VC cross-border syndication can help domestic portfolio companies establish strategic cooperation partnerships with foreign portfolio companies invested by foreign VCs, thus promoting corporate innovation.

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TABLE 2 Summary statistics.

Variable	N	Mean value	Standard deviation	Minimum	Maximum
CI	1,311	0.775	8.244	0	237
Ne	1,311	2.479	11.240	0	163
Np	1,311	13.841	61.635	0	634
CBQRC	1,311	0.046	0.209	0	1
Se	1,311	1.107	7.039	0	91
IPO	1,311	0.295	2.432	0	41
Rep	1,311	0.074	0.262	0	1
Sob	1,311	0.291	0.455	0	1
Syn	1,311	0.223	0.416	0	1
Da	1,311	0.320	0.467	0	1
CEO	1,311	0.022	0.147	0	1
Pci	1,311	1.849	7.367	0	54
Tech	1,311	0.613	0.487	0	1
Early	1,311	0.718	0.450	0	1
Age	1,311	2.841	4.357	0	36

Robustness test

To further test the robustness of the benchmark results, we adopt the instrumental variables approach and the Heckman two-step model to verify the impact of VC cross-border syndication on corporate innovation.

Test of endogenous problems

Due to the limited availability of some data, some important control variables may have been omitted in this paper. As previously discussed, the technical support provided by VCs to their portfolio companies (Chemmanur et al., 2014) and the incentive programs designed for innovation projects (Maas et al., 2020) are likely to influence corporate innovation, as well as the intention to collaborate between domestic firms and foreign firms (Ozmel et al., 2013b). However, since the technical support and incentive programs provided by VC firms to their portfolio companies cannot be observed, the previous benchmark regressions do not control for these two influences that may affect corporate innovation, which implies that the results of the benchmark regressions in this paper may have endogeneity problems caused by the omission of important control variables. This paper performs a two-stage regression test using the instrumental variables approach to address this issue.

The instrumental variable in this paper is VC's prior regional investment experience (Prie), which is measured by the number of provinces (including autonomous regions and municipalities directly under the central government) in China in which VC firms have invested before investing in domestic firms. The higher the value of VC's previous regional investment experience, the higher the degree of regional diversification of VC's investment in China. Therefore, this instrumental variable should be positively correlated with the explanatory variables. In addition, whether VC firms can promote corporate innovation and help domestic portfolio companies establish strategic cooperation partnerships with foreign firms invested by foreign VC depends crucially on VC firms' post-investment management strategies. Therefore, instrumental variables are not related to the explanatory or mediating variables.

Table 4 shows the regression results of the endogeneity problem test. The regression results from the first stage in Models (1) and (2), indicate that Prie are positively correlated with Ne and Np, respectively, suggesting that the instrumental variables are highly positively correlated with the explanatory variables. In addition, the values of Cragg-Donald are 128.183 and 170.410, respectively, which are much greater than the critical value of 16.38 at 10% bias, rejecting the original hypothesis of weak instrumental variables. The values of the underidentification test are 117.996 and 152.350, respectively, rejecting the original hypothesis of underidentification at the 1% level of significance. The above results suggest that VC's prior regional investment experience (Prie) is an appropriate instrumental variable. Moreover, the regression results from the second stage in Models (3)–(8) are generally consistent with the baseline regression results, showing that the regression results continue to support hypotheses 1 and 2. Therefore, the conclusions obtained in this paper are robust after excluding possible endogenous problems.

Test of sample selection bias

Another important factor that may interfere with the reliability of the baseline regression results is the sample selection bias. Khurshed et al. (2020) found that syndication with foreign VCs will change the investment behavior of domestic VC firms, and the richer the syndication experience

TABLE 3 Baseline regression results.

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	CI	CI	CBQRC	CBQRC	CI	CI
Ne	0.076***		0.059***		0.034	
	(2.770)		(5.592)		(1.114)	
Np		0.013***		0.010***		0.006
		(2.951)		(6.483)		(1.213)
CBQRC					3.425***	3.374***
					(3.379)	(3.354)
Se	0.026	0.026	0.037**	0.039***	−0.018	−0.017
	(0.706)	(0.703)	(2.397)	(2.676)	(−0.402)	(−0.377)
IPO	−0.074	−0.034	0.013	0.023	−0.045	−0.027
	(−0.764)	(−0.357)	(0.175)	(0.320)	(−0.413)	(−0.257)
Rep	−1.803	−1.989*	0.935*	0.680	−1.720	−1.813*
	(−1.528)	(−1.710)	−1.914	−1.393	(−1.570)	(−1.657)
Sob	−0.206	−0.206	−0.384	−0.374	0.005	0.004
	(−0.559)	(−0.561)	(−0.895)	(−0.864)	(0.013)	(0.011)
Syn	1.969***	1.975***	0.468	0.503	2.033***	2.038***
	(4.106)	(4.126)	(1.406)	(1.505)	(4.641)	(4.651)
Da	2.073***	2.077***	0.901***	0.935***	1.342***	1.348***
	(5.887)	(5.92)	(2.886)	(2.988)	(3.708)	(3.726)
CEO	1.857	1.916	0.974	0.977	1.796	1.827
	(1.360)	(1.402)	(0.942)	(0.944)	(1.350)	(1.372)
Pci	0.049**	0.049**	0.034***	0.033***	0.055**	0.055**
	(2.176)	(2.170)	(2.805)	(2.644)	(2.388)	(2.387)
Tech	2.036***	2.043***	0.855**	0.952***	1.697***	1.703***
	(5.468)	(5.492)	(2.444)	(2.706)	(4.847)	(4.862)
Early	−1.281**	−1.285**	0.091	0.08	−1.157**	−1.159**
	(−2.371)	(−2.382)	(0.180)	(0.159)	(−2.499)	(−2.502)
Age	−0.020	−0.020	−0.012	−0.010	−0.074	−0.074
	(−0.351)	(−0.354)	(−0.252)	(−0.199)	(−1.459)	(−1.447)
Constant	−4.108***	−4.111***	−6.154***	−6.196***	−3.614***	−3.623***
	(−5.484)	(−5.492)	(−8.528)	(−8.483)	(−5.412)	(−5.420)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−596.728	−596.388	−142.53	−141.195	−588.298	−588.199
N	1,311	1,311	1,311	1,311	1,311	1,311

The values in parentheses are z-statistics. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

with foreign VC firms, the more likely domestic VC firms are to invest in high-tech or early-stage startups. Therefore, based on the findings of Khurshed et al. (2020), the baseline regression results in this paper may have a sample selection bias, that is, the experience of cross-border syndication of domestic VCs may have changed their criteria and ability to select projects that can help them choose more innovative companies as investment targets.

Potential impact of sample selection bias is controlled for by using Heckman two-stage model. First, a probit model for domestic VC firms' choice is estimated. Second, the inverse Mills ratios (Imr) are included as an instrument in the second stage regression. The dependent variable (AI) in the probit selection model is a dummy variable that takes the value of 1 if the domestic firm in which the domestic VC firm abandoned its investment received an investment from another VC firm within the same month of the investment event, and 0 otherwise. The exogenous variable used to model domestic VC firms' choice is the industry matching degree (Imd) between domestic VC firms and their portfolio companies. The measure of industry matching degree (Imd) is as follows: before investing in domestic $firm_A$, the number of investment events of the industry in which VC_B invests in $firm_A$ is divided by the total number of investment events of VC_B in China. The industry

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TABLE 4 Robustness checks for the endogenous problems.

Variables	First stage		Second stage					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
	Ne	Np	CI	CI	CBQRC	CBQRC	CI	CI
Prie	0.758***	4.586***						
	(11.322)	(13.054)						
Ne			0.227**		0.059***		0.180*	
			(2.562)		(2.661)		(1.810)	
Np				0.038**		0.009**		0.030*
				(2.578)		(2.332)		(1.819)
CBQRC							5.773***	5.967***
							(2.873)	(3.114)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Underidentification test	117.996	152.35						
Cragg-Donald	128.183	170.41						
Stock-Yogo critical value	16.38	16.38						
N	1,311	1,311	1,311	1,311	1,311	1,311	1,311	1,311

In the first-stage regression, the values in parentheses are the t-statistics of the regression coefficients, and in the second-stage regression the values in parentheses are the z-statistics. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. The coefficients of the following variables are not reported due to space considerations: Se, IPO, Rep, Sob, Syn, Da, CEO, Pci, Tech, Early, Age.

TABLE 5 Robustness checks for the sample selection bias.

Variables	First stage		Second stage					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
	AI	AI	CI	CI	CBQRC	CBQRC	CI	CI
Imd	0.378***	0.378***						
	(9.727)	(9.727)						
Ne	−0.000		0.080***		0.058***		0.035	
	(−0.024)		(2.883)		(5.471)		(1.151)	
NP		−0.000		0.014***		0.010***		0.006
		(−0.028)		(3.067)		(6.413)		(1.250)
CBQRC							3.461***	3.409***
							(3.409)	(3.382)
Imr			2.348	2.357	−1.686	−1.461	2.351	2.349
			(1.368)	(1.374)	(−1.101)	(−0.952)	(1.498)	(1.496)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−6137.866	−6137.866	−595.737	−595.381	−141.707	−140.517	−587.209	−587.107
N	56,274	56,274	1,311	1,311	1,311	1,311	1,311	1,311

The values in parentheses are z-statistics. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. The coefficients of the following variables are not reported due to space considerations: Se, IPO, Rep, Sob, Syn, Da, CEO, Pci, Tech, Early, Age.

matching degree (Imd) reflects the degree of VC's preference for the industry in which the portfolio company is located, and the larger the value of this variable, the higher the degree of VC's preference for the industry. The results are provided in Table 5. From the first stage regression results, Imd are positive and significant in Models (1) and (2), indicating that the exogenous variable is appropriate. In second stage regression, the regression coefficients of Imr are not significant in Models (3)–(8), indicating that there is no sample selection bias, and the regression results for the other explanatory variables are

generally consistent with the previous findings. Therefore, the baseline regression results in this paper are reliable.

Conclusion and discussion

Conclusion

This paper empirically investigates the impact of VC cross-border syndication on the innovation of their portfolio companies and its path of action using a sample of first-round investments in domestic firms by domestic VC firms from 2014 to 2016. The results show that (1) VC cross-border syndication has a significant positive impact on the innovation of their portfolio companies. Specifically, the more VC cross-border syndication investment events (or the more VC cross-border syndication partners), the more likely they are to promote the innovation output of their portfolio companies. (2) The CBQRC formed by four innovation agents—domestic firm—domestic VC firm—foreign VC firm—foreign firm—is the mechanism through which VC cross-border syndication affects innovation of their portfolio companies. The above findings imply that VC's active integration into global innovation networks through cross-border syndication can help domestic firms enhance innovation capabilities in open partnerships.

Theoretical contributions

The main contributions are as follows. First, this study proposes a new perspective to explain the impact of domestic VC cross-border syndication on domestic firm innovation. Two theories have been proposed in the previous literature to elucidate the impact of cross-border syndication by domestic VCs on themselves and their domestic portfolio companies: inter-organizational learning theory (Khurshed et al., 2020) and cross-border relationship embedding theory (Meuleman et al., 2017). Inter-organizational learning theory suggests that domestic VC can learn foreign VC's investment skills to improve investment behavior and enhance investment performance through cross-border syndication. Cross-border relationship embedding theory suggests that if domestic VC and foreign VC have had cross-border syndication experience, they are both more likely to co-invest in domestic firms again. Compared with these two theories, we focus on the CBQRC formed by the four innovation subjects in the investment relationship, which helps to understand the impact of domestic VC cross-border syndication on themselves and domestic portfolio companies more comprehensively and deeply.

Second, this study finds a new impact mechanism for the role of domestic VCs in driving innovation in their domestic portfolio companies, which is one of the most critical issues in the field of entrepreneurship and finance. A variety of possible mechanisms have been identified in previous research, including providing technical support to portfolio companies (Chemmanur et al., 2014; Maas et al., 2020), assigning directors to portfolio companies (Amornsiripanitch et al., 2019), replacing CEOs of portfolio companies with experienced external CEOs (Conti and Graham, 2020), enhancing interaction with portfolio companies (Bernstein et al., 2016), optimizing incentive programs for innovation projects of portfolio companies (Maas et al., 2020). Unlike previous studies, this paper identifies a new impact mechanism by which domestic VC firms help domestic portfolio companies establish strategic cooperation partnerships with foreign portfolio companies invested by foreign VC firms, which are cross-border syndication partners of domestic VC firms. The discovery of this mechanism helps expand the options of strategies for VC firms to promote innovation in their portfolio companies.

Theoretical implications

Our findings have important theoretical implications. First, VC firms can influence the innovation activities of their portfolio companies after their involvement in startups. This paper explores the relationship between VC cross-border syndication and innovation in portfolio companies, providing a new perspective for research in the context of VC internationalization. Second, this paper provides insight into the mechanisms of VC cross-border syndication that affect corporate innovation. Specifically, based on existing research, this paper finds that the CBQRC formed by domestic and foreign VCs and their respective portfolio companies affects domestic portfolio companies' innovation. Finally, the formation of CBQRC proposed in this paper also reflects the fact that prior relationships between domestic and foreign VC firms can influence the strategic choices of portfolio companies, specifically, the linkages between VC firms of different backgrounds can serve as a bridge to guide the strategic choices of which firms to partner with.

Managerial implications

Our findings also have significant managerial implications. First, given that the national policy-making level attaches great importance to the important role of VC in China's innovation-driven strategy, especially in the context of gradually building a new pattern of double-cycle development, there is an urgent need to play the role of VC in supporting and catalyzing technological innovation, this paper can provide a strategic reference for domestic VC firms to enhance the innovation capability of Chinese local enterprises. Second, in the context of globalization of China's economy and capital, domestic VC firms have also started to vigorously lay out internationalization with the intention of investing in outstanding companies globally

and participating in global competition and cooperation. This paper provides an inspiration for domestic VC firms to use overseas investment to improve the innovation capability of their invested companies. Specifically, this paper focuses on the impact mechanism of VC cross-border syndication on corporate innovation, and the proposed cross-border quadratic relationship closure can also be used to explain how domestic VC firms can cultivate new advantages for China to participate in international cooperation and competition through the aggregation of capital power in the new situation.

Limitations and future research

The CBQRC formed by the innovation subjects in the investment relationship complements the literature on the role of VC firms in their portfolio companies by showing that VC firms collect or monitor information about their portfolio companies not only for screening and monitoring purposes, but also to help companies build networks of collaborative relationships. However, limited by the data availability, this paper does not directly observe other forms of inter-firm collaboration. In the future, if we obtain other data on the exchange and interaction between domestic and foreign firms, we will further deepen and expand based on this paper to improve the completeness of our findings.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the Northwest University Ethics Committee. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

HH created and designed the theoretical model and wrote the first manuscript. LG conceptualized the study, collected and analyzed the data, and improved the manuscript. JD contributed to the revised manuscript's review and editing and supported scientific research funding. All authors contributed to the article and approved the submitted version.

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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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How does capability reconfiguration impact the innovation performance of Chinese manufacturing firms?

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This study explores the relationship between capability reconfiguration and firm innovation performance by analyzing a sample of 375 manufacturing firms in China. The results suggest that the relationship between capability reconfiguration and innovation performance is affected by both the catch-up stage and the mode of capability reconfiguration (evolution or substitution). The catch-up stage of enterprises significantly impacts the moderating effects of innovation magnitude on the relationship between capability substitution and firm innovation performance, however, it has no obvious effects on the moderation of innovation magnitude on the relationship between capability evolution and innovation performance. This study contributes to the theory of dynamic capability and catch-up by revealing how innovation magnitude affects capability reconfiguration and subsequent innovation performance in different catch-up stages. The implication of this study is to remind managers to take full account of the innovation magnitude and catch-up stage in their decision-making.

KEYWORDS

innovation magnitude, catch-up in China, capability substitution, capability evolution, incremental innovation, radical innovation

Introduction

It is now widely recognized that innovation plays an important role in enhancing an enterprise's competitive advantage (Davis and Tomoda, 2018; Udriyah et al., 2019; Distanont and Khongmalai, 2020; Yang and Wu, 2021). A firm's innovation capability mainly lies in its capability both to integrate and build upon its current resources and competencies, while simultaneously developing fundamentally new capabilities, particularly within the late-industrial context (Bogers et al., 2019; Ferreira et al., 2020). Capability reconfiguration, as a key dynamic capability (Lavie, 2006; Ovuakporie et al., 2021), has been considered as an important means to promote enterprise innovation

and maintain a competitive advantage in a dynamic environment (Helfat and Peteraf, 2015; Girod and Whittington, 2017; Teece, 2018). Capability reconfiguration occurs when a firm engages in adding, redeploying, recombining, and divesting resources to maintain or enhance competitive advantage in a dynamic environment (Karim and Capron, 2016; Zhou et al., 2019). There are two capability reconfiguration mechanisms: (1) capability evolution, which involves continuous improvement of particular routines; and (2) capability substitution, which offers an immediate and strong response to environmental change (Lavie, 2006).

A great deal of literature on dynamic capability and strategic management of innovation shows that capability reconfiguration has a significant impact on firm innovation (Lavie, 2006; Karim and Capron, 2016). Capability evolution and capability substitution affect corporate innovation in different ways and paths (Girod and Whittington, 2015; Thomas and Douglas, 2022; Xie et al., 2022). Evolutionary capability reconfiguration is the recombination and redeployment of internal and external resources of firms that, helps enterprises discover and capture new opportunities (Wogwu and Hamilton, 2018; Saura et al., 2021). In a rapidly changing environment, the core rigidity and organizational inertia of enterprises will prevent them from making more organizational changes and technological or market-based innovation, thus requiring the necessary changes to suit the rapidly changing technology environment and market environment (Teece, 2007; Bai and Wang, 2016). Through the integration of existing resources and the reconstruction of current capabilities, enterprises can repair, improve some organizational routines, change the old system not suitable for innovation, and update the management strategy adapted to the innovation and competitive environment (Xie et al., 2022). Therefore, from this point of view, capability evolution is usually able to release the potential of the resources leading to innovation (Girod and Whittington, 2017; Ovuakporie et al., 2021). Substitutional capability reconfiguration allows firms to substitute new capabilities for existing capabilities through fundamental change and renewal of organizational capabilities and innovation mechanisms (Lavie, 2006; Hu et al., 2021). Sometimes the local capability adjustment is difficult to completely change the original organizational routine, and the impact of the original convention remains strong. At this time, breaking the original rules and order, to implementing a complete substitution of the overall capability portfolio, is more conducive to the realization of disruptive technological innovation (Lavie, 2006; Karim and Capron, 2016; Girod and Whittington, 2017). So far, the mechanisms by which incremental and rapid innovation impact capability reconfiguration have not been fully revealed (Li et al., 2022; Wang H. et al., 2022).

Corporate decision-makers may need to confront the difficult choices of different capability reconfiguration paths or mechanisms when faced with radical or incremental innovation (Peng et al., 2021; Zhang Z. et al., 2021). The concept of incremental innovation and radical innovation is divided from the perspective of innovation magnitude (Pini and Santangelo, 2010). Incremental innovations are the minimal improvement and minor adjustments to the existing technology (Munson and Pelz, 1979), which involve continuously refining, and exploiting within an existing current technological trajectory (Dewar and Dutton, 1986), while radical innovations represent a risky departure away from an existing technological trajectory (Dosi, 1982; Schoenmakers and Duysters, 2010; Ashford and Hall, 2011). A lot of the literature focuses on the study of the concepts (Dewar and Dutton, 1986; Chandy and Tellis, 1998; McDermott and O'Connor, 2002; Zhang and Chen, 2011), characteristics (Henderson and Clark, 1990; Leifer et al., 2001; O'Connor and Veryzer, 2001; Zhang and Chen, 2011), differences (Danneels, 2004; Fu and Zhang, 2004; Wang H. et al., 2022) and influencing factors (Sandberg and Aarikka-Stenroos, 2014; Simms et al., 2021) of the two modes of innovation. There are also several pieces of literature discussing the possible impact of capability reconfiguration on incremental or radical innovation, such as capability evolution and capability substitution have asymmetric effects on incremental and radical innovation performance (Lennerts et al., 2020; Ovuakporie et al., 2021), and capability evolution and capability substitution generation have quite different effects on enterprise radical innovation in the long and short term (Liu and Su, 2022).

Some researchers find that different innovation magnitudes generate distinct organizational effects on firm capability development, innovation outcomes, and performance (Woschke et al., 2017; Gomes et al., 2019; Tiberius et al., 2021). For example, the strength of radical innovation affects the choice of enterprise capability reconfiguration (Peng et al., 2021). Some empirical studies also show that radical innovation has a positive impact on the substitutional capability reconfiguration, and ultimately it will bring better firm performance (Kim and Mauborgne, 1997; Henard and Szymanski, 2001). However, few studies indicate how the impact of capability evolution and capability substitution on innovation performance varies in different innovation magnitude scenarios.

In the last decade, a growing body of literature on innovation strategic management pays more attention to the dynamic development of firm capabilities, especially the evolution of innovation capabilities of backward enterprises in the process of technology catch-up (Alpkan and Gemici, 2016; Saura et al., 2021). For companies in different stages of catch-up, their technology and knowledge stocks are different, and the capability development path and innovation performance of enterprises should also be different (Hu et al., 2021). However, few studies take the catch-up stage as an important moderator of the impact of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance, although it may become an important variable that influences the direction and way of

capability reconfiguration (Kim, 1998; Dutrénit, 2004). For latecomer enterprises, capability reconfiguration is not an overnight change, but a process accompanied by enterprise technology catch-up (Wang, 2018). For example, studies show that latecomer firms promote capability evolution through accumulating knowledge and perpetuating organizational practices in the initial catch-up stage; but they replace old knowledge with new knowledge and reconstruct new organizational practices to achieve capability substitution in the industry frontier stage (Peng et al., 2021). Therefore, different reconfiguration models, innovation magnitude, and catch-up stages will all have a certain impact on the innovation performance of enterprises (Girod and Whittington, 2017; Hu and Yu, 2017; Wang, 2018; Hu et al., 2021).

Therefore, the goal of this paper is to reveal the inherent evolutionary mechanism of capability reconfiguration by examining how innovation magnitude moderates the relationship between capability reconfiguration and firm innovation performance and how the moderating effects vary during different stages of catch-up.

The research questions involved in this study are as follows:

Q1: Whether and how the incremental/rapid innovation affects the relationship between capability and performance?

Q2: Whether and how the impact mentioned above changes as latecomer enterprises are in different catch-up stages?

To answer the above two questions, we seek to achieve the following objectives:

To clarify the three groups of relative concepts: capability evolution/substitution, incremental/rapid innovation, and early/late stage of catch-up.

To establish a measurement of core variables (e.g., catch-up stage).

To explore how the innovation magnitude moderates the relationship between capability reconfiguration and innovation performance, establish a theoretical model and test the size and direction of the moderating effect.

To reveal the path and mechanism of the moderation of innovation magnitude changing with the growth process of the latecomer enterprises, by creating an expansion model containing the variable of catch-up stage, to test and find how the interaction between the catch-up stage and the innovation magnitude affects the relationship between the capability configuration and innovation performance.

The novelty of this paper lies in that, first of all, previous empirical studies have either used incremental/radical innovation as the dependent variable (Li and Qu, 2017; Han et al., 2018, Han et al., 2020; Thneibat, 2021) or as the explanatory variable (Baker et al., 2014; Kim et al., 2019). In present studies, the innovation magnitude is taken as the moderating variable to investigate the path selection and the performance of capability reconfiguration under the background of incremental or/and radical innovation. More importantly, the view of capability evolution over time is also fully considered in our models. Previous studies have rarely introduced catch-up process variables to analyze the capability evolution of latecomer enterprises in different stages, although the catch-up process may exert a significant impact on the capacity accumulation and reconstruction of enterprises (Dutrénit, 2004; Figueiredo, 2017). The studies build a three-way interaction model of the capability reconfiguration, innovation magnitude, and catch-up stages, which method used by Lu and Sun (2016), Sun et al. (2018), to analyze the dynamic effects of capability reconfiguration of latecomer enterprises and its innovation outcomes in the process of technology catch-up, and to explore the influence of time heterogeneity and innovation environment on the dynamic capability and performance.

Theory and hypotheses

Capability reconfiguration and firm innovation performance

According to the resource-based view modified by dynamic capability theory, market position and resource advantage are no longer sufficient foundations for sustainable competitive advantage. With rapidly changing technology, the capability to reconfigure and upgrade routines and organizational competencies are the keys to maintaining and enhancing sustainable competitive advantage (Hwang et al., 2020). This has been designated as capability reconfiguration and refers to the activities by which firms engage when adding, redeploying, recombining, or divesting resources or business units. Lavie (2006) suggested: "capability reconfiguration mechanisms are distinct from the notion of dynamic capability, the notion of dynamic capability indicates whether the incumbent can alter the configurations of its capabilities, whereas the notion of capability reconfiguration mechanism suggests how these configurations are likely to change." According to Lavie (2006), the notion of capability reconfiguration is the integration of Raudino (2016)'s views on technological discontinuities with the perspective of dynamic capabilities. The result is that capability evolution and capability substitution may be considered two extremes of the same continuum. Evolution builds on dynamic capabilities and evolutionary economics to offer an evolution mechanism by which existing capabilities can be adapted. Substitution offers a mechanism of discontinuous change resulting from innovation in which newly acquired capabilities replace capabilities that have been rendered obsolete.

Capability reconfiguration is necessary to match the pace of environmental change (Eisenhardt and Martin, 2000). Reconfiguring resources (whether of internally developed or acquired product lines) and using them in different ways or new combinations provides firms with innovative opportunities (Teece, 2007; Helfat and Peteraf, 2015; Zhou et al., 2019;

Khan et al., 2020). Theorists often distinguish between two reconfiguration mechanisms: capability evolution and capability substitution (Karim, 2006; Lavie, 2006). Capability evolution involves the continuous improvement of particular routines. In a rapidly changing environment, a firm's core competencies will become core rigidities which can cause the firm to lose competitive advantage (Teece, 2007). Therefore, the only way for a firm to sustain a competitive advantage is to continuously invest in and update its resources and capabilities (Lu et al., 2015). Integrating continuous evolution within existing organizational principles, capability evolution is necessary for a firm to match the pace of environmental change (Girod and Whittington, 2017).

On the other hand, capability substitution offers an immediate and strong response to environmental change at the level of the overall capability portfolio. Capability substitution involves changes in fundamental principles of organizational capabilities. Although capability substitution involves relatively large capability changes, (i.e., capability updates, renewals, and iterations at the level of the overall capability portfolio) the configuration of existing capabilities tends to remain intact and organizational design and principles can remain invariant (Lavie, 2006). By changing many elements of the capability portfolios at the same time, capability substitution can avoid the asynchrony of organizational routine adjustment (Haapanen et al., 2016). Compared with capability pitching and adjusting, capability destroying and acquiring are more likely to break core rigidities and path dependencies (Lavie, 2006). Therefore,

Hypothesis 1a: Capability evolution is positively related to firm innovation performance.

Hypothesis 1b: Capability substitution is positively related to firm innovation performance.

The moderating effects of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance

Different innovation magnitudes may have divergent effects on organizational capability development and performance (Migdadi, 2019). Existing literature suggests that technological innovations can be divided into incremental innovations and radical innovations that reflect the magnitude of technological innovations (Schoenmakers and Duysters, 2010; Lin and Chang, 2015).

Two characteristics distinguish incremental innovations from radical innovations. The first difference between the two innovative models is embodied in the technological trajectory. The technological trajectories of incremental innovations are linear and continuous, while the technological trajectories of radical innovations are divergent and discontinuous. In other words, incremental innovations involve continuous improving, refining, and exploiting existing current technological trajectories (Schoenmakers and Duysters, 2010), while radical innovations represent a risky departure away from existing technological trajectories (Dosi, 1982). Another difference between incremental and radical innovations is the way a firm allocates existing resources and capabilities. Incremental innovations are based on the existing resources and capabilities of the enterprise and involve continuous improvements or minor adjustments in current technology (Schoenmakers and Duysters, 2010). Radical innovations, however, can ruin existing technology and even destroy existing resources and capabilities, which represent fundamental changes in technology and a risky departure away from existing routine and practice (Mohr, 1981). These different characteristics also influence the impact of capability evolution and capability substitution on firm innovation performance. Thus, radical innovations will induce different outcomes than incremental innovations.

Capacity evolution is the gradual adjustment of organizational routines and existing capabilities. The role of capability evolution may be influenced by innovation magnitude. When the innovation magnitude is lower, the enterprise mainly takes the incremental innovation, which is linear and mild. Incremental innovation is often based on existing knowledge and continually improves current technology by reusing, complementing, and extending the present knowledge (Lin and Chang, 2015). Under the context of incremental innovation, the positive effects of capability evolution would play a better role. Capability evolution is to repair and improve existing capabilities at less cost of change. However, capability substitution is often an overall or fundamental change in capabilities which is costly and risky in the context of incremental innovation and may even have a negative impact on innovation outcomes (Girod and Whittington, 2015, 2017).

With the increase in innovation magnitude, enterprises are more and more inclined to radical innovation. Radical innovation is a non-linear and revolutionary technological change, often accompanied by an update of the technological paradigm and a transition of a technological path (Rialti et al., 2019). Therefore, knowledge creation, technology innovation, and capability iteration are very important to the success of innovation. The greater the innovation magnitude, the greater the expansion of the enterprise knowledge set, and the decrease of dependence on existing knowledge. Capability evolution induces firms to partial adjustment of routines and activities (Rialti et al., 2019) and the local pitching may have overall negative knock-on effects (Girod and Whittington, 2017). Relative to capability evolution, capability substitution involves changes in fundamental organizational principles and can provide firms with access to new solutions (Tetlock, 2007)

and replacement of existing capability (Lavie, 2006; Girod and Whittington, 2017). Therefore,

Hypothesis 2a: Innovation magnitude weakens the positive relationship between capability evolution and firm innovation performance.

Hypothesis 2b: Innovation magnitude strengthens the positive relationship between capability substitution and firm innovation performance.

The re-moderating effects of catch-up stages on the moderation of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance

Beyond considering the impact of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance, we should also examine the influence of the stage of catch-up. The dynamic resource-based view of the firm argues that organizational capabilities evolve, and proposes that capabilities pass through multiple stages of development before their impact begins to decline (Helfat and Peteraf, 2003). Research on firms in the catch-up stage examined the dynamic processes of their capability building (Kim, 1998; Dutrénit, 2004) and showed that firm capabilities may be accumulated and restructured in different directions and at differing rates (Figueiredo, 2002). Bell (2003) indicated that a technological backward firm, before finally gaining a core technology and becoming an international technological leader, has to go through a period of technological learning and upgrading. Firms upgrading technological capability who are at different stages of catching up are likely to demonstrate different effects in innovation performance depending on whether they use capability evolution or capability substitution. Therefore, we expect that at some point between the early and late stages of catch-up there will be a significant change.

Firms lack basic technological capabilities during their start-up phase. They must first master technical know-how quickly and develop zero-order capabilities (Zollo and Winter, 2002) through learning and imitation. By adding, patching, or deleting routines without change to the overall capability portfolio and structure (Eisenhardt and Brown, 1998; Karim, 2006; Girod and Whittington, 2015), capability evolution can help firms to develop routine capabilities, such as technology-using skills, knowledge, and so on. In the early stage of catch-up, firms have a strong path dependence on existing capabilities, so they must develop fluent organizational routines (Eisenhardt and Brown, 1998). They can do so by using more limited but continuous adjustments instead of substitution, to maintain evolutionary fitness (Teece, 2007). In the case of incremental innovations, firms can use historical experiences and current knowledge more, which will help them to absorb new knowledge more effectively (Han et al., 2018). However, as the magnitude of innovation becomes more radical, the contribution of firms' existing knowledge and experience to innovation begins to decline. Thus, the positive impact of capability remediation and refinement based on historical experience and existing capabilities on innovation diminishes significantly.

The late stage of catch-up has been termed a transition process from being a laggard to a leader (Dutrénit, 2004). Although firms already have a wealth of knowledge and capabilities, the existing knowledge, skills, experiences, routines, and competencies are all necessary for enterprises to gain a competitive advantage. These existing resources and capabilities are the starting point for enterprises to acquire higher capabilities. Thus, exploiting established competencies provides certain and immediate returns for firms at less cost and risk (Dosi, 1988; Audia and Goncalo, 2007; Phelps, 2010). This is especially true for the case of incremental innovation, which mainly uses the existing knowledge to make the partial adjustment to the production process, products, and technology to enhance short-term performance (Lin and Chang, 2015). However, with the increasing innovation magnitude, firms adopt more radical innovation and will experience a risky departure away from existing routine and practice (Deffains-Crapsky and Klein, 2016). When this occurs the positive impact of capability evolution on innovation will be diminished, or may even eventually turn into negative effects (Phelps, 2010; Girod and Whittington, 2015).

It is generally believed that capability substitution can optimize the capability structure by replacing outdated capabilities with new capabilities, and thereby improve the allocation efficiency of innovation resources. However, the effects of capability substitution on firm innovation performance may be moderated by the magnitude of innovation.

When a firm adopts incremental innovations with low innovation magnitude the firm's technology innovations only involve minor improvements or simple adjustments in current technology (Dewar and Dutton, 1986). Thus, firms in the early stages of catch-up that adopt incremental innovations can achieve product innovation by tracing leading technology and knowledge and following the basic logic of innovation of following, imitating, and catching up. Decision-makers will replace obsolete existing capabilities with new capabilities that have been proven reliable or mature by technology and markets.

When a firm adopts radical innovations with high innovation magnitude, it has to experience a risky departure away from the existing technological trajectory. In this case, the enterprise will find it very difficult to acquire new capabilities from peer firms and will need to turn to independent research

and development. Capability substitution, which involves capability updates, renewals, and iterations at the level of the overall capability portfolio, will lead to higher costs in contrast to more gradual capability evolution. Although capability evolution may also incur short-term performance penalties (Lamont et al., 1994), especially in the early stages of catch-up. Nevertheless, the more radical a firm's innovation, the more difficult it will be to acquire new technology, and the greater will be the risks and costs of innovation.

In the late stage of catch-up, enterprises already have a certain foundation of knowledge and capability, but the enterprise is striving to achieve technological catch-up and leapfrogging. In this stage, devalued capabilities become core rigidities that handicap the firm in its attempt to adapt to the new environment of competition (Leonard-Barton, 1992). This capability trap, owing to the long-run development of organizational inertia, hinders the innovation and the growth of firms. Substitution can change many elements at the same time to break the core of this capability trap and unleash innovation potential (Girod and Whittington, 2017). The more radical the innovations, the more urgent will be the firms' appeal to break existing routines and capabilities, and this will lead to greater positive effects on innovation. Therefore,

Hypothesis 3a: Catch-up stages do not significantly affect the moderating effects of innovation magnitude on the relationship between capability evolution and firm innovation performance. Innovation magnitude weakens the positive relationship between capability evolution and firm innovation performance in both the early and late stages of catch-up.

Hypothesis 3b: Catch-up stages significantly affect the moderating effects of innovation magnitude on the relationship between capability substitution and firm innovation performance. In the early stage of catch-up, innovation magnitude weakens the positive relationship between capability substitution and firm innovation performance. In the late stage of catch-up, innovation magnitude strengthens the positive relationship between capability substitution and firm innovation performance.

Methodology

Sample and data collection

We sampled 11 different manufacturing industries. To ensure the validity of the survey responses, the questionnaire was distributed to primary administrators who are familiar with the company's overall situation. A total of 750 questionnaires were distributed and 290 valid questionnaires were returned for a 38.7% response rate. Of the 290 received, 208 (about 72%) were received initially, and 82 were received at a later stage. Characteristics of the firms and informants in the sample are shown in **Table 1**. The questionnaire items asked about respondents' tenure and expertise to verify the appropriateness of the respondents as knowledgeable key informants (Kumar et al., 1993). Overall, 81.4% of the participants had been in their current enterprise for over 6 years. Respondents are mainly managers or top management, and this ensured that they were familiar with firm technological innovation. We checked for nonresponse bias by comparing early and late respondents (Armstrong and Overton, 1977). Results of *t*-tests showed that no systematic differences ($p > 0.05$) were found between the early and late respondents. Thus, non-response bias is not likely not to have affected the results.

We checked for common method variance (CMV) using Haman's single factor test (Podsakoff and Organ, 1986). We made an orthogonal rotation principal components analysis of all items. The results show that the total explanatory power of the factor reached 77.6%. Moreover, the first factor explained only 17.72% of the variance, which was significantly less than 50%. As a result, the common method variance was unlikely to be a pervasive problem in this study.

Measures

Survey items were derived from the existing mature scales at home and abroad and were supplemented through field interviews to improve measurement.

Firm innovation performance was measured using a scale adapted from Zhang and Li (2010) and Chen et al. (2011). Firm innovation performance was measured with the following items: (1) novelty of new products, (2) number of new products, (3) speed of new product development, (4) ratio of sales revenue of new products to total sales, (5) new product's added value and profit margin, and (6) market share of new products. Respondents were asked to give a subjective evaluation of innovation performance from the past 3 years.

Capability reconfiguration was measured using a scale adapted from Gatignon et al. (2002). According to Lavie (2006)'s explanation of capability evolution and substitution, capability evolution means the adjustment and improvement of existing capabilities, and capability substitution includes abandonment of outdated capabilities and acquisition of new capabilities. Thus, our capability evolution measured included 4 items measuring competence-enhancing in the original scale: (1) adjust existing capabilities and practices, (2) develop the existing knowledge base, (3) learn from the existing knowledge, (4) seek solutions from previous experience. In addition, we obtained six items measuring capability substitution by merging new competence acquisition scale items and competence destroying scale items adapted from the original scale: (1)

TABLE 1 Sample characteristics distribution of returned questionnaires.

	Sample	Percentage		Sample	Percentage
Firm size			Firm age (years)		
<500	111	38.28%	<5	43	14.83%
501∼2000	97	33.45%	6∼10	88	30.34%
2000∼5000	65	22.41%	11∼15	37	12.76%
>5000	17	5.86%	16∼20	81	27.93%
			>21	41	14.14%
Ownership			Education		
State-owned	55	32.41%	Doctor	37	12.76%
Private	127	43.79%	Master	89	30.69%
Foreign-funded	94	18.97%	Undergraduate	132	45.52%
Other	14	4.83%	Other	32	11.03%
			Tenure of respondent in firm(years)		
Province			≤5	54	18.62%
Liaoning	42	14.48%	6∼10	119	41.03%
Jilin	35	12.07%	11∼15	87	30.00%
Heilongjiang	54	18.62%	≥16	30	10.34%
Beijing	58	20.00%	Position of respondent		
Tianjin	40	13.79%	Member of executive board	88	30.34%
Shanghai	33	11.38%	Head of R and D	137	47.24%
Other	28	9.66%	R and D project leader	45	15.52%
			Other (e.g., key member of technical expert team)	20	6.90%

develop new concepts or principles; (2) develop new skills that were not previously available; (3) create new knowledge to replace outdated knowledge; (4) learn knowledge from different knowledge bases; (5) adopt different methods, practices, or processes; and (6) discard obsolete capabilities.

Catch-up stages were measured by two indexes: the technological level and the technological capability of enterprises. According to the existing literature research, the firm catch-up process involves four common stages: starting, following, synchronizing, and leading (Cirera et al., 2020; Peng and Liu, 2021). We ask the interviewees to evaluate the gap in technological levels between their enterprises and the leaders in the past 3 years, and choose their stage in the following options: (1) The gap between us and the leader is huge, and our technology is just beginning; (2) we have a certain gap with the leading enterprise, but we are catching up at full speed; (3) There is no gap between our technology and that of the leading enterprises, which is roughly equivalent; (4) our technology is in the leading position at present, some core technologies are slightly higher than other advanced enterprises. Considering that these measurements may contain some subjective elements that affect the results of the study, we further adopt some mature practices in the existing literature to measure the catch-up stage according to the development of firm technological capability (Xiao et al., 2013; Guo et al., 2015; Park, 2017). The respondents are asked to answer the current state of the enterprise's technological capability, and there were four items: (1) we are copying the technology of other advanced enterprises or are looking for replicable target enterprises; (2) we are digesting and absorbing the technology of advanced enterprises, and we have also made some initial innovation based on imitation; (3) we have equal R&D cooperation with other leading peers, or we mainly focus on our technology patents and integrate other technologies; (4) we have the capability to innovative technologies and have independent intellectual property rights. According to the answers, we mark each item 1–4 and calculate the average score of the two items, and then judge which stage the firm is in (indicated by the letter D):$1 \leq D < 2$ as the initial stage; $2 \leq D < 3$ as the following stage; $3 \leq D < 4$ as the synchronization stage; $D = 4$ as the leading stage. Finally, the initial and the following stages were classified as the early stage of catch-up while the synchronization and the leading stage belonged to the late stage of catch-up.

Innovation magnitude was measured using a scale adapted from Gatignon et al. (2002). Innovation magnitude was measured on a 7-point scale indicating whether each innovation: (1) is a minor improvement over the previous technology (Reversed), (2) is a breakthrough innovation, (3) leads to products that are difficult to replace with substitutes using older technology, and (4) represents a major technological advance in the subsystem. The higher the score was, the more radical the innovation, and the lower the score the more incremental the innovation.

Control variables. Firm size and firm age affect innovation variables such as investment (Baysinger and Hoskisson, 1989; Hoskisson et al., 2002). The larger the firm size, the longer the firm age, the greater the absolute number of resource accumulation, and the more the number of innovative resources (Lee et al., 2001). Therefore, this paper chooses the firm size and firm age as control variables.

Reliability and validity

Confirmatory factor analysis of variables was carried out using SPSS 21.0 and AMOS 21.0 software. The Cronbach's alpha of all constructs exceeded 0.7 (**Table 2**), indicating sufficient reliability for each variable. According to Hair et al. (2013), we deleted the items "discard obsolete capabilities" which resulted in the Chi-square Freedom Ratio exceeding 3 and RMSEA exceeding 0.08, indicating sufficient goodness of fit for the model (Zhang and Li, 2010).

The convergent validity test showed that the SMC value is greater than 0.5, the standard factor loading was greater than 0.7, the composite reliability (CR) value was greater than 0.7, and the average variance of extraction (AVE) was greater than 0.5, demonstrating that the items have good convergent validity (Hair et al., 2013).

We tested the discriminant validity of the model by using the AVE method (see **Table 3**). The results showed that the square root values of the average variance extracted for each variable were greater than the Pearson correlation coefficient, which indicated that the questionnaire had good discriminant validity (Fornell and Larcker, 1981).

Analyses and results

We first examined several commonly used indicators of fit: Chi-square degrees of freedom (x^2/df), Goodness-of-fit index (GFI), Adjusted goodness of fit index (AGFI), Root-mean-square error of approximation (RMSEA), and Standard root-mean-square residual (SRMR) which tested the absolute fitness (AFI); Normed fit index (NFI) and Comparative fit index (CFI), which represented the incremental fitness indices; Parsimonious normed fit index (PNFI), Parsimonious comparative fit index (CFI), which are simplified fitness indices (Hair et al., 2013). Results showed AFI x^2/df 1.499 < 2.00, GFI = 0.872 > 0.85; AGFI = 0.872 > 0.85, RMESE = 0.042 < 0.05, SRMR = 0.049 < 0.05; the incremental fitness index, NFI = 0.936 > 0.90, CFI = 0.978 > 0.95, IFI = 0.978 > 0.95, RFI = 0.927 > 0.90, TLI = 0.975 > 0.95; and the simplified fitness index, PNFI = 0.824 > 0.50, PGFI = 0.732 > 0.50, PCFI = 0.861 > 0.50. These results demonstrated acceptable model fit.

Table 3 shows the descriptive statistics and the correlation matrix of the main variables in our study. We checked the variance inflation factors (VIFs) to investigate the multicollinearity problem. The individual VIFs ranged from 1.005 to 2.293. Given that all the VIFs were far below the commonly accepted value of 10 (Cohen et al., 1983), multicollinearity was unlikely to be a big problem in our study.

Table 4 contains the results from the hierarchical OLS regression analysis. The control variables (firm age and size) were entered in model 1, which indicated that only firm size is found to have a significant effect ($p < 0.001$). The main predictors (capability evolution, capability substitution) were in model 2, the interactions between capability reconfiguration and innovation magnitude were in model 3, and the three-way interactions between capability reconfiguration, innovation magnitude, and catch-up stages were entered in model 4. The four regression equations were significant at $p < 0.05$, and the adjusted R2 values range from 0.115 for model 1 to 0.778 for model 4. In addition, we mean-centered the interactions to reduce multicollinearity. All values of the resulting variance inflation factor were lower than 2.0, which indicated that multicollinearity was not a concern.

Hypothesis 1 predicted that both capability evolution and capability substitution are positively related to firm innovation performance. The results of our hierarchical linear regression analysis in Model 2 (see **Table 4**), supported this hypothesis, revealing a significant positive relationship between capability evolution, capability substitution, and firm innovation performance (β_1 −0.462, $p < 0.05$; β_2 0.295, $p < 0.05$).

Hypothesis 2 predicted that innovation magnitude weakens the positive relationship between capability evolution and firm innovation performance while strengthening the positive relationship between capability substitution and firm innovation performance. Results of model 3 presented in **Table 4** supported this hypothesis, revealing a significant negative interaction between innovation magnitude and capability evolution (β_1 = −0.301, $p < 0.001$), and a significant positive interaction between innovation magnitude and capability substitution (β_2 = 0.902, $p < 0.001$). The results of regression analysis indicated that the more innovation tends to breakthrough, the smaller the positive impact of capability evolution on firm innovation performance, and the greater the positive impact of capability substitution on the firm.

Hypothesis 3 predicted that catch-up stages would not have a significant impact on the interaction between capability evolution and innovation magnitude, while catch-up stages would change the interaction between capability substitution and innovation magnitude. The results of our hierarchical modeling analysis in Model 4, supported this hypothesis. The interaction coefficients between capability evolution and innovation magnitude (β_1 = −0.352, $p < 0.01$), as well as the three-way interaction coefficients between

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TABLE 2 Measurement scales.

	Factor loading	CR	AVE	Cronbach's α
Capability evolution		0.932	0.773	0.932
Adjust existing capabilities and practices	0.853			
Develop the existing knowledge base	0.875			
Learn from the existing knowledge	0.894			
Seek solutions from previous experience	0.894			
capability substitution		0.886	0.598	0.886
Develop new concepts or principles	0.812			
Develop new skills that were not previously available	0.863			
Create new knowledge to replace outdated knowledge	0.851			
Learn knowledge from different knowledge bases	0.791			
Adopt different methods, practices, or processes	0.795			
Innovation magnitude		0.905	0.704	0.904
Innovation is a minor improvement over the previous technology (Reversed)	0.818			
Innovation is a breakthrough innovation	0.824			
Innovation leads to products that are difficult to be replaced with substitute using older technology	0.886			
Innovation represents a major technological advance in subsystem.	0.826			
Innovation performance		0.942	0.701	0.939
Novelty of the new products	0.843			
Number of new products	0.914			
Speed of new product development	0.861			
ratio of new products sales to total sales	0.898			
Innovative profit margins for new products	0.842			
Market share of new products	0.836			

TABLE 3 Descriptive statistics and correlation coefficients.

Variables	Mean	SD	Correlation			
			1	2	3	4
Capability evolution	3.66	1.58	**0.88**			
Capability substitution	3.89	1.38	0.38*	**0.77**		
Innovation magnitude	4.01	1.54	0.11*	−0.23*	**0.91**	
Innovation performance	3.95	1.49	0.65**	0.51**	−0.05**	**0.84**

*$p < 0.05$, **$p < 0.01$; The bold number in the diagonal position is the square root of AVE, and the others are the Pearson correlation coefficients.

capability evolution, innovation magnitude, and catch-up stages ($\beta_2 = -1.031$, $p < 0.001$) were all significantly negative, indicating that innovation magnitude weakens the positive relationship between capability evolution and firm innovation performance in both early and late stages of catch-up. The interaction coefficient between capability substitution and innovation magnitude was significant negative ($\beta_1 = -1.202$, $p < 0.001$), while the three-way interaction coefficient between capability evolution, innovation magnitude, and catch-up stages was significantly positive ($\beta_2 = 1.595$, $p < 0.001$), indicating that catch-up stages significantly affected the moderating role of innovation magnitude on the relationship between capability substitution and firm innovation performance. The results showed innovation magnitude weakens the positive relationship between capability substitution and firm innovation performance in the early stage of catch-up while strengthening the positive relationship between capability substitution and firm innovation performance in the late stage of catch-up. The moderating effects of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance in different stages of catch-up are illustrated in Figures 1–4.

Discussion

In recent years, capability reconfiguration has become an important driving force for enterprises to accelerate

TABLE 4 Results of hierarchical linear regression analysis for firm innovation performance.

Dependent variable: Firm innovation performance	Model 1	Model 2	Model 3	Model 4
Control variables				
Firm age	0.011(0.012)	0.010(0.009)	0.012(0.008)	0.005(0.006)
Firm size	0.287(0.047)***	0.157(0.037)***	0.127(0.032) ***	0.090(0.025)***
Independent variables				
Capability evolution		0.462(0.043)***	0.889(0.071)	0.519 (0.113)***
Capability substitution		0.295 (0.049)***	0.285(0.052)	0.478(0.195)*
Innovation magnitude			0.138(0.111)	−0.076(0.115)
Catch-up stages				−0.127(0.146)
Interaction between variables				
Capability evolution × Innovation magnitude			−0.301(0.074)***	−0.352(0.130)**
Capability substitution × Innovation magnitude			0.902(0.088)***	−1.202(0.210)***
Innovation magnitude × Catch-up stages				0.467(0.186)*
Capability evolution × Catch-up stages				−0.082(0.189)
Capability substitution × Catch-up stages				0.582(0.231)*
Capability evolution × Innovation magnitude × Catch-up stages				−1.013(0.272)***
Capability substitution × Innovation magnitude × Catch-up stages				1.595(0.291)***
Adjusted R^2	0.109	0.484	0.621	0.767
ΔR^2	0.115	0.376	0.139	0.148
ΔF	18.728***	105.183***	35.315***	30.524***

Standard errors in parentheses: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

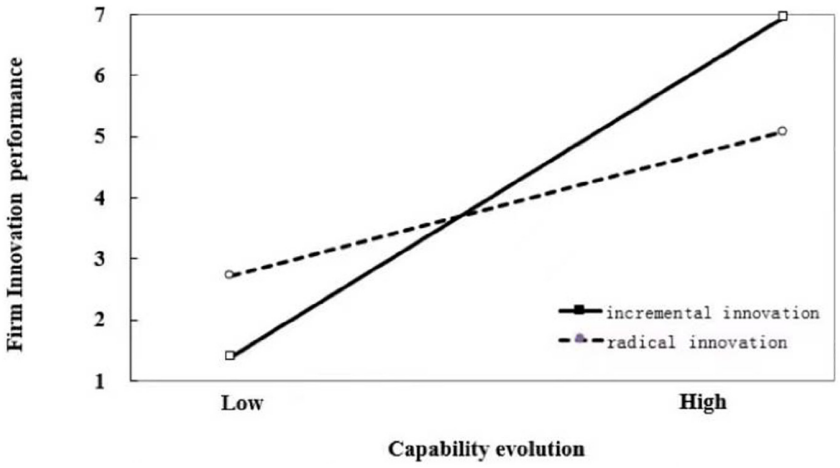

FIGURE 1
Moderating effect of innovation magnitude on the relationship between capability evolution and firm innovation performance in the early stage of catch-up.

innovation and enhance competitiveness (Chen et al., 2022). However, there are still different voices about whether evolutionary and substitutional capability reconfiguration can contribute a positive role to innovation performance (Karim and Capron, 2016; Girod and Whittington, 2017). In our results, both capability evolution and capability substitution are significantly positively correlated with firm innovation performance. This is similar to the results of some other studies (Lavie, 2006; Karim and Capron, 2016; Valdemarin and Mayrhofer, 2022; Xie et al., 2022). Moreover, the path coefficient of capability evolution impacting innovation performance is 0.462 ($p < 0.001$), which is greater than that of capability substitution ($\beta = 0.295$, $p < 0.001$). This could mean the evolutionary capability reconfiguration brings more innovation outcomes to firms (Eisenhardt and Brown, 1999; Girod and Whittington, 2015), which is in agreement with the empirical results obtained by Zhang and Lv (2014).

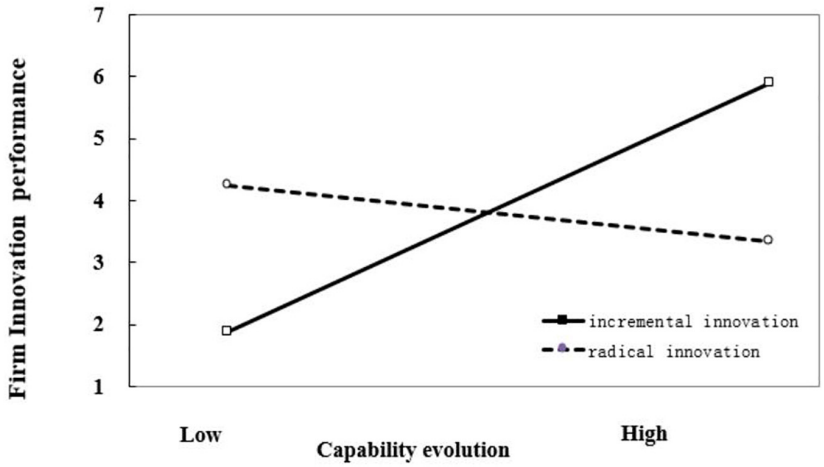

FIGURE 2
Moderating effect of innovation magnitude on the relationship between capability evolution and firm innovation performance in the late stage of catch-up.

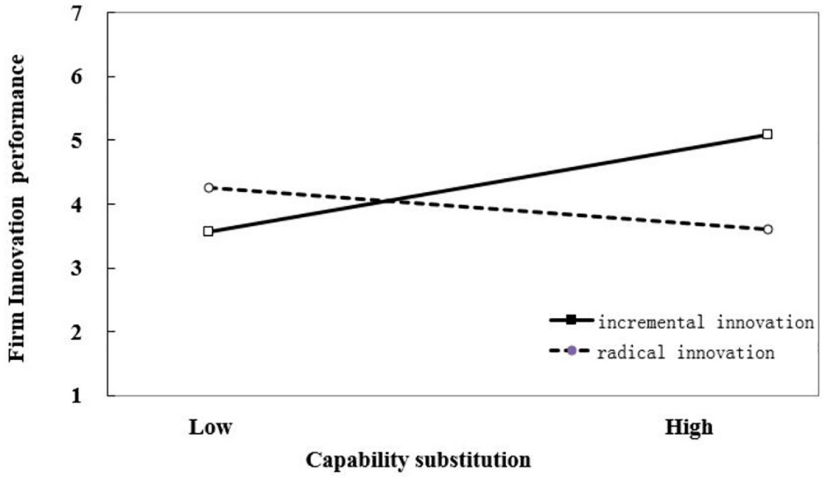

FIGURE 3
Moderating effect of innovation magnitude on the relationship between capability substitution and firm innovation performance in the early stage of catch-up.

Some studies have also shown that the heterogeneity of innovation magnitude and technical level may become important factors affecting capability reconfiguration and innovation performance (Zhong et al., 2014). In the study, it is found that the interaction coefficient for the two variables, capability evolution and innovation magnitude to innovation performance is −0.301 ($p < 0.001$). It suggests that innovation magnitude weakens this positive effect of capability evolution on firm innovation performance. Specifically, the positive effect of capability evolution on firm innovation performance will be stronger for incremental innovation than for radical innovation. Therefore, it is more suitable for the friendly and mild innovation environment to adjust and perfect the capability from the inside of the enterprise, which is similar to some findings of existing studies (Capron and Mitchell, 2009). When the innovation magnitude is low, the enterprise is mainly committed to the transformation of the technology platform, the improvement of general technical means, and existing products (Hansen and Ockwell, 2014; Figueiredo, 2017), which is exactly the strength of evolutionary capability reconfiguration. Through capability evolution, enterprises update their knowledge and technology, thus deepening their understanding of market knowledge, popular technical means, and current competition. This approach not only achieves better market performance but also reduces the excessive costs of developing new technologies (Shankar et al., 1999). The interaction coefficient of capability

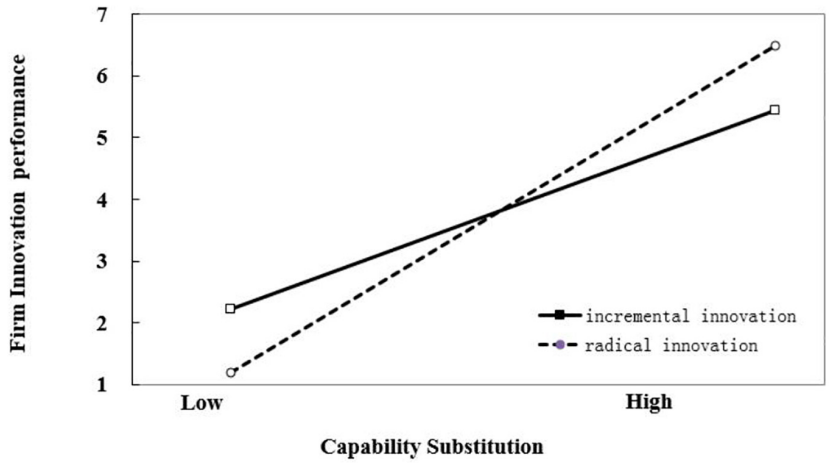

FIGURE 4
Moderating effect of innovation magnitude on the relationship between capability substitution and firm innovation performance in the late stage of catch-up.

evolution and innovation magnitude to innovation performance is 0.902 ($p < 0.001$). It suggests that innovation magnitude strengthens the positive effect of capability substitution on firm innovation performance. In other words, the positive effect of capability substitution on firm innovation performance will be stronger for radical innovation than for incremental innovation. The results show capability renewal based on externally sourced capabilities is more suitable for the innovation environment full of challenge and competition (Capron and Mitchell, 2009). Rapid innovation is the subversion and reconstruction of existing knowledge and technology. Through exploratory learning and capabilities rebuilding, it can get rid of the dependence on the existing knowledge inertia, experience inertia, and learning inertia, which is more conducive to promoting enterprise innovation (Chandy and Tellis, 2000; Li and Zeng, 2019).

Furthermore, our results also show that the impact of innovation magnitude on capability substitution varies at different stages of technological catch-up. This is consistent with previous studies: dynamic capability and innovation strategy of enterprises vary at different stages of technology catch-up (Alpkan and Gemici, 2016; Peng et al., 2021; Zhang L. et al., 2021). The interaction coefficient between capability substitution and innovation magnitude was significant negative ($\beta_1 = -1.202$, $p < 0.001$), while the three-way interaction coefficient between capability evolution, innovation magnitude, and catch-up stages was significantly positive ($\beta_2 = 1.595$, $p < 0.001$). This suggests that the catch-up stage exerts a significant effect on the moderating effect of the innovation magnitude on the relationship between capability substitution and firm innovation performance. In the early stage of catch-up, enterprises in emerging economies had low technology level and weak knowledge reserves (Dutrénit, 2004; Zhong et al., 2014), and innovation based on learning and imitation was more suitable (Mathews, 2002). It is necessary for enterprises to complete their knowledge reserve and gradually complete their capability accumulation, which is the focus of enterprise strategic development (Figueiredo, 2017). Due to the constraints of their organizational inertia and path dependence, the greater the innovation magnitude is adopted, the more aggressive capability reconfiguration will make enterprises face higher innovation costs and a greater risk of failure (Zhong et al., 2014). With the latecomer firms approaching the technological frontier, the technical level and innovation capability have been comprehensively improved (Lv and Su, 2009; Figueiredo, 2017). At this time, if enterprises want to further innovate, they must constantly break the original conventions and practices, and break through the existing knowledge domain and technology set (Hu et al., 2021). Radical innovation has the characteristics of innovating existing technologies, leading the market, and reshaping consumer preferences (Zhou, 2006), which is conducive to enterprises to fundamentally establish the status of "sheep", and increase their market competitiveness by increasing brand loyalty and other ways (Zhong et al., 2014). And it can further reduce the cost of production and advertising, thus in this stage, the more radical the innovation is, the more conducive to the improvement of enterprise innovation performance.

On the other hand, the negative moderation of innovation magnitude on the relationship between capability evolution and firm innovation performance does not show a directional change in the early and late stages of catch-up. Innovation magnitude always negatively moderates the positive relationship between capability evolution and firm innovation performance both in the whole stages of catch-up. The empirical results further show that the negatively moderating effect of innovation magnitude on the relationship between capability evolution and enterprise innovation performance in the later stage of

catch-up is greater than that of the early stage, with the three-way interaction coefficient being negative 1.013 ($p < 0.001$). Xie et al. (2022) noted that capability evolution allows enterprises to adjust the method of value innovation and the direction of product innovation. This capability is undoubtedly to realize the transfer and application of structural knowledge from a familiar domain to a completely new domain (Berends et al., 2016). Capability evolution is much more dependent on the existing organizational routine, knowledge, and experiences (Dang et al., 2013). The lower the magnitude of innovation, the more effective the knowledge inertia can reduce the complexity and uncertainty in innovation, and the more effective the capability evolution based on exploiting learning (Xie et al., 2016; Li and Zeng, 2019). On the contrary, the more radical the innovation is, the more enterprises need to subvert the original technical methods and management philosophy and try more exploratory learning to acquire new knowledge, methods, and skills (Chandy and Tellis, 2000; Liu et al., 2017). In this case, the more difficult the role of capability evolution is to play. Moreover, the closer the enterprises are to the technology frontier, the stronger the demand for the acquisition of new knowledge, methods, and technologies is, and the capability to adjust, add and improve organizational routine will be continuously weakened.

Conclusion

This study provides a detailed understanding of the mode of capability reconfiguration and innovation magnitude and their important contributions to firm innovation performance. Based on the perspective of dynamic capability, this study uses moderating effect model with three-way interaction variables to examine the impact of innovation magnitude and catch-up stage on the relationship between capability substitution and firm innovation performance. The main conclusions are as follows: Firstly, both capability evolution and capability substitution, as two common forms of capability reconfiguration, have a positive impact on firm innovation performance, which is consistent with the mainstream research findings (Lavie, 2006; Karim and Capron, 2016). Secondly, innovation magnitude was a moderator between capability reconfiguration and firm innovation performance. Innovation magnitude weakens the positive relationship between capability evolution and firm innovation performance, but it strengthens the positive relationship between capability substitution and firm innovation performance. This result shows that the heterogeneity of innovation magnitude ultimately affects the reconfiguration mode of enterprise capability and its effect through the differences in knowledge composition, organizational learning, technological trajectory, innovation strategy, and so on (Li and Zeng, 2019). Thirdly, in the early and late stages of catch-up, there is a great difference in the intensity and direction of the moderation of innovation magnitude on the relationship between capability reconfiguration and innovation performance. The results make a basic conclusion: in the early stage of catch-up, the lower the innovation magnitude, the more obvious the positive role of capability evolution; but in the late stage, the higher the innovation magnitude, the more significant the positive role of capability substitution is. This study contributes to the dynamic capability theory and the catch-up theory: it specifically demonstrates how the dynamic capability reconfiguration path is affected by the technology catch-up process; it also explains that the technology catch-up strategy of the latecomer enterprises should be appropriately adjusted according to the innovation magnitude of the enterprises and the industry. This study contributes to the theory of dynamic capability and catch-up by revealing how innovation magnitude affects capability reconfiguration and subsequent innovation performance in different catch-up stages. It also reminds managers to take full account of the innovation magnitude and catch-up stage in their decision-making.

Theoretical implications

This study makes several contributions. First, this study contributes to the literature on dynamic capability by providing one of the few empirical tests of capability reconfiguration on firm innovation performance. Through testing and comparing the performance outcomes of two forms of reconfiguration, this research supports the assertion that evolution and substitution have different effects on organizational innovation (Lavie, 2006; Girod and Whittington, 2017). In addition, we further found distinct contributions of capability evolution and capability substitution on innovation outcomes in different catch-up stages. These findings are not only a response to the literature based on the strategic evolution and capability evolution of the enterprises in developed countries (Helfat and Peteraf, 2003; Davis and Tomoda, 2018), but also to explore and describe the capability development path of the latecomer enterprises, which improve and supplement the theory of capability accumulation and capability construction of catch-up enterprises (Dutrénit, 2004; Figueiredo, 2017).

Second, this study contributes to the theory of incremental and radical innovation in several ways. For one thing, departing from past empirical studies which either consider incremental/radical innovation as an explanatory variable (Baker et al., 2014; Kim et al., 2019; Wang et al., 2020) or consider it as being explained (Dunlap-Hinkler et al., 2010; Zhou and Li, 2012; Thneibat, 2021). By using innovation magnitude as a moderator, the present study examines how incremental and radical innovation affects the innovation process and outcome based on a dynamic capability perspective. The finding enriches our understanding of the underlying mechanisms for

which innovation magnitudes influence the capability evolution process (Zhang and Lv, 2014; Zhou et al., 2019).

For another, previous studies suggested that firms have distinctly different performances in incremental and radical innovations (Morone, 1993; Woschke et al., 2017), our results not only support this view but also reveal possible mechanisms by which these differences arise. The path dependence, organizational inertia, and the correlation of product innovation on the old knowledge and experience under the background of different innovation magnitude greatly affect the role of capability evolution and capability substitution, which provides new research ideas for rapid innovation and capability reconstruction in the future (Chen and Qiu, 2022; Wang W. et al., 2022).

Third, our study contributes to catch-up theory by verifying the significant effects of catch-up stages on the moderating effects of innovation magnitude on the relationship between capability reconfiguration and firm innovation performance. The existing literature on technological catch-up holds that the catch-up stages of firms may be important variables that influence the direction and magnitude of capability building (Kim, 1998; Dutrénit, 2004). Our research provides an attempt to reveal that the early stage and late-stage catch-up are not the only factors that determine the capability construction of enterprises, the innovation condition (incremental or radical) faced by enterprises is also one of the important factors.

Practical implications

The findings have implications for managerial practices. Capability reconfiguration is considered an important driver of technology innovation and a firm's growth (Ovuakporie et al., 2021). Our research suggests that capability substitution is not necessarily the most beneficial way for innovation, and the capability evolution is a model worth considering under relatively moderate innovation magnitude for decision-makers (Zhang and Lv, 2014). In practice, other factors, such as the magnitude of innovation, should be considered in choosing evolution or substitution. If the enterprise is in the traditional manufacturing enterprise, more inclined to gradual innovation environment, capability evolution is more recommended; on the contrary, if the enterprise is high-tech or emerging innovative enterprises, more inclined to radical innovation environment, capability substitution should be the first choice of managers (Zang and Zhang, 2021; Wang D. et al., 2022). More importantly, the strategy makers of the enterprise should clearly understand the development stage and knowledge potential of the enterprise and develop the capability reconfiguration strategy based on fully considering the degree of industrial competition and enterprise innovation magnitude (Liu and Dang, 2013).

Limitations and further research

First of all, this study focuses on the influence of technological radical/incremental innovations on the dynamic capability and innovation outcomes, which are the most prominent types of innovations in manufacturing firms (Phene et al., 2006; Liu et al., 2020). However, what's worth noticing is that the other types of innovation such as product innovation and market innovation are also important for a firm's capability development and performance (Davis and Tomoda, 2018). Future studies can investigate the effects of other types of resource constraints.

Second, we discuss the impacts of innovation magnitude on the relationship between capability reconfiguration and innovation performance in the early and late stages of catch-up, while there are several patterns of catch-up such as path-following, path-skipping, and path-creating (Lee and Ki, 2017), and a few different stages such as initial, following, synchronizing and leading (Sui and Chen, 2015). The development and evolution of the innovation capability of firms may be distinguished in different modes of stages of catch-up (Guo and Zheng, 2019). Future studies can explore the capability evolution and innovation outcome of different modes and stages. Thirdly, a potential extension of this study would be to employ a longitudinal study design to empirically test causality and assess innovation capability and firm performance outcomes over time.

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.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/ participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

PH and YH designed the research and methodology, compiled the literature, and put forward the policy recommendations. GW provided the guidance throughout the entire research process. All authors contributed to the article and approved the submitted version.

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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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Executive poverty experience and innovation performance: A study of moderating effects and influencing mechanism

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This paper analyzes the impact mechanism of executive poverty experience on innovation performance from the two logics of "innate endowment" and "endogenous power." It then explores the moderating role of executive characteristics, firm nature, and market competition from the perspective of heterogeneity, and finally proves the influence mechanism. Using the data of Chinese A-share listed companies from 2012 to 2020, the empirical results show that executives' poverty experience improves corporate innovation performance. Further studies find that female executives with poverty experience have a more significant impact on innovation performance. Additionally, state-owned enterprises (SOEs) weaken the positive effects of executives with poverty experiences on innovation performance. The impact of executive poverty experience on innovation performance is more significant in fierce market competition. The mediating result suggests that executive poverty experience improves innovation performance partly by inhibiting R&D manipulation. The findings remain valid through Propensity Score Matching (PSM) tests, the Heckman two-stage, and alternative indicator measures. Using the early life poverty experience of executives, this study promotes research on the factors influencing corporate innovation. It also provides empirical evidence for improving corporate innovation performance through a study of moderating effects and influencing mechanisms.

KEYWORDS

poverty experience, innovation performance, executive gender, market competition, R&D manipulation

Introduction

The innovation has become a decisive factor in accelerating economic growth, profoundly affecting the competitive landscape of major nations, development of enterprises, and quality of life of people universally (Gherghina et al., 2020; Pan et al., 2022). The Chinese government attaches great importance to science and technology

innovation and has achieved remarkable results. The World Intellectual Property Organization (WIPO) recently published its Global Innovation Index Report 2021, in which China ranked 12th, increasing steadily over the past 9 years. As the main force of innovation in the market economy, enterprises play an essential role in enhancing a country's comprehensive innovation level and building an innovative nation (Gherghina et al., 2020). Consequently, understanding the internal rules of corporate innovation activities and studying their influencing factors have always been of interest to both theoretical and practical circles.

As decision-makers and senior executives of companies, executives' background experiences influence corporate investment and financing decisions, as well as growth and development, etc. (Bernile et al., 2017; Bandiera et al., 2020; Park et al., 2021). Innovation is an essential strategy for sustainable corporate development, and executives with overseas, academic, and innovation experience have a positive impact on corporate innovation (Yuan and Wen, 2018; Lee J. M. et al., 2020; Quan et al., 2021).

Early life experiences of poverty can influence executives' cognitive structure, decision-making preferences, value orientations, and so on (Holman and Silver, 1998; Pandya, 2020; O'Sullivan et al., 2021). This influence is "imprinted" as cognitive habits and behavioral characteristics, persistent in the subconscious of executives and reflected in their decisions (Marquis and Tilcsik, 2013). Executives' early life experiences of poverty, such as lack of materials, lack of education, family financial difficulties, economic turmoil, and the surrounding poor environment, are more likely to shape their cognitive patterns, mental preferences, and value judgments later in life (Malmendier et al., 2011; Xu and Ma, 2021).

From a neuroscientific perspective, early life experiences of poverty have profound effects on the brain and biological systems. The traumatic impact on the brain is persistent and irreversible; and the early economic stress and upbringing of decision-makers continue to influence their psychological characteristics and financial behaviors (Adamkovič and Martončik, 2017; Ayllón and Fusco, 2017); Long et al. (2020) found executives who have experienced early life poverty, reduce the risk of stock price collapse.

Executives, as the core of management and strategic decision-making of listed companies, are more likely to be influenced by their early life poverty experiences in corporate decision-making, while corporate innovation is an important activity that concerns competitive market position and future sustainable development. Therefore, it is essential to study the impact of executives' early life poverty experiences on corporate innovation performance. Firms and industries, as well as personal attributes, have significant effects on executive behavior. However, the extent to which poverty affects firm innovation performance and the boundaries of its effects are yet to be explored in related research. This study provides an opportunity to close this gap.

The research questions addressed in the present study are as follows: How does an executive's early life experience of famine affect innovation performance and will the role of this poverty experience be affected by other factors? To solve these two problems, our research objectives include clarifying the theoretical logic of the impact of executive poverty experience on corporate behavior, analyzing the boundary conditions of the impact of senior executives' poverty experience, discussing the interactive influence of internal and external characteristics of enterprises on enterprise investment, exploring the mechanism to improve the innovation performance of enterprises, and providing reference.

This study takes Chinese A-share listed companies from 2012 to 2020 as the research object and uses a multiple regression analysis method to analyze the relationship between executive poverty experience and enterprise innovation. Referring to the research of Long et al. (2020), we examine whether there is an early poverty experience in the childhood of senior executives by using whether they experienced the "Great Chinese Famine" from 1959 to 1961. The number of patents applied for by the enterprise within 3 years is used as the research variable for research innovation, and the number of patents granted within 3 years is used as the robustness test. Patents include invention, utility model, and design patents. Invention patents are more innovative than conventional patents. In this study, different patent types are regressed separately to understand the impact of executive poverty experience on various types of innovation.

This study adds scientific value by revealing the impact and mechanism of the early experience of senior executives on innovation from the perspective of poverty experience, and explores the boundary conditions of these experiences from many aspects, supplementing the relevant theories of senior management teams and enterprise innovation. Previous studies have explored the impact of executives on corporate decision-making based on the economic man hypothesis. This study found that executives with a higher moral level could inhibit R&D manipulation and improve innovation performance, deepening the cognition of corporate decision-making behavior motivation based on moral emotional factors. Thus, we analyze from the perspective of gender, property rights, and market competition to set a framework for the research hypothesis (see **Figure 1**) and extend the existing research on related topics.

The remainder of this paper is organized as follows. Section "Theoretical analysis and hypothesis development" reviews the relevant literature and proposes theoretical assumptions. Section "Data and methods" introduces the study data and methods. The results are presented in Section "Results." Section "Discussion" discusses these findings. Finally, the conclusions, theoretical and practical implications, and current limitations are presented in Section "Conclusion."

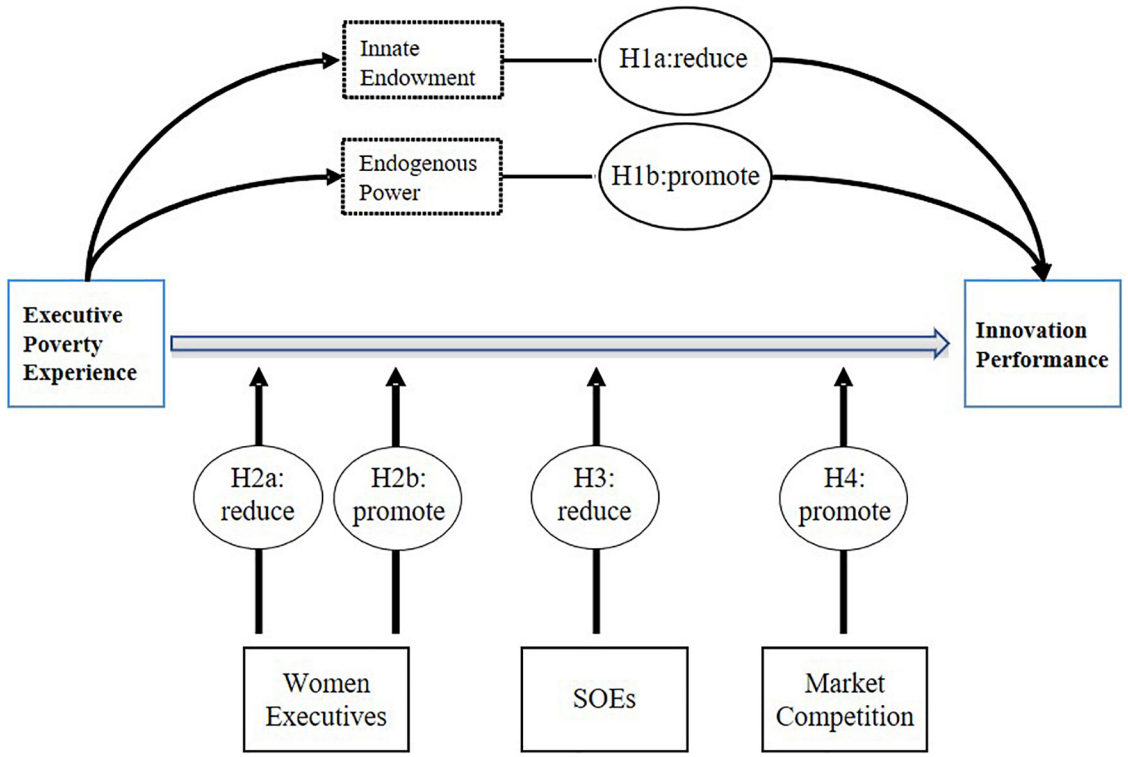

FIGURE 1
Conceptual framework.

Theoretical analysis and hypothesis development

Upper echelons theory suggests that innovation strategy choice, innovation outcomes, and innovation efficiency are influenced by executives' limited rationality, cognitive patterns, and internal and external factors of the firm (Hambrick and Mason, 1984; Li Q. et al., 2018; You et al., 2020). To some extent, an executive's personal experience will impact the distinctive knowledge structure, cognitive patterns, and value orientations in influencing their decision-making, feeding back to the firm, affecting strategic decision-making (Hambrick and Mason, 1984; Kong et al., 2021). When faced with opportunities to expand overseas, identify threats, and integrate resources, executives with poverty experiences are influenced by the subconscious "imprint" of their early life poverty experiences, which affects their risk appetite (Marquis and Tilcsik, 2013). In particular, when faced with risky activities such as innovation investment, the influence of early life experiences may be stimulated and amplified. Behavioral decisions may be characterized as "stigmatized" when faced with innovation activities. Therefore, this study analyzes the mechanism of poverty experiences on executives' innovation decisions from the two logics of "innate endowment" and "endogenous power."

First, from the perspective of "innate endowment," the early stage of growth with fewer resources leads to a subconscious sense of material deprivation among executives, prone to attention depletion and risk aversion, and negatively impacts corporate innovation. Attention depletion refers to the fact that the experience of long-term poverty tends to cause individuals to pay more attention to immediate survival issues, obtain immediate benefits, and lack attention to long-term development issues (Haisley et al., 2008; Shah et al., 2012; Dalton et al., 2020; De Bruijn and Antonides, 2021). Therefore, individuals tend to focus more on immediate survival issues and less on long-term development issues. Innovation is characterized by high upfront investment costs and irreversibility of investment (Merton, 2013; Nanda and Rhodes-Kropf, 2017). If executives with poverty experience suffer from attention loss, they are likely to overlook the positive implications of innovation decisions on the company's future development. In addition, early life experiences of poverty can limit human capital accumulation, and executives with a background in poverty may be more likely to feel insecure and risk-averse when faced with external changes (Lusardi and Mitchell, 2014; Bernile et al., 2017). Corporate innovation, as an activity with high uncertainty and large investment amounts, may deter executives from breaking the mold and taking innovation risks. The psychological effect of "innate

endowment" will make executives with poverty experience easily form the thoughts of "focusing on the present" and "seeking stability"; their behavioral decision-making will be more stable. However, this has an adverse impact on corporate innovation performance.

Secondly, the logic of "endogenous power" suggests that the stress of early life poverty experiences can sharpen executives' willpower and self-control, which in turn leads to the motivation to "change." Poverty may lead executives to be mentally and voluntarily refined. Executives are more likely to form tenacious characters and action forces that are indomitable and never give up (Stephens et al., 2014). Executives who have experienced poverty during their youth are more likely to consider change when they are poor. Through their efforts at a later stage, they can change the poverty situation of their families, where "seeking change" becomes a meaningful way to change their predicament and a major characteristic of innovation. Born and raised in poverty, individuals becoming executives will have a process of cognitive reconstruction of risk, rethink the value of risk, re-perceive the size of risk, and find it easier to eliminate the fear of risk and uncertainty (Heilman et al., 2010). This results in stronger psychological tolerance and failure tolerance. Thus, these executives are more likely to choose innovative activities to promote the development of the enterprise when faced with innovative decisions. In this regard, executives with early life poverty experiences are more likely to devote more resources and energy to creative R&D activities.

Based on the above analysis, the following hypotheses are proposed:

H1a: Based on the logic of "innate endowment," innovation performance is lower in firms with executives who have experienced poverty.

H1b: Based on the logic of "endogenous power," innovation performance is higher in firms with executives who have experienced poverty.

According to upper echelons theory, executives of different genders can significantly differ in risk appetite and behavioral decisions (Hambrick and Mason, 1984; Liu, 2018; Post et al., 2022). Earlier studies found significant differences in investment decisions and risk preferences adopted by executives of different genders, with women exhibiting higher risk aversion and being less likely to be overconfident (Cumming et al., 2015; Chen et al., 2016). According to psychology, women's emotional experiences are stronger and it is easier to perceive and identify external stimuli (Berkley, 1997). Consequently, women are prone to be nervous about risks (Maxfield et al., 2010). Based on conservative and robust traits, female executives are more willing to improve corporate disclosure (Gul et al., 2011); Faccio et al. (2016) analyzed European listed companies and found that female CEOs take 2% less risk than male CEOs, demonstrating that female CEOs exhibit more robust behaviors. Thus, when female executives experience poverty, "innate endowments," and "gender differences," may result in stronger risk-averse preferences and conservative business and investment decisions in high-risk innovation activities, possibly reducing company innovation performance.

However, women are at a disadvantage in the workplace; they need to work harder, and have a longer-term and innovative strategy to overcome gender biases in the workplace to gain promotion (Wille et al., 2018). For conservative and steady women, it is challenging to assume the role of corporate executives and lead their companies to success. In the context of the poverty experience, women need to be more decisive, independent, and hard working to thrive in the workplace in the long-term. Moreover, in the field of innovation, it takes courage to take risks and the ability to deal with them. Female executives possess unique human capital, such as attentiveness and sensitivity, and such attributes may help female executives grasp changes in customers and markets, which are important drivers for corporate innovation (Torchia et al., 2018; Audretsch et al., 2022). Finally, female executives are more likely to adopt a democratic approach and have greater influence, which can increase organizational members' motivation to participate in decision-making (Gul et al., 2011; Carbajal, 2018). A tolerant and democratic attitude also contributes to a favorable innovation climate in the company, which drives the technological innovation process. Accordingly, when female executives have experienced poverty, they may abandon traditional female risk preferences and reinforce the logical path of "endogenous power," having a positive impact on the innovation performance of the company.

Based on the above analysis, the following hypotheses are proposed:

H2a: Female executives suppress the positive impact of poverty experiences on firm innovation performance.

H2b: Female executives promote a positive effect of poverty experience on firm innovation performance.

State-owned and private enterprises differ significantly in terms of corporate governance, operational objectives, investment decisions, and so on, which are likely to affect the motivation and costs associated with innovation decisions (Belloc, 2014; Jia et al., 2019). State owned enterprises (SOEs) generally face burdens such as redundant employee costs, high tax rates, and policy investments, which crowd out significant corporate economic resources and adversely affect innovation activities that require them. Additionally, SOEs implement annual and tenure appraisal systems; where an important indicator of the evaluation of senior management is the level of value maintenance and appreciation of state-owned assets, directly affect the political advancement of senior management

(Bai and Bennington, 2005). However, innovative investment activities are characterized by high investment and high-risk. Once the investment fails, the profit level and asset situation of the enterprise fluctuate (Hock-Doepgen et al., 2021), which has a negative impact on the performance appraisal of executives. In cases where the operational pressure of SOEs conflicts with innovation risk-taking, executives with poverty experience are more likely to adopt a strategy of stable operations and reduce corporate innovation activity. Therefore, SOEs undermine the "endogenous power" logic of the impact of executives with poverty experience on innovation. In situations of conflict between innovation risk-taking and the operating pressures of SOEs, executives with poverty experience are more likely to adopt a strategy of stable operation and reduce corporate innovation activities.

Based on the above analysis, the following hypothesis is proposed.

> H3: SOEs significantly inhibit the positive effects of executives with poverty experiences on innovation performance.

Competitive market pressure is an exogenous driving force for firms to innovate, assisting them to gain competitive advantage in the market. Competitive market pressure can also influence executives' innovation behavior. Firms face increased business risks in a competitive market environment, and innovation assists in gaining a certain monopoly market and excess profits through R&D patents (Boone, 2001). Andrevski and Ferrier (2019) found that excessive competition leads to higher costs and lower performance; however, when firms have special technological resources, they can benefit from competition. Therefore, in the face of fierce market competition, corporate executives have strong incentives to conduct R&D innovation activities based on salary contracts, occupational safety, and professional reputation. For executives with poor experience, perceived market or business risk is greater when the company faces a higher degree of external competition. Therefore, from the logical perspective of "endogenous power," in a situation of intense market competition, executives with poor experience are more motivated to proactively promote corporate innovation, thereby acquiring innovation benefits, and gaining advantages in market competition. However, when market competition is weak, corporate innovation gains are insufficient. Therefore, executives cannot be encouraged to carry out innovation activities.

Based on the above analysis, the following hypothesis is proposed.

> H4: The degree of market competition significantly increases the positive effect of having poverty-experienced executives on innovation performance.

Data and methods

Sample selection

This study focuses on the innovation performance of a full sample of companies and selects A-share listed companies from 2012 to 2020 as the research object. The following treatments were carried out during the data collection process. We excluded financial industry code companies, including banks and non-banking financial enterprises, insolvent companies, ST and *ST companies, and samples with missing data. The tails of the key continuous variables were reduced by 1% above and below. Ultimately, 20,834 observations were obtained. The executive background, corporate characteristics, and other data are taken from the China Stock Market Accounting Research Database (CSMAR) and China Research Data Services Platform (CNRDS). The statistical software used in this study is STATA 15.0.

Variable measures

Explanatory variables

We examined general managers responsible for making and executing business decisions. There are two methods to measure the early life poverty experience of senior executives: one is whether senior executives were born in a poor national county, and the other is whether senior executives experienced economic difficulties in their childhood, such as 1929–1933 in the United States and 1959–1961 in China (Long et al., 2020). Information disclosure of senior executives in listed companies has less disclosed information on the origin of senior executives, especially at the county level. Further, senior executives seldom publicly mention their place of birth. Thus, there are many missing values in collecting whether senior executives were born in poor counties, regardless of whether the information was from the company's annual report or online. However, the corporate annual report discloses the age information of senior executives, which can be used to obtain complete data on whether senior executives have experienced poverty. Therefore, the early life poverty experience is determined by whether senior executives experienced the "Great Chinese Famine" from 1959 to 1961. With regard to the definition of childhood, the upper limit of the child time limit is roughly defined as 14 years old, regardless of the use of age, brain development, or psychological maturity indicators (Tulving, 2002). This study selected the period of 0–14 years as the time span for childhood, considering the continuity of psychological development. The Famine is assigned a value of 1 when the executive was born between 1947 and 1961, meaning that the executive's childhood was from 1959 to 1961; otherwise, the value is 0.

Explained variables

The variables used to measure the innovation performance of enterprises are typically the number of patent applications or patents granted to enterprises. However, the period for granting patents cannot be unified effectively because the time from application to grant varies, with invention patents taking longer to grant (generally 2–3 years) and other patents taking shorter. Therefore, the number of patents applied for by enterprises is used as the research variable, and the number of patents granted within 3 years is used as a robustness test. There are three main types of patents: invention, utility model, and design. Different patents differ significantly in their innovativeness and invention patents are generally considered more innovative. We use three different measurement methods to measure the innovation performance of enterprises. The variable SLpatent1 is calculated as the natural logarithm of the sum of all patent applications; the variable Lpatent2 is calculated as the natural logarithm of the number of invention patent applications; and the variable Lpatent3 is calculated as the natural logarithm of the sum of the number of utility model patents and design patent applications, respectively.

Moderating variables

This study selected three moderating variables from the perspective of heterogeneity to test the boundary effect of the executive poverty experience: executive gender, the nature of property rights, and the degree of market competition. First, the variable Female is set, and Female has a value of 1 if the executive is female, and 0 otherwise. In the next step, the variable Soe is set to have a value of 1 when the executive's company is a SOE and 0 if it is a private enterprise. In this study, we evaluate whether it is a SOE based on the top ten shareholders of the enterprise, and define it as a SOE if the largest shareholder of the company is the state or national legal entity. The third step involves setting the variable CompH and measuring the degree of marketplace competition using the Lerner Index. To calculate each company's Lerner index, the specific formula is PCM = (operating income operating costs–selling expenses–administrative expenses)/operating income. The industry average of the Lerner index calculated above is reduced to obtain a measure of competitive impact; that is, the Lerner index of a single listed company is subtracted from the sales-weighted Lerner index within the industry. The larger the CompH variable, the higher the competitive position in the industry and the lower the degree of competition; the smaller the CompH variable, the higher the competitive pressure faced by the company. The regulatory variable is multiplied by the independent variable because of the regression, and the magnitude, significance, and positive and negative signs of the multiplicative term illustrate the extent of the regulatory effect. Since the independent variable is a 0–1 variable, it is easy for the interactive term to produce strong collinearity. Therefore, in the regulatory effect model, the independent and regulatory variables are centralized (i.e., the independent variable minus the sample mean), and the interactive term is generated for multiple regression analysis.

Control variables

Some firm-specific characteristics and fixed effects may affect innovation performance and thus should be controlled. Previous studies indicate that innovation performance is more likely to be created in firms with lower leverage ratios, higher profitability, more total assets, longer listing durations, more intangible assets, or more free cash flow (Acharya and Xu, 2017; Petruzzelli et al., 2018; Xin et al., 2019b). Previous studies also indicate that sales growth, cash holdings, ownership concentration, and management shareholding influence innovation performance (Belloc, 2012; De Jong et al., 2014; Yang et al., 2015; Xin et al., 2019a; Lee C. et al., 2020; Zhang et al., 2021).

Consistent with prior research, this study controls for the following factors that may impact firms' innovation performance. The leverage ratio is measured as the ratio of total debt to total assets (Xin et al., 2019b). Firm profitability is measured using return on assets (ROA) (Acharya and Xu, 2017). Firm growth is a proxy for the sample firm's market performance and is measured as current sales revenue minus previous sales revenue, divided by current sales revenue (De Jong et al., 2014). Firm size is measured by log-transformed total assets at the year-end (Petruzzelli et al., 2018). The firm's listing age is measured by the log-transformed (one plus) listing duration (Petruzzelli et al., 2018). Tangible assets are fixed assets scaled by total assets (Acharya and Xu, 2017). Equity concentration controlled for the sample firm's shareholders dominates and is measured by the percentage of shares owned by the largest shareholder (Belloc, 2012; Yang et al., 2015). Free cash flow is measured as the ratio of a company's cash flow from operating activities to total assets (Xin et al., 2019a). Cash holdings are measured using cash and cash equivalents scaled by total assets (Acharya and Xu, 2017). Management shareholding is measured as total management shareholding divided by the total number of shares (Zhang et al., 2021). Additionally, the regression model includes industry and year dummy variables, which can be used to control for the impact of industry and year (Zhang et al., 2021). **Table 1** presents the variable names, symbols, and definitions for all the variables.

Descriptive statistics

Table 2 presents the descriptive statistics of the variables. The mean value of SLpatent1 is 0.791, the median is 0, and the maximum value is 9.724. The mean value of Lpatent2 is 0.613 and the maximum value is 8.996. The mean value of Lpatent3 is 0.483 and the maximum value is 9.198. The mean value of the independent variable Famine is 0.186, indicating that the percentage of executives who experienced the Great Chinese

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TABLE 1 Variable definitions.

Nature of variables	Variable name	Variable symbols	Variable definition
Dependent variable	Corporate innovation performance	SLpatent1	Natural logarithm of the number of invention, utility and design patent applications of the company
		Lpatent2	Natural logarithm of the number of invention patent applications of the company
		Lpatent3	Natural logarithm of the sum of the number of utility and design patent applications for the company
Independent variable	Executive poverty experience	Famine	The value of this indicator is 1 if the executive has experienced the "3 Years of Difficulty Period" as a child, i.e., was born between 1947 and 1961. Otherwise, it is 0.
Adjustment variables	Executive gender	Female	Female is assigned a value of 1, or 0 otherwise.
	Property rights	Soe	State-owned enterprises take the value of 1 for this indicator, while private enterprises take the value of 0
	Market competition	CompH	The Lerner Index, adjusted for industry
Control variables	Financial leverage	Leve	leverage ratio, i.e., total liabilities divided by total assets
	Profitability	Roa	Net profit margin on total assets, i.e., the ratio of a company's net profit to its total assets
	Firmgrowth	Growth	Current period sales revenue minus prior period sales revenue, divided by current period sales revenue
	Firm size	Size	Natural logarithm of total assets at the end of the year
	Firm age	Listage	Natural logarithm of the number of years the company has been listed
	Size of fixed assets	Ppeta	Ratio of fixed assets to total assets
	Shareholding Concentration	Share1	Percentage of shareholding of the largest shareholder
	Free cash flow	Cfo	Ratio of cash flow from operating activities to total assets of the company
	Cash holding levels	Cash	Ratio of the company's cash and cash equivalents to the company's total assets
	Management shareholding	Esh	Total number of shares held by management divided by total number of shares in the company
	Industry dummy variables	Indu	Following the guidelines of the Industry Classification of Listed Companies (2012 Edition) of the Securities and Futures Commission, the manufacturing industry is classified according to the secondary industry code, while the remaining sector is classified according to the primary industry code.
	Year dummy variables	Year	The study sample covered a period of 19 years, and 18 dummy variables were generated.

TABLE 2 Descriptive statistics.

Variables	Average value	Standard deviation	Minimum value	25th percentile	Median	75th percentile	Maximum value
SLpatent1	0.791	1.380	0.000	0.000	0.000	1.099	9.724
Lpatent2	0.613	1.165	0.000	0.000	0.000	0.693	8.996
Lpatent3	0.483	1.111	0.000	0.000	0.000	0.000	9.198
Famine	0.186	0.389	0.000	0.000	0.000	0.000	1.000
Female	0.068	0.251	0.000	0.000	0.000	0.000	1.000
SOE	0.314	0.464	0.000	0.000	0.000	1.000	1.000
CompH	0.022	0.136	−0.824	−0.043	0.014	0.085	0.551
Leve	0.410	0.203	0.053	0.244	0.398	0.560	0.881
Roa	0.041	0.059	−0.244	0.016	0.039	0.070	0.193
Growth	0.187	0.658	−0.848	−0.049	0.092	0.260	4.802
Size	22.143	1.276	19.902	21.218	21.960	22.851	26.179
Listage	1.985	0.927	0.000	1.386	2.197	2.833	3.296
Ppeta	0.209	0.158	0.002	0.087	0.177	0.296	0.695
Share1	0.344	0.146	0.087	0.231	0.324	0.441	0.743
Cfo	0.049	0.067	−0.149	0.011	0.048	0.089	0.239
Cash	0.164	0.126	0.012	0.074	0.128	0.216	0.609
Esh	0.153	0.205	0.000	0.000	0.016	0.298	0.685

Famine in the sample is 18.6%. The descriptive statistics of the moderating variables show that the proportion of female executives in China's listed companies is very low, accounting for only 6.8%. SOEs accounted for 31.4% of the sample, and the average Lerner index is 0.022. The descriptive statistics of the other control variables are similar to those in related studies.

Results

Correlation analysis

Table 3 provides the Pearson correlation coefficient matrix of key variables. The results show that the correlation coefficient between SLpatent1 and Lpatent2 is 0.956, and the correlation coefficient between Lpatent2 and Lpatent3 is 0.899. The correlation coefficient between Lpatent2 and Lpatent3 is 0.784. These results indicate that the correlation of the three alternative variables of innovation performance is very high, consistent with the index setting. The correlation coefficient of the independent variable Famine and SLpatent1 is 0.019, the correlation coefficient of the independent variable Famine and Lpatent2 is 0.013, and the correlation coefficient of Famine and Lpatent3 is 0.032. Famine is significantly and positively correlated with SLpatent1 and Lpatent3; however, has weaker significance with Lpatent2. Without controlling for other factors, these results suggest that executives who have experienced the Great Chinese Famine have a significant positive correlation with corporate innovation performance, which to some extent supports the previous hypothesis. According to Table 3, there is no significant multicollinearity in the study variables. In support of this conclusion, the highest off-table VIF value is only 2.05.

Empirical regression results

Table 4 shows the impact of executive poverty experiences on enterprise innovation performance. Columns (1–3) show the univariate regression results of the independent variable Famine on the dependent variables SLpatent1, Lpatent2, and Lpatent3, respectively. The findings indicate that the coefficients of the effect of the independent variable Famine on the dependent variable are significantly positive, regardless of other factors. Columns (4–6) show the regression results

TABLE 3 Correlation coefficient matrix.

Variables	SLpatent1	Lpatent2	Lpatent3	Famine	Female	SOE	CompH	Leve
Lpatent2	0.956***	1						
Lpatent3	0.899***	0.784***	1					
Famine	0.019***	0.013*	0.032***	1				
Female	−0.030***	−0.031***	−0.025***	0.006	1			
SOE	0.129***	0.128***	0.125***	0.035***	−0.065***	1		
CompH	0.021***	0.024***	0.000	−0.019***	0.020***	−0.146***	1	–
Leve	0.138***	0.129***	0.149***	0.023***	−0.020***	0.308***	−0.285***	1
Roa	0.024***	0.026***	0.006	0.007	0.007	−0.118***	0.562***	−0.366***
Growth	0.021***	0.019***	0.014**	−0.022***	−0.003	−0.046***	0.088***	0.063***
Size	0.387***	0.379***	0.362***	0.025***	−0.039***	0.373***	0.009	0.539***
Listage	0.137***	0.136***	0.113***	0.001	−0.021***	0.448***	−0.252***	0.402***
Ppeta	0.022***	0.022***	0.023***	0.062***	−0.031***	0.215***	−0.110***	0.101***
Share1	0.048***	0.044***	0.068***	0.038***	0.008	0.232***	0.052***	0.050***
Cfo	0.040***	0.043***	0.028***	0.009	0.017**	−0.029***	0.301***	−0.172***
Cash	−0.082***	−0.075***	−0.078***	0.005	0.031***	−0.089***	0.178***	−0.406***
Esh	−0.104***	−0.105***	−0.094***	−0.046***	0.041***	−0.479***	0.196***	−0.339***
Variables	**Roa**	**Growth**	**Size**	**Listage**	**Ppeta**	**Share1**	**Cfo**	**Esh**
Growth	0.135***	1						
Size	−0.045***	0.079***	1					
Listage	−0.247***	−0.034***	0.451***	1				
Ppeta	−0.088***	−0.047***	0.120***	0.153***	1			
Share1	0.123***	0.009	0.174***	−0.071***	0.090***	1		
Cfo	0.390***	0.022***	0.061***	−0.028***	0.214***	0.094***	1	
Cash	0.268***	−0.035***	−0.264***	−0.280***	−0.318***	0.035***	0.162***	1
Esh	0.186***	0.009	−0.381***	−0.561***	−0.179***	−0.090***	0.021***	0.185***

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

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TABLE 4 Regression results of executive poverty experience and firm innovation performance.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	SLpatent1	Lpatent2	Lpatent3	SLpatent1	Lpatent2	Lpatent3
Famine	0.068***	0.040*	0.092***	0.056**	0.036*	0.068***
	(2.627)	(1.865)	(4.256)	(2.532)	(1.933)	(3.614)
Leve				−0.382***	−0.344***	−0.211***
				(−6.908)	(−7.281)	(−4.746)
Roa				0.283*	0.244*	−0.041
				(1.715)	(1.748)	(−0.306)
Growth				−0.030**	−0.025**	−0.033***
				(−2.398)	(−2.305)	(−3.306)
Size				0.525***	0.438***	0.381***
				(47.094)	(43.371)	(37.953)
Listage				0.039***	0.029***	0.003
				(3.291)	(2.875)	(0.354)
Ppeta				−0.587***	−0.459***	−0.367***
				(−8.655)	(−7.939)	(−6.552)
Share1				0.028	0.019	0.105*
				(0.412)	(0.333)	(1.873)
Cfo				0.054	−0.003	0.130
				(0.402)	(−0.024)	(1.200)
Cash				0.020	0.038	0.058
				(0.271)	(0.613)	(0.985)
Esh				0.019	−0.014	0.042
				(0.387)	(−0.351)	(1.060)
Indu	No	No	No	Yes	Yes	Yes
Year	No	No	No	Yes	Yes	Yes
Constant	0.779***	0.606***	0.466***	−10.705***	−8.910***	−8.008***
	(74.673)	(68.338)	(56.324)	(−45.452)	(−41.709)	(−38.123)
N	20834	20834	20834	20834	20834	20834
Adj-R^2	0.000	0.000	0.001	0.236	0.221	0.211

T-values in parentheses, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, same later.

after adding control variables. The regression coefficients of Famine with SLpatent1, Lpatent2, and Lpatent3 are 0.056, 0.036, and 0.068, respectively, which are significantly positive at the 5, 10, and 1% levels, respectively. These results indicate that experiencing the Great Chinese Famine during childhood significantly enhances the overall level and specific types of innovation in firms. Results in Table 4 support the previous logical perspective of "endogenous power," (i.e., H1b) which suggests that executives who have experienced poverty are more likely to enhance their competitive advantage through innovation and improve their innovation performance to a greater extent. Regarding the control variables, corporate financial leverage (Leve), sales growth (Growth), and fixed asset size (Ppeta) significantly lower the level of innovation, while corporate profitability (ROA), firm size (Size), and firm age (Listage) significantly increase innovation performance.

The effect of executive gender heterogeneity on the impact of executive poverty on corporate innovation is examined empirically based on executive gender heterogeneity. We incorporated the interaction terms of the variables Famine and Female into the regression model. The regression results are presented in Table 5, showing that the interaction terms are significantly positive. It is evident from the results that the positive impact of poverty experiences on innovation is enhanced when executives are female. Female executives have a relatively weaker impact on invention patents and a more significant impact on utility model and design patents. This interesting finding differs from the traditional conclusion that women are conservative and steady. The study argues that female executives who have experienced poverty are likely to demonstrate a greater risk appetite and will be more willing to take risks and carry out innovative activities. Our study complements and enhances the existing literature on women.

TABLE 5 Regression results of moderating effects under gender heterogeneity.

Variables	(1)	(2)	(3)
	SLpatent1	Lpatent2	Lpatent3
Famine*Female	0.219**	0.157**	0.234***
	(2.420)	(2.041)	(2.941)
Famine	0.041*	0.025	0.051***
	(1.787)	(1.309)	(2.665)
Female	−0.049	−0.044	−0.042
	(−1.349)	(−1.402)	(−1.475)
Leve	−0.383***	−0.344***	−0.211***
	(−6.912)	(−7.284)	(−4.754)
Roa	0.278*	0.240*	−0.046
	(1.683)	(1.720)	(−0.347)
Growth	−0.030**	−0.025**	−0.033***
	(−2.357)	(−2.272)	(−3.250)
Size	0.524***	0.438***	0.381***
	(47.115)	(43.360)	(37.992)
Listage	0.038***	0.029***	0.002
	(3.217)	(2.815)	(0.254)
Ppeta	−0.587***	−0.459***	−0.367***
	(−8.658)	(−7.939)	(−6.556)
Share1	0.032	0.023	0.110*
	(0.479)	(0.393)	(1.958)
Cfo	0.056	−0.000	0.131
	(0.418)	(−0.004)	(1.213)
Cash	0.016	0.036	0.053
	(0.213)	(0.566)	(0.907)
Esh	0.014	−0.018	0.036
	(0.282)	(−0.430)	(0.905)
Indu	Yes	Yes	Yes
Year	Yes	Yes	Yes
Constant	−10.687***	−8.897***	−7.990***
	(−45.454)	(−41.685)	(−38.154)
N	20834	20834	20834
Adj-R^2	0.237	0.221	0.212

T-values in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Additionally, based on the corporate property rights and market competition perspectives, the boundary effects of executive poverty experience on the impact of corporate innovation are tested empirically, and the regression results are shown in Table 6. Columns (1–3) in Table 6 provide the regression results for the moderating effect of property rights. In the regression with the dependent variables SLpatent1 and Lpatent2, the coefficients of the interaction term Famine*Soe are −0.094 and −0.113, respectively, which are statistically significant at the 10 and 1% levels, respectively. Nevertheless, it is insignificant in the regressions where Lpatent3 is the dependent variable. In SOEs, executives with poverty experience contribute less to innovation; while executives with poverty experiences have a greater impact on innovation in non-state-owned enterprises. Thus, Hypothesis 3 is verified. More specifically, property rights have a greater impact on innovative invention patents and do not affect utility models or design patents. One possible reason is that the risks in these two types of innovation are small, and executives of SOEs prefer to increase their innovation levels through these two types of patents to meet the innovation requirements of their performance appraisals. As a result, the poverty experience will not be affected.

Columns (4–6) of Table 6 present the regression results for the moderating effect of market competition. The interaction terms Famine × CompH were both significantly negative in the regression results. Since the variable CompH is the industry-adjusted Lerner index, the smaller the value, the greater is the competitive pressure. The negative interaction coefficient indicates that the higher the competitive pressure faced by the firm, the greater the impact of the executive poverty experience on firm innovation. In other words, the executive poverty experience has a significant impact on corporate innovation under fierce market competition. Thus, H4 is verified. The coefficients of the interaction term Famine*CompH are −0.288, −0.189 and −0.292, respectively, which are statistically significant at 5, 10, and 1%, respectively, when the dependent variables are SLpatent1, Lpatent2, and Lpatent3.

Impact mechanisms

The above theoretical analysis and empirical tests have confirmed that executives with poverty experiences have a greater positive impact on firms' innovation performance. In this section, we analyze the impact mechanism from the perspective of R&D manipulation. R&D investment is the main driving force and engine of firm innovation; however, due to the professional and technical nature of R&D activities, there is a high degree of information asymmetry in the R&D process. It is possible that some executives whitewash R&D investment through surplus manipulation to satisfy performance appraisals, obtain personal gains, or obtain government subsidies, adversely affecting corporate innovation. If executives possess high ethical integrity, they can avoid compromising their business decisions with short-term goals, resist egoistic and opportunistic tendencies, and inhibit R&D manipulation.

Research has demonstrated that childhood experiences contribute to the development of an individual's character and will continue to influence moral judgment and value orientation. Early life experiences of poverty have a stronger impact on a CEO and are more likely to develop a sense of social responsibility and morality, such as greater compassion (Malmendier et al., 2011) and an increased sense of responsibility (O'Sullivan et al., 2021; Xu and Ma, 2021). According to Feng and Johansson (2018),

TABLE 6 Regression results of the moderating effects of the nature of property rights and market competition.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	SLpatent1	Lpatent2	Lpatent3	SLpatent1	Lpatent2	Lpatent3
Famine*Soe	−0.094*	−0.113***	0.008			
	(−1.939)	(−2.768)	(0.202)			
Famine*CompH				−0.288**	−0.189*	−0.292***
				(−2.278)	(−1.811)	(−2.859)
Famine	0.060***	0.040**	0.069***	0.061***	0.039**	0.073***
	(2.723)	(2.172)	(3.703)	(2.757)	(2.114)	(3.872)
Soe	0.143***	0.133***	0.086***			
	(6.052)	(6.516)	(4.405)			
CompH				−0.054**	−0.035*	−0.055***
				(−2.304)	(−1.827)	(−2.915)
Leve	−0.406***	−0.365***	−0.225***	−0.385***	−0.345***	−0.213***
	(−7.292)	(−7.693)	(−5.024)	(−6.952)	(−7.313)	(−4.808)
Roa	0.258	0.221	−0.056	0.353**	0.289**	0.032
	(1.558)	(1.578)	(−0.423)	(2.104)	(2.042)	(0.236)
Growth	−0.026**	−0.021*	−0.031***	−0.030**	−0.025**	−0.033***
	(−2.070)	(−1.953)	(−3.049)	(−2.392)	(−2.301)	(−3.298)
Size	0.520***	0.434***	0.378***	0.525***	0.438***	0.381***
	(46.703)	(43.052)	(37.679)	(47.126)	(43.388)	(37.986)
Listage	0.021*	0.012	−0.008	0.039***	0.029***	0.003
	(1.680)	(1.149)	(−0.759)	(3.237)	(2.834)	(0.292)
Ppeta	−0.644***	−0.512***	−0.400***	−0.591***	−0.461***	−0.371***
	(−9.420)	(−8.792)	(−7.093)	(−8.712)	(−7.978)	(−6.621)
Share1	−0.048	−0.050	0.059	0.023	0.016	0.101*
	(−0.704)	(−0.856)	(1.042)	(0.348)	(0.286)	(1.794)
Cfo	0.134	0.073	0.174	0.071	0.008	0.148
	(1.001)	(0.651)	(1.605)	(0.527)	(0.073)	(1.359)
Cash	−0.047	−0.024	0.018	0.019	0.038	0.057
	(−0.641)	(−0.383)	(0.312)	(0.260)	(0.605)	(0.960)
Esh	0.097*	0.058	0.087**	0.020	−0.014	0.042
	(1.921)	(1.401)	(2.155)	(0.395)	(−0.344)	(1.067)
Indu	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−10.534***	−8.761***	−7.885***	−10.705***	−8.910***	−8.006***
	(−44.511)	(−40.921)	(−37.467)	(−45.476)	(−41.722)	(−38.148)
N	20834	20834	20834	20834	20834	20834
Adj-R^2	0.238	0.223	0.212	0.236	0.221	0.211

T-values in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

CEOs who experienced the Great Chinese Famine in their youth were less likely to commit fraud and showed higher levels of ethics (Feng and Johansson, 2018). Therefore, executives with early life poverty experiences are more likely to restrain R&D manipulation and improve innovation performance.

Based on the above analysis, this study proposed a mediating effect test. In accordance with Gunny's method (Gunny, 2010), variable *Abn* measures the level of corporate R&D manipulation. In this model, normal R&D expenditure is estimated using Equations (1) and (2), and abnormal expenditure is calculated using Equation (3). In the following equations, *Rd* is the firm's R&D expenditure, *Ta* is total assets, *Mv* is the natural logarithm of the firm's market value, *Tbq* is Tobin's *Q*-value, and *Int* is the firm's operating profit.

$$\frac{Rd_{i,t}}{Ta_{i,t-1}} = \beta 0 + \beta 1 \frac{1}{Ta_{i,t-1}} + \beta 2 Mv_{i,t} + \beta 3 Tbp_{i,t} + \beta 4 \frac{Int_{i,t}}{Ta_{i,t-1}} + \beta 5 \frac{Rd_{i,t-1}}{Ta_{i,t-1}} + \varepsilon_{i,t} \quad (1)$$

TABLE 7 Test for mediating effects of R&D manipulation.

Variables	(1)	(2)	(3)	(4)
	Abn	SLpatent1	Lpatent2	Lpatent3
Famine	−0.001***	0.054**	0.035*	0.066***
	(−5.352)	(2.455)	(1.876)	(3.495)
Abn		−3.210**	−2.015*	−4.247***
		(−2.329)	(−1.660)	(−3.937)
Leve	0.001***	−0.378***	−0.341***	−0.204***
	(4.475)	(−6.825)	(−7.219)	(−4.614)
Roa	0.010***	0.316*	0.265*	0.003
	(9.538)	(1.910)	(1.893)	(0.021)
Growth	0.001***	−0.027**	−0.023**	−0.029***
	(9.061)	(−2.138)	(−2.115)	(−2.880)
Size	0.000	0.525***	0.438***	0.381***
	(0.510)	(47.135)	(43.397)	(38.005)
Listage	0.000***	0.040***	0.030***	0.004
	(3.782)	(3.353)	(2.922)	(0.455)
Ppeta	−0.003***	−0.596***	−0.464***	−0.379***
	(−7.767)	(−8.774)	(−8.020)	(−6.753)
Share1	−0.000	0.027	0.019	0.105*
	(−0.068)	(0.411)	(0.332)	(1.873)
Cfo	0.004***	0.066	0.005	0.147
	(4.647)	(0.496)	(0.046)	(1.354)
Cash	0.002***	0.026	0.042	0.066
	(4.051)	(0.353)	(0.673)	(1.119)
Esh	−0.000	0.019	−0.015	0.041
	(−0.610)	(0.375)	(−0.360)	(1.039)
Indu	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Constant	0.008***	−10.680***	−8.894***	−7.976***
	(7.237)	(−45.396)	(−41.676)	(−38.077)
N	20834	20834	20834	20834
Adj-R^2	0.132	0.237	0.221	0.212

T-values in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

$$Norm_{i,t} = \hat{\beta}0 + \hat{\beta}1\frac{1}{Ta_{i,t-1}} + \hat{\beta}2Mv_{i,t} + \hat{\beta}3Tbp_{i,t} + \hat{\beta}4\frac{Int_{i,t}}{Ta_{i,t-1}} + \hat{\beta}5\frac{Rd_{i,t-1}}{Ta_{i,t-1}} \quad (2)$$

$$Abn_{i,t} = \frac{Rd_{i,t}}{Ta_{i,t-1}} - Norm_{i,t} \quad (3)$$

This study first examines the effect of the independent variable Famine on R&D manipulation (*Abn*) and then applies *Abn* to the regression model as a mediating variable to verify the significance of the independent and mediating variables. The regression results are presented in Table 7. Column (1) of Table 7 examines the relationship between executive poverty experience and R&D manipulation when Famine is the independent variable. The regression coefficient is 0.001, which is significant at the 1% level. This indicates that executives' early life poverty experience significantly reduces the level of corporate R&D manipulation. According to the regression results in Column (2), the effect of the independent variable Famine on innovation performance remains significantly positive, whereas the effect of the mediating variable *Abn* on overall firm innovation performance (SLpatent1) is significantly negative. In other words, the mediating effect persists for executives' early life poverty experience by reducing R&D manipulation, which in turn enhances the firm's performance in innovation. Furthermore, when analyzing the impact of different types of innovation, the results in Columns (3) and (4) indicate that the effect of R&D manipulation on the number of patent applications (Lpatent2) is negative and statistically significant at the 10% level (coefficient = −2.015, *t*-value = −1.66). The effect of R&D manipulation on the number of types and design patent applications (Lpatent3) is significantly negative at the 1% level (coefficient = −4.247, *t*-value = −3.937). Therefore, this result suggests that the mediating effect of R&D manipulation is more pronounced on the impact of poverty-experienced executives in the utility model and design patents, and relatively weak in more innovative invention patents.

Robustness tests

Propensity score matching

Since an executive's early life poverty experience is innate, there is no reverse causality issue in terms of the firm's impact. However, this study focuses on all A-share listed companies, and the percentage of executives with early life poverty experiences is only 18.6%, suggesting that the sample selection may have been biased. Therefore, the propensity matching score method (PSM) is used to conduct the robustness test. The overall sample is first divided into an experimental group of executives who have experienced the Great Chinese Famine and a control group of executives who have not experienced the Great Chinese Famine. Second, a logit model is used to estimate the propensity scores of executives who have experienced the Great Chinese Famine. The dependent variable is poverty experience (Famine), which includes financial leverage (Leve), profitability (Roa), firm growth (Growth), firm size (Size), firm age (Listage), fixed assets share (Ppeta), equity concentration (Share1), free cash flow (Cfo), cash holding level (Cash), and management ownership (Esh) while controlling for industry and year fixed effects. Third, the one-to-one nearest neighbor matching method is used for matching, and 7081 observations were obtained after matching. By matching the samples, the standard deviations of the experimental and control groups were effectively controlled, and the standard deviation of the majority of samples decreased by more than 80%. The sample regression results are shown in Columns (1–3) of Table 8, and the previous conclusions are still valid when the sample selection deviation is excluded.

TABLE 8 PSM test and Heckman two-stage test regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	SLpatent1	Lpatent2	Lpatent3	SLpatent1	Lpatent2	Lpatent3
Famine	0.074**	0.057**	0.078***	0.061***	0.041**	0.071***
	(2.556)	(2.349)	(3.211)	(2.738)	(2.185)	(3.748)
Leve	−0.632***	−0.546***	−0.431***	−0.397***	−0.356***	−0.214***
	(−6.274)	(−6.466)	(−5.106)	(−7.170)	(−7.547)	(−4.816)
Roa	0.218	0.055	0.074	0.360**	0.308**	0.001
	(0.700)	(0.206)	(0.289)	(2.178)	(2.205)	(0.010)
Growth	0.023	0.014	0.003	−0.032**	−0.027**	−0.035***
	(0.865)	(0.611)	(0.112)	(−2.529)	(−2.487)	(−3.464)
Size	0.576***	0.477***	0.444***	0.542***	0.453***	0.389***
	(29.634)	(27.214)	(24.541)	(47.388)	(43.854)	(38.220)
Listage	0.016	0.006	−0.027	0.008	0.002	−0.009
	(0.735)	(0.342)	(−1.502)	(0.589)	(0.217)	(−0.809)
Ppeta	−0.730***	−0.574***	−0.491***	−0.539***	−0.415***	−0.342***
	(−6.399)	(−5.955)	(−5.101)	(−7.737)	(−6.971)	(−5.911)
Share1	0.021	−0.014	0.105	−0.003***	−−0.003***	−0.001
	(0.182)	(−0.140)	(1.041)	(−4.446)	(−4.354)	(−1.353)
Cfo	0.180	0.152	0.185	0.093	0.033	0.150
	(0.747)	(0.754)	(0.902)	(0.700)	(0.292)	(1.390)
Cash	−0.227*	−0.182*	−0.136	0.062	0.075	0.079
	(−1.793)	(−1.704)	(−1.279)	(0.837)	(1.191)	(1.331)
Esh	0.056	0.023	0.049	0.033	−0.002	0.038
	(0.636)	(0.321)	(0.701)	(0.667)	(−0.053)	(0.977)
imr2				0.109**	0.105**	0.055
				(2.162)	(2.458)	(1.303)
Indu	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−11.533***	−9.483***	−9.179***	−10.993***	−9.183***	−8.150***
	(−28.053)	(−25.603)	(−24.269)	(−42.720)	(−39.916)	(−36.508)
N	7081	7081	7081	20834	20834	20834
Adj-R^2	0.276	0.262	0.250	0.237	0.222	0.211

T-values in parentheses, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Heckman's two-stage test

The Heckman two-stage regression is used for robustness testing to address possible omitted variables. In the first stage, the inverse Mills ratio (*imr2*) is calculated using the regression results estimated by the probit model. This is based on whether executives have experienced poverty (Famine) as the explained variable, and introducing the proportion of executives with experience of poverty in other companies in the industry as exogenous tool variables, plus all the control variables included in the main regression. In the second stage, the *imr2* calculated in the first stage is incorporated into the second stage regression model for fitting purposes. The specific regression results are presented in Columns (4–6) of Table 8. Even though the coefficient of *imr2* is significant in the second stage of analysis, the regression coefficient of Famine is still significant, indicating that the positive relationship between executive poverty experience and corporate innovation performance is robust after controlling for the omitted variable problem; supporting the conclusions of this study.

Variation substitution test

We selected four alternative indicators of innovation performance to avoid the singularity of innovation performance research indicators to increase the robustness of our findings. It takes an average of 2–3 years for general invention patents to be granted but less than 1 year for other patents because of the significant differences in the length of time from filing to grant. Consequently, the variable Gpatent1 is set to calculate the natural logarithm of the total number

TABLE 9 Alternative measures of variables.

	(1)	(2)	(3)	(4)
	Gpatenth1	Gpatenth2	R&D1	R&D2
Famine	0.058***	0.064***	0.175***	0.001***
	(3.112)	(3.015)	(3.870)	(4.849)
Leve	−0.260***	−0.220***	−0.207	0.002***
	(−6.090)	(−4.231)	(−1.253)	(2.962)
Roa	0.042	0.012	−0.287	0.006***
	(0.353)	(0.078)	(−0.585)	(2.862)
Growth	−0.014	−0.039***	0.095***	0.000***
	(−1.412)	(−3.134)	(2.682)	(3.818)
Size	0.315***	0.449***	0.533***	−0.001***
	(32.054)	(39.951)	(18.723)	(−7.014)
Listage	0.028***	0.012	−0.327***	−0.001***
	(3.036)	(1.105)	(−10.357)	(−9.497)
Ppeta	−0.427***	−0.404***	−1.467***	−0.006***
	(−7.886)	(−6.239)	(−6.880)	(−9.631)
Share1	0.077	0.084	−0.486***	−0.002***
	(1.417)	(1.313)	(−2.961)	(−3.577)
Cfo	0.170*	0.042	2.030***	0.015***
	(1.666)	(0.331)	(4.669)	(10.126)
Cash	−0.096*	0.025	−1.100***	0.001
	(−1.663)	(0.380)	(−5.460)	(1.042)
Esh	0.016	0.016	0.235***	0.000
	(0.432)	(0.368)	(2.619)	(0.528)
Indu	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Constant	−6.233***	−9.486***	−10.319***	0.010***
	(−29.977)	(−40.278)	(−17.813)	(5.522)
N	20834	20834	20834	20834
Adj-R^2	0.233	0.222	0.879	0.519

T-values in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

of invention patents granted within 3 years of the patent application; the variable Gpatent2 is calculated using the natural logarithm of the total number of utility and design patents granted within 1 year of application. Moreover, this study examines innovation performance but also allows for some lag between R&D and innovation output to better capture the impact of executives on R&D investment. Therefore, the alternative variable R&D1 is defined as the natural logarithm of a company's R&D expenditure. The alternative variable R&D2 is defined as R&D expenditure divided by total assets of the company. The regression results, presented in **Table 9**, indicate that the regression coefficients of Famine and Gpatenth1, Gpatenth2, R&D1, and R&D2 are 0.058, 0.064, 0.175, and 0.001, respectively; all are significantly positive at the 1% level, indicating the robustness of previous research findings.

Discussion

Innovation plays an increasingly important role in maintaining enterprise competitiveness and improving performance; additionally, the impact of enterprise executives on innovation has also been recognized by scholars (Raffaelli et al., 2019). An increasing number of scholars have begun to pay attention to the relationship between executive characteristics and innovation performance and how executives with different background characteristics view the role of innovation risk in the innovation process (Chen and Nadkarni, 2017; Kiss et al., 2021). However, existing studies pay more attention to marital status (Roussanov and Savor, 2014), political relations (Hutton et al., 2014), professional background (Schoar and Zuo, 2017), senior executives at the later stage of their growth, and pay less attention to the impact of their early experiences on innovation activities.

Based on theoretical frameworks such as upper echelons theory and imprint theory, we studied whether the early life experience of senior executives in the Great Chinese Famine affected their company's innovation performance. The results show that companies with executives who have famine experience produce better innovation results than those without. Adamkovič and Martončik (2017) showed that poverty affects economic decision-making via cognitive load, executive functions, and intuitive thinking styles. However, the effect of poverty experience on innovation behavior has not been further analyzed.

From the perspective of risk, innovation is a high-risk investment activity, and people who conduct innovation activities should have a certain risk preference. People affected by poverty are more reluctant to take risks, and prefer deterministic financial incentives (Haushofer and Fehr, 2014). However, a person who has experienced poverty needs to make more effort to become an enterprise executive. According to this study, people who have experienced poverty may have a greater change in their risk attitude in the process of becoming a senior executive and can more fully understand the relationship between risk and return.

In addition, in the case of two-rights separation, executives are motivated to damage the interests of shareholders for their own interests, in which earnings management is a common opportunistic behavior. In the R&D process, enterprises exhibit R&D manipulation behavior, which affects innovation performance. Yang et al. (2017) found that R&D regulation is positively correlated with tax benefits and government subsidiaries received by enterprises, whereas existing studies pay less attention to the impact of executive ethics on corporate R&D manipulation. Feng and Johansson (2018) find that CEOs who experienced the Great Chinese Famine in their youth were less likely to commit fraud and showed a higher level of ethics. Therefore, this study tests whether executives with poor experiences inhibit R&D manipulation. This conclusion shows

that executives with high moral quality improve innovation performance by reducing R&D manipulation.

As for research on female executives, many studies prove that female executives are risk-averse and that the company's decision-making is more conservative (Maxfield et al., 2010; Cumming et al., 2015; Chen et al., 2016). Therefore, female executives may reduce innovation expenditures and enterprise innovation performance. The results of this study shows that the innovation performance of female executives is better and argues that the reasons for the high innovation performance of enterprises should be analyzed from multiple perspectives including risk. The steady behavior style and higher moral quality of female executives are conducive to improving the success rate of enterprises' R&D. In addition, by classifying patents, this study found that female executives have a higher impact on innovation types with lower risk. Therefore, the low-risk preferences of female executives may manifest more in different types of innovation activities.

Finally, compared with non-state-owned enterprises, there are great differences in management objectives, corporate governance models, and incentive assessment schemes of SOEs. Belloc (2014) believes that the innovation efficiency of SOEs is low because of the differences in property rights. This study finds that in SOEs, the role of senior executives' human capital, which is also an important factor affecting the innovation performance of SOEs, has not been fully played.

Conclusion

Personal experience affects the knowledge structure, cognitive model, and value orientation of executives, which then affects the strategic decision-making of enterprises. Poverty experiences are imprinted on executives' sub consciousness, which largely affect their risk appetite and behavioral decision-making. Existing research on how poverty experience affects executives' decision-making when faced with risky innovation activities lacks in-depth analysis and empirical research. Therefore, we propose a comprehensive research framework to analyze the influence mechanism of executives' early life poverty experiences on innovation performance.

Based on the data of Chinese A-share listed companies from 2012 to 2020, the empirical results show that executives who have experienced the Great Chinese Famine significantly improve corporate innovation performance. This study discusses the boundary of poverty experience affecting enterprise innovation from the perspective of gender, the nature of property rights, and market competition. Further, study on the influence mechanism revealed that executives who experience poverty during their early life have a stronger sense of morality and responsibility, which inhibits corporate R&D manipulation and can therefore positively affect the organization's innovation performance. This study enriches the research on the factors influencing enterprise innovation performance and combines the theories of psychology and sociology to provide empirical evidence for improving enterprise innovation performance.

Theoretical implications

Theoretically, this study finds that executive poverty experience plays a vital role in corporate innovation performance from the perspective of early life executive experience, and verifies the boundary and mechanism of its influence, which provides exceptional insight into the factors affecting corporate innovation performance. It also provides empirical support for improving corporate innovation performance by combining psychological and sociological theories.

This study provides an in-depth analysis of the impact of executive background experiences on corporate innovation, supporting and enriching the existing literature. Existing studies related to poverty experience focus more on the effects of micro-firm investment and financing, social responsibility, and financial asset allocation (Malmendier et al., 2011; Bernile et al., 2017; O'Sullivan et al., 2021). Using previous research, this study investigates the impact of executives' childhood experiences of the Great Chinese Famine on corporate innovation using data from Chinese A-share listed companies. It analyzes the overall innovation level of enterprises by focusing on the variables of enterprise innovation as well as explores group regression based on the innovation of patent categories, explores the differences in the impact of poverty experiences on different innovation types of enterprises, and improves relevant research conclusions.

Further, we contribute to relevant research by examining and discussing the effects of poverty in terms of heterogeneity regarding gender, property rights, and market competition on firm innovation. We find that female executives from poor backgrounds abandon traditional female "conservative" risk preferences (Faccio et al., 2016). Moreover, female executives from poor backgrounds have greater risk-taking abilities and courage due to their experience in the business world. An analysis of the nature of property rights finds that operating pressures specific to SOEs have a negative impact on corporate innovation and that executive poverty experience plays a more significant role in non-state-owned enterprises. The competitive market environment faced by firms can also moderate the role of executive poverty experience to varying degrees.

Finally, this study clarifies the mechanism behind the impact of executive poverty experience on corporate innovation from the perspective of R&D manipulation through a mediating effects model. The literature on the effect of executive background on innovation performance is more likely to develop mechanistic studies from the perspective of corporate

risk-taking than from an individual perspective. A controversial issue is the impact of executive poverty on corporate risk-taking (Stephens et al., 2014; Bernile et al., 2017; Hu et al., 2020). Thus, this study builds on the fact that executive poverty experience can increase their sense of morality and responsibility and empirically finds that executive poverty experience can inhibit R&D manipulation behavior. Further, it plays a partial mediating role in the effect of executives' early life poverty experiences on corporate innovation, expanding research relevant to the subject, and supporting Feng and Johansson's conclusions.

Practical implications

In this new era, innovation has emerged as a key component in accelerating the economic development of nations. In addition, innovation facilitates the "deepening of structural reform on the supply side" and accelerates the construction of a truly innovative nation. The practical implications of this study are as follows.

First, executives' early life experiences can profoundly influence their behavioral decisions. Therefore, it is important to pay attention to candidates' background experiences when selecting and hiring executives, as well as to fully understand the role of personality traits in organizational behavior. According to strategic planning, an enterprise should increase the selection of senior executives with a "matching degree" to minimize the trial-and-error cost of the enterprise. In the recruitment process, executive applicants with impoverished backgrounds should follow the principles of "competency matching," regardless of the origin, and pay attention to their ability and moral quality. In addition, the early life experiences of executives may be influenced by individual, corporate, and market characteristics, and it is necessary to examine a variety of factors rather than relying solely on one when analyzing the behavior of executives.

Second, the government should actively improve the corporate governance system of SOEs, optimize the employment system, and fully stimulate the positive role of senior executives in innovation. This study finds that in SOEs, the positive impact of executives with poverty experience on innovation is weakened. This may be related to corporate governance factors such as the assessment system of SOEs. The government should actively formulate reform policies and improve the corporate governance structure to improve the efficiency and effect of innovation in SOEs. Only by promoting a market-oriented personnel selection mechanism and issuing supporting compensation incentive policies can SOEs continuously stimulate their innovation vitality.

Finally, this study finds that there is R&D manipulation in the process of enterprise innovation, and that enterprise innovation performance is affected by the moral level of senior executives. Innovation activities of enterprises are important references for capital market valuation. R&D manipulation is detrimental to the stable development of enterprises, reduces the efficiency of the capital markets, and damages investors' interests. The government should punish and regulate enterprises' behaviors that harm public interest through R&D manipulation. For enterprises with high executive ethics and less R&D manipulation, the government should provide policy support, including financial subsidies, government investment, government procurement, and government approval.

Limitations and future research

This study has some limitations and provides additional opportunities for future research. First, due to data limitations, our research results may be limited to Chinese listed companies. The listing conditions for Chinese enterprises are quite strict and need to be reviewed by the Securities Supervision Commission (Tian, 2011; Li Y. et al., 2018; Xiaoyan and Lianghua, 2021). A person needs to have comprehensive qualities in all aspects to become an executive of a listed company in China. The impact of early poverty experience on executives of listed companies may limit the universality of our research results. Future research can focus on the performance of people with poverty experience in unlisted companies, and the research object can also be a broader group of executives.

Additionally, it is difficult to obtain accurate data collection and analysis to assess the level of executive poverty experience. Although the Great Chinese Famine of 1959 to 1961 can generally be approximated, a more detailed and in-depth analysis of the research problems may be helpful if there is a better alternative measurement method. Whether executives were born in distressed area, disadvantaged families, poor countries, etc. can measure whether they have early poverty experience.

Third, there are many types of innovation activities. This paper focuses on invention patents, utility models patents and designs patents. Innovation activities can also be divided into independent innovation and open innovation. With the increasing complexity and uncertainty of innovation, open innovation has gradually become the mainstream mode of innovation. Open innovation has the characteristics of risk sharing and achievement sharing. This model emphasizes the interdependence and cooperation of multi organizations in innovation activities (Saura et al., 2022). What impact the early experiences of executives will have on open innovation is still a question worthy of in-depth study.

Finally, this study examines the influence mechanism of R&D manipulation; however, we believe that there may be other ways to influence senior executives' early life poverty experiences, which need to be explored in the future.

And, this study found that factors such as the background characteristics of executives, business characteristics, and market characteristics have specific differences in the effects of innovative patents. Thus, what may cause these differences and how to promote highly innovative patent development need to be further examined in the future.

Data availability statement

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

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved the final manuscript. XJ: research ideas, concept and design, obtaining funding, statistical analysis, interpretation of data, and study supervision. TW: data curation, concept and design, statistical analysis, and interpretation of data. CC: research ideas, concept and design, data curation, and writing up.

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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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Application and extension of the UTAUT2 model for determining behavioral intention factors in use of the artificial intelligence virtual assistants

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Virtual Assistants, also known as conversational artificial intelligence, are transforming the reality around us. These virtual assistants have challenged our daily lives by assisting us in the different dimensions of our lives, such as health, entertainment, home, and education, among others. The main purpose of this study is to develop and empirically test a model to predict factors that affect users' behavioral intentions when they use intelligent virtual assistants. As a theoretical basis for investigating behavioral intention of using virtual assistants from the consumers' perspective, researchers employed the extended Unified Theory of Acceptance and Use of Technology (UTAUT2). For this research paper, seven variables were analyzed: performance expectancy, effort expectancy, facilitating conditions, social influence, hedonic motivation, habit, and price/value. In order to improve consumer behavior prediction, three additional factors were included in the study: perceived privacy risk, trust, and personal innovativeness. Researchers carried out an online survey with 304 responses. The obtained sample was analyzed with Structural Equation Modeling (SEM) through IBM SPSS V. 27.0 and AMOS V 27.0. The main study results reveal that factors, such as *habit, trust*, and *personal innovation*, have a significant impact on the adoption of virtual assistants. However, on the other side, *performance expectancy, effort expectancy, facilitating conditions, social influence, hedonic motivation, price/value*, and *perceived privacy risk* were not significant factors in the users' intention to adopt this service. This research paper examines the effect of personal innovation, security, and trust variables in relation to the use of virtual assistants. It contributes to a more holistic understanding of the adoption of these intelligent devices and tries to fill the knowledge gap on this topic, as it is an emerging technology. This investigation also provides relevant information on how to successfully implement these technologies.

KEYWORDS

virtual assistants, UTAUT2, users' behavioral intentions, technology implementation, artificial intelligence

Introduction

The most recent developments around digital technologies open new possibilities in the Human-to-machine interaction (Dix, 2017). Virtual assistants (VAs) are remarkable for their functionalities by providing close to real conversations with humans using interfaces, and by representing a human-like image that simulates social skills recreating personable qualities that interact with humans *via* imitation. Some human abilities that are commonly recreated or represented as communicative traits include speech recognition, feedback loop, and interacting with the tool of the exchange in a conversation (Cassell, 2000). Some known VAs in everyday activities, Alexa, Siri, Cortana, and Bixby, complete essential tasks: starting phone calls, reporting weather, processing math and calculations, playing music lists, and many more (Chattaraman et al., 2019; Robinson et al., 2019). Artificial Intelligence (AI) is providing the tools for VAs to offer advanced voice interfaces, and to allow users to carry an interaction *via* internet connection by using real speech. These VA platforms are integrated in consumer devices *via* smartphones and tablets, as well as *via* platforms for home entertainment, incorporating speakers, bots, and messenger platforms (Guzman, 2019). Workplace environment interfaces can include: functions *via* chatbots, graphic design, speech recognition, media publishing, video editing, and accounting, etc., and can be found in VAs. The most recent dissemination from devices powered by AI and integrated business software into market technology will provide a bottom line 4.2 billion devices, which is estimated to double in number to 8.4 billion in 2024 (Statista, 2022).

In this context, scholars in the Information Technologies area have created a framework of the UTAUT2 theory (Venkatesh et al., 2012), where any empirical information and collected data can be studied to apply in different fields with varying angles within the technology realm (Venkatesh et al., 2016). This approach, and growing interest in VAs, provides field research to understand factors that lead to VAs adoption. This growing interest on studying factors from a consumer decision-making side creates a number of rationales that allow for insightful predictions within the adoption segment (Yang and Lee, 2019; Hasan et al., 2021; Pitardi and Marriott, 2021). It seems that there are not enough studies framing the factors that are influencing, or directly or indirectly changing, everyday needs and expectations in order to evolve according to users' needs. This became apparent mainly after many changes drastically affected our standard of living and interactions, as those that occurred in Spain during and after the last global pandemic caused by COVID-19.

The model UTAUT2 is the base framework, with an emphasis on *Perceived Privacy Risk* and *Perceived Trust* as constructs taken into consideration. As a result, the theoretical model is improved by adding *Personal Innovation* to the seminal notions developed by Dinev and Hart (2006) for an integrated framework. The following research questions and objectives lead the study.

Research questions:

- What are the factors impacting behavioral intention in the process of use for VAs?
- What degree of trust, perceived privacy risk, and personal innovation can be measured from VA usage?

Objectives:

- To explore the factors included in the model UTAUT2 directly impacting user behavior around VAs.
- To add rationales from the model UTAUT2 impacting user behavior around VAs.
- To evaluate the model of behavioral user intention aligned with empirical data in correlation with guiding variables.
- To establish a preliminary guideline from intention to usage for plausible advances around this area.

The study is presented in 6 sections. Section 1 is the Introduction. Section 2 sets a Theoretical framework, before introducing the hypothesis linked to relevant variables from the theories applied in Section 3, Selected variables for the study. Next, Section 4, Methodology, sets research standards, including methods, data collection, and data analysis. In Section 5 presents results and discussion. In Section 6, Conclusions and implocations are explained, prior to Section 7, Limitations and future research which provides the scope and closing remarks.

Theoretical framework

Virtual assistants

The use of artificial intelligence is being developed in line with the improvement of technology and tasks relating to AI implementations (Saad et al., 2017; Yang and Lee, 2019; Lopatovska et al., 2021). AI implementation in VA consumer devices, also called voice assisted tools, revolves around integrated data in IoT applications. These communicate with users, *via* speech, text, facial recognition, and gestures (Laranjo et al., 2018) to allow user interaction *via* natural language (Stieglitz et al., 2018). These devices are designed to provide a similar-to-human environment, having improved voice activated technology from the previous generation of devices; and due to the additional learning capability from input for a better performance, this technology has advanced a step further in its potential for personalization (Bawack et al., 2021; Vimalkumar et al., 2021). In general, the latest generation of voice assisted devices offers better-quality tools for services providing added space for personalization with regard to previous interactions (McLean and Osei-Frimpong, 2019;

Pantano and Pizzi, 2020). Accordingly, digital adaptations in voice assisted devices extend on the expectation for performance and productivity in the workplace, so their link to hedonic pleasure and utility derived from usage has an impact on the balance that its users attain in their personal lives (Mishra et al., 2021; Jain et al., 2022). Popular personal assistant devices in the present-day marketplace, such as, Siri, Alexa, Cortana, and Bixby, are integrating common every day-use devices in consumer technology, such as speakers, autonomous vehicles and mobile devices, by integrating voice recognition into AI, so users interact with smartphones from a creative, novel, and more immediate interface. In recent years, VAs with integrated AI functionalities have been a leading trend in consumer technology due to the potential benefits derived from personalization, both in the workplace and in the home, and for the ease of use and added capabilities, which, in turn, create a positive feeling around VAs (Moriuchi, 2019).

UTAUT2

The analysis of factors in technology adoption are core to research studies in the field for a great number of authors. The UTAUT model was derived *via* an evolved model from at least eight developments from different fields of study, pinning down technological change and adoption: Innovation Diffusion Theory IDT (Rogers, 1961); Theory of Reasoned Action TRA (Ajzen and Fishbein, 1980); Theory of Planned Behavior TPB (Ajzen, 1991); Social Cognitive Theory SCT (Bandura, 1986); Technology Acceptance Model TAM (Davis, 1989); Model of PC Utilization MPCU (Thompson et al., 1991); Motivational Model MM (Davis et al., 1992); C-TAM; Combined TAM-TPB (Taylor and Todd, 1995). The main value of this model arises from bringing a historic light in technology use by working around a set of constructs; that is, concepts that encapsulate what is central to the effects of technology use from a user's intention perspective (Yu, 2012). The UTAUT model centered on four constructs: *Performance Expectancy, Effort Expectancy, Social Influence*, and *Facilitating Conditions* with moderating demographic inputs: gender, age, level of expertise (experience), and perceived usefulness (Venkatesh et al., 2003). From these eight variables, a wrapping theory with their activated items from constructs, are presented in Table 1.

With UTAUT's underlying theoretical context, Venkatesh et al. (2012) provided a seminal framework to focus on the consumer viewpoint for an extended version UTAUT2, which aggregated three factors for considerations: *Hedonic Motivation, Price/value*, and *Habit*. This allows for a predictive capability built-into the model that substantially increases its potential for estimating user adoption up to 74% (Venkatesh et al., 2016). The applicable dimension of the theoretical approach had been well-established as a general framework within the technology industry. The large number of studies produced are evidence

TABLE 1 Core constructs of UTAUT.

Constructs	Variables	Model contributing to constructs
Performance expectancy	Perceived usefulness	Technology Acceptance Model (TAM) 1–3; Combined TAM-TPB (Theory of Planned Behavior)
	Extrinsic motivation	Motivation Model (MM)
	Job-fit	Model of PC Utilization (MPCU)
	Relative advantage	Innovation Diffusion Theory (IDT)
	Outcome expectations	Social Cognition Theory (SCT)
Effort expectancy	Perceived ease of use	TAM 1–3
	Complexity	MPCU
Social influence	Subjective norms	TRA, TAM2, TPB/ DTPB, and combined TAM-TPB
	Social factors	MPCU
	Image	DOI
Facilitating conditions	Perceived behavioral control	TPB/DTPB and combined TAM-TPB
	Facilitating conditions	MPCU
	Compatibility	DOI

Created using source data from Venkatesh et al. (2003).

of a model that is fruitful for analysis in the new technologies' adoption areas and within innovative approaches, and as part of varying cultural and social contexts, gives us an enhanced framework for adoption (Šumak and Šorgo, 2016). Some fields of practical application and user, behavioral, and standard approach are often used for virtual classroom and learning (Dizon, 2021); banking and finances (Khan and Rabbani, 2021), and ecommerce (Biduski et al., 2020).

Scientific research regarding virtual assistants

Many studies have approached user intention, as well as the factors for adoption in VA. Lu et al. (2021) focused on the context of Tourism and Hospitality from a defined consumer approach for long term integration of AI and robotics into common transactions around services for hotels, restaurants, airlines, and retail shop networks. From the analysis of lever factors, the variables that are rated as directly correlated to adoption, are: *PE, Intrinsic Motivation, (ergonomics), Social Influence, Facilitating Conditions*, and *Emotions*. Related to Tourism and Hospitality, the travel segment inspired another

study focusing on devices for Intelligent Travel Assistants as these relate to eight variables impacting adoption, which are: *ease of use, trust, enjoyment, design, usefulness, quality, safety,* and *empathy*. External factors are showing an overall influence, such as, *usage, trust, hedonic motivation*, and *design*, to be followed by *utility, quality*, and *empathy*. In the institutional context and within organizations, the approach to study technology and VA adoption is taken from a task-oriented, work-environment approach. Some of the factors determining how satisfactory work conditions for a person can be, stem from technology use, as it is impacting productivity and level of tasks completion (Marikyan et al., 2022). In this context, the results point at *Performance Expectancy, Perceived Enjoyment, Social Presence*, and *Trust*, as positive factors directly impacting productivity and commitment from workers. Research conducted by McLean and Osei-Frimpong (2019), combined the theoretical underpinnings of Uses and Gratifications Theory (U&GT) with technological theories to obtain a clearer understanding of user motivations in their intent and use of voice assistants around the home. This research establishes a moderating role for the *Perceived Privacy Risks* that can diminish and negatively influence the use of voice assistants in the home. The results indicate the importance of the benefits that these devices grant us, since it will motivate the use of a voice assistant at home. Yang and Lee (2019) explain the intent and use of VA devices through *Perceived Utility, Perceived Enjoyment*, and product design-related, ergonomic, features. The results show that the *Perceived Usefulness* and *Enjoyment* have a significant impact on users' intention. From a hedonic value perspective, the content quality, which is also a functional attribute of VA devices, as well as visual appeal, positively affect *Perceived Enjoyment*.

UTAUT 2 has been used in diverse fields from widespread contexts. Vimalkumar et al. (2021) analyzed the factors that motivate people to use voice assistants for the home, adding other variables to the original set: *Perceived Privacy concerns*, *Perceived Privacy Risk*, and *Perceived Trust*. In the Kessler and Martin (2017) research, they identify the perceptions and determinants of potential future users linking to VA technology by adding the variables *Data Security, Compatibility*, and *Relationship* with the device to the framework model. Kalinić et al. (2019) analyzes the disposition of customers to use smart speakers for online purchases, adding the *Perceived Risk* variable to the model (Malarvizhi et al., 2022). Almahri et al. (2020) examines the factors that can deter or facilitate the acceptance and use of chatbots by university/college students in post-secondary education. Gansser and Reich (2021) analyzes factors influencing the use of VAs in a daily life environment in three segments of mobility, home, and health, adding the variables *wellbeing* and *health, convenience, comfort, sustainability, safety* and *security*, and *Personal Innovation*. Schmitz et al. (2022) investigated patients' intention in order to take advantage of virtual medical appointments by adding *Perceived Security*, and *Perceived Product Advantage* to the user intention model of variable analysis.

Selected variables for the study

Performance expectancy

The PE has been defined as "the degree to which the use of a technology will provide benefits to consumers in carrying out certain activities" (Venkatesh et al., 2003, p. 447). Therefore, it denotes the degree to which an individual perceives that virtual assistant can facilitate greater performance and productivity. Being a relatively recent technology, one foreseeable barrier was set at the possibility of visualizing potential for added tasks within the VA platform. The effect of this variable, on the attitude toward the use of technology, has been well-documented in previous literature on virtual assistants (Cyr et al., 2007; Hassanein and Head, 2007; Moriuchi, 2019; Ye et al., 2020). From this perspective, PE reflects the extrinsic degree of motivation or the expected result of the use. Previous research has seen this variable for its influence on the adoption of VA (McLean and Osei-Frimpong, 2019; Wagner et al., 2019; Koon et al., 2020; Vimalkumar et al., 2021). Therefore, based on this, the following hypothesis is proposed:

H1: PE positively and directly influences user's intention to use VA.

Effort expectancy

EE is "the degree of ease associated with using the system" (Venkatesh et al., 2003, p. 450). In context it refers to the perceived ease in VAs usage. This factor is considered a fundamental predictor of technology adoption in research settings (Wirtz et al., 2019). When interacting with AI-based VAs, EE will appear to be implicit in most cases, being a barrier if they are not provided to the level expected by consumers (Wirtz et al., 2018, 2019) or require a high effort, since VAs have to allow consumers to execute tasks with minimal effort (McLean and Osei-Frimpong, 2019). The objective is therefore to have users achieve a positive perception regarding the "degree of ease" (Venkatesh et al., 2012), Previously it has been shown that confidence in one's own abilities to deal with technical systems has a significant influence, directly impacting the intention to use them (Fridin and Belokopytov, 2014). Previous research has studied this variable to understand its influence on VAs' adoption (Chopra, 2019; Zaharia and Würfel, 2020; Mishra et al., 2021; Moriuchi et al., 2021). Therefore, based on this it is hypothesized that:

H2: EE positively and directly influences user's intention to use VA.

Social influence

SI is "the extent to which consumers perceive their significant others (like family and friends) believe they should use a particular technology" (Venkatesh et al., 2003, p. 451). In the context of the study, it is the degree to which an individual believes that important people support their use of VAs for their daily tasks. The SI based variable models an individual's beliefs and behavior through the interactional mechanisms of compliance, internalization, and identification (Moriuchi, 2021). Previous studies have provided empirical support that evidences the impact of SI on the use of technology in different contexts (Moriuchi, 2021). They have also studied this variable to examine its influence on the adoption of VAs (Chopra, 2019; Zaharia and Würfel, 2020; Mishra et al., 2021; Moriuchi et al., 2021). In this context our proposed hypothesis is the following:

H3: SI positively and directly influences user's intention to use VA.

Facilitating conditions

Facilitating conditions are "consumers' perceptions of the resources and support available to perform a behavior" (Venkatesh et al., 2003, p, 453). Underlying this perception, there is the idea of acceptance; an information system depends on a preliminary assessment of one's own ability to master the new technology (Wong et al., 2020). Users need to perceive the presence of a solid support infrastructure that facilitates the learning and usage of the technology, so the usefulness of a technological device will be executed under the premise that facilitating conditions are actively working on a given environment (Canziani and MacSween, 2021). This scenario is particularly true in the context of AI-based technology, whether for individual or organizational use; it is necessary to have infrastructure that facilitates use (Grover et al., 2020). Vimalkumar et al. (2021) confirmed the positive influence of *facilitating conditions* on consumer adoption of digital voice assistants. In addition, previous research analyzed FC from the standpoint of influence on adoption, specifically, VAs (Gunasinghe et al., 2020; O'Connell et al., 2021; Al Shamsi et al., 2022) where the findings point at confirming the presence of this variable, thus:

H4: FC positively and directly influences user's intention to use VA.

Hedonic motivation

HM is "the fun element, joy, or pleasure derived from the use of a particular technology without any specific additional benefit" (Venkatesh et al., 2012, pp. 157–178). Some authors state that HM is a key factor in consumer behavior (Holbrook and Hirschman, 1982), and that aspect linked to the fun and pleasure derived from usage, can be seen as crucial when evaluating, in advance, acceptance and technology use (Childers et al., 2001; Brown and Venkatesh, 2005). The greater the fun and pleasure elements anticipated from the use of a technology, the more likely consumers are to accept it. Understanding *hedonic motivation* for technology use relies on the assumption that arousal inherently makes people excited and more willing to accept and use something new—a natural tendency to initiate actions, that makes individuals, joyful, positive, and helpful. Previous research has analyzed this variable in experiences and VA adoption (Gunasinghe et al., 2020; O'Connell et al., 2021; Al Shamsi et al., 2022), and it has established that:

H5: HM positively and directly influences user's intention to use VA.

Price/value

PV has been defined as "consumers' cognitive trade-off between the perceived benefits of apps and the cost of using them" (Venkatesh et al., 2012, pp. 157–178). Therefore, PV is a measure of the net benefit obtained by using a technology. In fact, people are always out to maximize net profit. This implies that, if the adoption and use of technology generate positive gains, individuals will accept the cost of it. Previous studies have confirmed the effect that price/value has on technology adoption, a process that is enhancing in itself, and as such, provides a positive feeling and impact on users (Moorthy et al., 2019; Palau-Saumell et al., 2019). In addition, the studies confirm that price/value and behavioral intention are closely related in positively improving intentional behavior and adoption due to the novel perception that it increases satisfaction (Moorthy et al., 2019; Palau-Saumell et al., 2019). Based on this variable and similar experiences in technology adoption for VAs (Ashfaq et al., 2021; Ling et al., 2021; Twum et al., 2021), the general conception is toward seeing:

H6: PV positively and directly influences user's intention to use VA.

Habit

The HB is "the extent to which individuals tend to perform behaviors automatically due to learning" (Venkatesh et al., 2012, p. 157–178). As a consequence of repeated performance, when people internalize habits, they may not think about, realize, or

evaluate the reasons for their actions (Mittal, 1988; Ouellette and Wood, 1998). In the context of VAs based on machine learning, habit allows the formation of a symbiotic relationship between the user and the technology (Jacucci et al., 2014). Hence, habit is not only an explanation of daily routines (Yen and Wu, 2016), but also an important factor that will determine the degree of user engagement with this type of technology (Perez-Vega et al., 2021). Previous research has analyzed this variable to study its influence on the adoption of VA (Kessler and Martin, 2017; Gunasinghe et al., 2020; Twum et al., 2021). Therefore, based on this the following hypothesis is suggested:

H7: HB positively and directly influences user's intention to use VA.

Perceived privacy risk

Perceived Privacy Risk indicates the degree of perceived certainty of consumers that their personal information is shared with an information system (Lee et al., 2021). Therefore, privacy implies not being subjected to unwanted intrusions (Merriam-Webster and Springfield, 2005), such as wiretapping, the exploitation of security vulnerabilities and user identity theft (Chung et al., 2017). VAs cause a growing concern about privacy and security that are impediments to their use and adoption (Saura et al., 2021; Vimalkumar et al., 2021). Since VAs need to collect sensitive and private data for proper operation, security issues are raised for, and this fact entails a barrier to, their full adoption (Pitardi and Marriott, 2021). Previous research has examined how privacy concerns influence consumer responses in a variety of settings (Pizzi and Scarpi, 2020). These studies provide evidence that privacy concerns can act as an inhibitor (Nepomuceno et al., 2014). Thus, based on previous research and following its impact on adoption around VAs, our hypothesis is the following:

H8: Perceived Privacy Risk negatively and directly influences user's intention to use VA.

Trust

Trust is generally conceived as a multidimensional concept that reflects perceptions of competence, integrity, and benevolence of another entity (Mayer et al., 1995). *TR* has been recognized as a key influencer of human-machine interactions (McLean et al., 2020). It builds on your perception of trustworthiness, which is enhanced by having faith in your interactions (Hengstler et al., 2016). *TR* is one of the most important elements to overcoming uncertainty (Yang and Lee, 2019). When technology is emerging, users often feel uncertain due to a lack of information. However, when users have a pre-existing feeling of trust toward a specific technology, a brand, or rely on referrals, this uncertainty can be eliminated. *TR* has been extensively researched in the VA field (Kuberkar and Singhal, 2020; Pitardi and Marriott, 2021; Vimalkumar et al., 2021). Previous research on *TR* highlights the role of technical features of websites and technology, such as ease of navigation, visuals, and ease of search, as signals that convey trustworthiness (Corritore et al., 2003). Prior research has analyzed this variable to study its influence on the adoption of VA (Kasilingam, 2020). Therefore, based on this our hypothesis is the following:

H9: TR positively and directly influences user's intention to use VA.

Personal innovativeness

This is the area of adaptation to technology with a higher interest from a behavioral intention standpoint—for individuals to display a high degree of adoption of new products within a set user-base or a specific community (Juaneda-Ayensa et al., 2016; Getnet et al., 2019). In the area of VA adoption, innovation is measured in terms of function, hedonic motivation, and cognitive motivation. The effect of such variables toward adoption in VA has been studied in previous research to present a thesis for positive rate with an effect on adoption. Previous research recognizes this variable for its influence on the adoption of VA (Kasilingam, 2020; Hasan et al., 2021; Winkler, 2021). In this context, the last hypothesis is:

H10: PI positively and directly influences user's intention to use VA.

Figure 1 presents the developed research model.

Methodology

Plan-design for data

The developed questionnaire for an effective market survey consists of two parts: (1) the instrument proposed by Venkatesh et al. (2012) to the context of Virtual Assistants with 24 questions that measure the 7 constructs of the UTAUT2; and (2) the questions of scholarly articles were adapted with 12 questions that measure the three factors added to the model. In addition, sociodemographic information is collected for contrasting data (Tables 2, 3). The 5-point Likert scale method is used, ranging from 1 (totally disagree) to 5 (totally agree). This scale avoids cognitive biases and the confusion of the respondents. In addition, it provides quality data, and it is recommended by researchers (Revilla et al., 2014). The structural equation model (SEM) was used for the analysis of the results, since it allows testing all the relationships between the observed and latent variables simultaneously, by combining multiple regression with factor analysis and provides general adjustment statistics (Iacobucci, 2010). In addition, it is capable of considering the

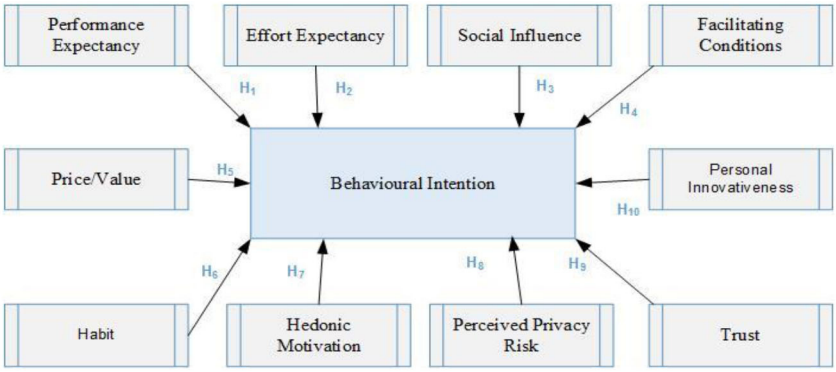

FIGURE 1
The research model.

TABLE 2 Variables for analysis.

ID	Constructs	Items	Source
1	Performance expectancy	4	Venkatesh et al., 2003
2	Effort expectancy	4	
3	Social influence	3	
4	Facilitating conditions	4	
5	Hedonic motivation	4	
6	Price/value	3	Venkatesh et al., 2012
7	Habit	3	
8	Perceived privacy risk	4	Featherman and Pavlou, 2003
9	Trust	3	Lu et al., 2011
10	Personal innovativeness	4	Agarwal and Prasad, 1998; Thakur and Srivastava, 2014
11	Behavioral intention	3	Venkatesh et al., 2003

measurement error with the observed variables (Hair et al., 2006).

Data collection

After completing the pilot test to clarify phrasing and eliminate items that were not identifiable in the questionnaire, the empirical data was obtained from the questionnaire and executed through a Google form that was *distributed online and in person, via* door-to-door survey to individuals in post-secondary campuses and in other urban districts, by using a QR code; it was implemented during the first quarter of 2022. Non-probabilistic convenience sampling was used. Three hundred and six responses were obtained. A first descriptive analysis using IBM SPPS Statistics 27 examined the data for missing pieces of information, uncommitted responses, outliers, and for data leveling. There were no missing data in the set. Thus, in Table 4 a descriptive sociodemographic data of the sample is presented.

Data analysis

Modeling analysis: Framework

Prior to the estimation analysis of the models the Mardia coefficient was calculated, which showed the multivariate non-normality of the data obtained, since it should not exceed the value 70. The results show a Kurtosis = 221.443 and a critical region = 29.693; however, considering that the skewness coefficients were <3 and the kurtosis coefficients <10, the maximum likelihood procedure was continued. A confirmatory factor analysis CFA test was performed using SPSS 27 and AMOS 27 tools to verify the measurement model by examining convergent validity, discriminant validity, and internal consistency of the constructs. To estimate convergent validity, the following were measured: the reliability of the measurement item (factor load), the reliability of each construct CR, and the average variance extracted AVE (Anderson and Gerbing, 1988). The values of the standardized factor loadings ranged between 0.588 and 0.933, which is higher than the required value of 0.50 (Gefen et al., 2000). Meanwhile, the composite reliability values demonstrated internal consistency of the latent constructs with values above the threshold of 0.70 (Heinzl et al., 2011). Finally, the values of the average variance extracted AVE, which are a measure of the variation explained by the latent variable to the random measurement error, ranged between 0.557 for *performance expectation* and 0.81 for *social influence*, above the lower stipulated limit of 0.50 (Fornell and Larcker, 1981). Therefore, all the predictors in this study, as can be seen in Table 5, are highly reliable, and the convergent validity results suggest that the latent constructs are good within the observed variables, since

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TABLE 3 Survey questions.

Constructs	Items	Question
Performance expectancy	PE1	Voice assisted devices appear useful for everyday common tasks…
	PE2	Voice assisted devices supplemented options for completing tasks that are essential to me…
	PE3	Voice assisted devices aided in completing tasks faster…
	PE4	Voice assisted devices increased productivity for…
Effort expectancy	EE1	In order to learn new information, voice assisted devices provided an easier means to…
	EE2	My interaction with voice assisted devices features a clear sound and easy to understand speech…
	EE3	I find that voice assisted devices are easy to use…
	EE4	It is easy for me to feel competent around voice assisted devices…
Social influence	SI1	People that are close to me consider that using voice assisted devices is…
	SI2	People that affect my everyday life and have an effect on my personal choices, consider that I should use voice assisted devices…
	SI3	People with opinions that are valuable to me have a preference for voice assisted devices…
Facilitating conditions	FC1	I have access to the necessary resources in order to be able to use voice assisted devices…
	FC2	I have the basic level of skill in order to be able to use voice assisted devices…
	FC3	Voice assisted devices are compatible with other devices that I already use…
	FC4	I am able to get online support for any difficulty arising during times when I use voice assisted devices…
Hedonic motivation	HM1	Using voice assisted devices is fun…
	HM2	Using voice assisted devices is enjoyable…
	HM3	Using voice assisted devices is entertaining…
Price/value	PV1	Voice assisted devices are reasonably priced…
	PV2	I am willing to pay for using platforms associates with the use of voice assisted devices…
	PV3	The cost for services added to voice assisted devices is manageable and it fits with added benefits…
Habit	HB1	Using voice assisted devices is fun…
	HB2	Using voice assisted devices is enjoyable…
	HB3	Using voice assisted devices is entertaining…
Trust	TR1	Voice assisted devices are trustworthy…
	TR2	I trust voice assisted devices for their ability to perform its functions…
	TR3	Voice assisted devices are capable of performing assigned tasks…
	TR4	Voice assisted devices in still trust in me…
Perceived privacy risk	PSE1	I have concerns about personal data protection and privacy whenever I use voice assisted devices…
	PSE2	I have concerns for security and data protection whenever I use Voice assisted devices…
	PSE3	I have concerns around privacy associated with the systems' use around voice assisted devices…
	PSE4	I have concerns around security issues associated with the systems' use around voice assisted devices…
Personal innovativeness	PI1	I like experimenting with voice assisted devices…
	PI2	I am generally an early user among colleagues and active user of voice assisted devices…
	PI3	Generally, I am hesitant to try the new voice assisted devices…
	PI4	I would seek new ways and experiment with voice assisted devices…
Behavioral intention	BI1	I intent to use voice assisted devices in the future…
	BI2	I will continue to use voice assisted devices regularly in my everyday life…
	BI3	My plan is to continue on using voice assisted devices often…

they are correlated with each other within the bottom-line model.

For the evaluation of discriminant validity, Heterotrait-Monotrait (Henseler et al., 2015) is used as an estimator of the correlation between two latent variables. According to this indicator, the coefficients must be below 0.90, in all cases they offered levels below 0.90, as can be seen in Table 6, which confirms the discriminant validity of all the latent used variables. For this, the construct measured items were required and they did not interlink with other concepts.

The general fit of the measurement model (Figure 2) to assess quality was performed through the evaluation of four goodness-of-fit indicators: the divided chi-square fit index PCMIN/DF, comparative goodness-of-fit index CFI, root of the

TABLE 4 Survey feature profile.

Variable	Description	Frequency	Percentage %
Gender	Female	189	61.8
	Male	117	38.2
	Prior to 1965	19	6.2
Year of birth	1965–1979	35	11.4
	1980–1999	90	29.4
	After 2000	162	52.9
Level of education	Elementary school	0	0.30
	Higher secondary school	5	1.6
	Bachelor	147	48
	High education	154	50.3
Use virtual assistants	Yes	230	75.2
	No	76	24.8
Frequency use virtual assistants (Last month)	0	63	20.6
	1–10	172	56.2
	11–20	36	11.7
	over 21x	35	11.5
Use of virtual assistants as only option	Yes	62	20.3
	No	244	79.7

residual root mean square of approximation RMSEA, and p of Close Fit (PCLOSE). The measurement model is considered sufficiently adjusted when these measurements are <3, ≥0.95, ≥0.90, ≤0.06 (Hair et al., 2006). The results: (PCMIN/DF 2.154, CFI 0.896, RMSA 0.050). This confirms that the measurement model has a high goodness of fit to (level) the data.

Structural model assessment

Data set sample validation

With the aim of validating the adequacy of samples collected, Hoelter's N critical index was applied with a significance level of 0.05, equivalent to 95% confidence (Hoelter, 1983; Bollen and Liang, 1988). The appropriate threshold for a good fit is 200, and values below 75 are considered unacceptable (75 ≤ value < 200; acceptable ≥ 200) (Wan, 2002; Garson, 2014). The size of the sample with 230 questionnaires is acceptable, since the Holter analysis concluded that the minimum size necessary for the sample would have been 117 questionnaires for a 95% reliability.

Framework-model analysis

Four common measures of model fit were used to assess the overall goodness of fit of the model. The results of the proposed research model showed an adequate fit: (PCMIN/DF 2.154, CFI 0.896, RMSA 0.050). The next step in evaluating the structural model (Figure 3) is to measure the explanatory power of the dependent variable measured as R-squared R^2. This is used as a measure of the explanatory power of the model ensemble and describes how much of the dependent variable is explained by the independent variables in the model. R^2 values range from 0 to 1. Values closer to 1 are indicative of more significant explanatory power, and values >0.9 are indicative of model overfitting that could cause inaccurate results. Behavioral user intention was found to have an R^2 of 0.898, indicating that 89.8% of the variable was explained by the independent variables in the model. That is, the model elucidated an 89.8% for measuring the behavioral intention in the realm of VAs.

One final step entails evaluating the chain relation in the cause linking constructs *via* the structural model (Hair et al., 2010). The relation between independent variables and dependable prove a median, average beta coefficient (β), the statistics T and the value of *p*. The SEM results in Table 7 display the guidelines H7, H9, H10, as significant, vs. *habit, trust* and *personal innovation* as being significantly correlated with user intention in VA's. Also, we consider *habit* ($\beta = 0.408, p < 0.001$) a good predictor, being followed by *trust* ($\beta = 0.291, p < 0.001$), and in last place, lowered score for *personal innovativeness* ($\beta = 0.267, p < 0.001$). The guidelines H1, H2, H3, H4, H5, H6, and H8, *performance expectancy* ($\beta = 0{,}136, p > 0.1$), *effort expectancy* ($\beta = -0.141, p > 0.1$), *social influence* ($\beta = -0.008, p > 0.1$), *facilitating conditions* ($\beta = 0.170, p > 0.1$), *hedonic motivation* ($\beta = 0.049, p > 0.1$), *price/value* ($\beta = -0{,}76, p > 0.1$) and *perceived privacy risk* ($\beta = 0.002, p > 0.1$) user intent does not represent a meaningful thrust in the context of a Spanish VAs user-base.

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TABLE 5 Results for the measurement model.

Constructs	Items	Standard loadings	CR	AVE
Performance expectancy	PE1	0.864	0.833	0.557
	PE2	0.652		
	PE3	0.715		
	PE4	0.74		
Effort expectancy	EE1	0.868	0.914	0.727
	EE2	0.77		
	EE3	0.887		
	EE4	0.88		
Social influence	SI1	0.875	0.927	0.81
	SI2	0.933		
	SI3	0.89		
Facilitating conditions	FC1	0.866	0.888	0.669
	FC2	0.901		
	FC3	0.853		
	FC4	0.62		
Hedonic motivation	HM1	0.907	0.91	0.77
	HM2	0.9		
	HM3	0.824		
Price/value	PV1	0.853	0.922	0.798
	PV2	0.94		
	PV3	0.885		
Habit	HB1	0.872	0.842	0.646
	HB2	0.614		
	HB3	0.894		
Trust	TR1	0.77	0.863	0.612
	TR2	0.79		
	TR3	0.774		
	TR4	0.796		
Perceived privacy risk	PSE1	0.889	0.863	0.765
	PSE2	0.933		
	PSE3	0.685		
	PSE4	0.588		
Personal innovativeness	PI1	0.737	0.855	0.597
	PI2	0.697		
	PI3	0.805		
	PI4	0.842		
Behavioral intention	BI1	0.84	0.894	0.738
	BI2	0.82		
	BI3	0.91		

Results and discussion

What are the factors impacting users' intention and VAs usage? The model framework UTAUT2 establishes an empirical base for several constructs and suggests that behavioral user intention responds to *habit, trust*, and *personal innovation*. The model assigns 89.8% of predictability to user intention. From the model analysis it is established that PE (H1), doesn't impact intention of usage. Despite a number of studies pointing at PE and benefit perceived in VAs toward higher adoption rate (Fan et al., 2022) for providing a pleasurable experience (Tsay and Patterson, 2018), that in turn will add to intention of use and to adoption rates (Almaiah et al., 2019), for the present case scenario didn't show a significant impact toward

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TABLE 6 Ratio heterotrait-monotrait.

	PE	EE	SI	FC	HM	PV	HB	PI	PSE	TR	BI
PE											
EE	0.544										
SI	0.67	0.29									
FC	0.434	0.873	0.229								
HM	0.562	0.725	0.336	0.732							
PV	0.399	0.319	0.341	0.323	0.44						
HB	0.785	0.425	0.629	0.339	0.441	0.59					
PI	0.61	0.256	0.549	0.182	0.4	0.39	0.675				
SS	0.2	0.097	0.164	0.06	0.068	0.21	0.142	0.215			
T	0.611	0.634	0.429	0.611	0.593	0.47	0.556	0.593	0		
B	0.796	0.534	0.582	0.494	0.59	0.48	0.83	0.788	0.104	0.78	

an increase in user perception or an improved expectation for performance. This bottom line is backed up by the referenced studies (Khalid et al., 2021; Pitchay et al., 2021). From a user skill consideration of VAs usage and adoption, most participants in the 52% spectrum were millennials and digital natives, so, functioning and display of simple commands, searches, and chat natural to the interface did not require any upgrades for the users' technical knowledge (Melián-González et al., 2021). Thus, this factor is irrelevant to EE by minimizing setting up and action-tasks specific to VA usage. Ease of use as a non-relevant factor has been established in several studies (Wirtz et al., 2018, 2019; Zarouali et al., 2018; Balakrishnan and Dwivedi, 2021; Lv et al., 2021; Aw et al., 2022; Moussawi et al., 2022).

Aligned with ease-of-use factors arising from SI, we can take into account that colleagues and close individuals provide a referential standard from a common core belief and a similar mindset toward technology adoption. For the geographical scope of the study, Spain's population without wider access to technology will not have an impact in usage. Presence on apps and smart platforms of VAs, such as Alexa, Siri, and Cortana, extends to 16.9% of the total population in Spain (Survey in TIC Hogares, 2020). For use of VAs, specific targets show a 9.4% frequent use, several times a day, while a 6.1% use them once a day (Statista, 2022). This low rate of penetration clearly links to a lower degree of influence within a network, as shown by previous research (Hu et al., 2019).

FC (H4) did not affect usage or behavioral intent, considering that individuals have the necessary skill and ability in order to use VAs without additional technical support. Then, *facilitating conditions* are not essential contributing causes used to deter or favor user intention as shown in scholarly research (Alalwan et al., 2017), bearing in mind that ease of use specific to assistant devices does not imply a need for structural support to install the platform or to use the application.

VA adoption is not impacted by a *hedonic motivation*, seeing that the most common tasks, searches, and easy questions, are accessible *via* these assistants to most Spanish users according to an AIMC Study (2021). The distribution of tasks in this category presents the areas of interactions that are most common—searches/questions, weather/traffic report, music streaming and internet radio, alerts, calendar reminders, to-do-lists, call display, newscasts, messaging, central control for home appliances, shopping/online orders/meal delivery providers—a landscape of everyday applications that aligns with previous research (Laumer et al., 2019; McLean and Osei-Frimpong, 2019; McLean et al., 2021).

Price/value (H6) is not a significant factor due to an added advantage originating in zero cost for installation and from the perception of affordability to access technology assisting devices, such as, central speakers.

Contrary to *price/value* as it relates to ease of use, *habit* (H7) has a significant effect over intention of use in the VAs segment. As part of social psychology, habits include learned actions, mnemonic rules, and repetition of sequences from experiences in the same way specific actions create a consistent, recurrent, and pattern in results (Verplanken and Faes, 1999). Therefore, an automated action will be completed with the expectation of a known incentive. The more an action yields a specific result, associated to a benefit, the more this link forms between action and reward, thus carrying a behavior over time and without added effort (Lally and Gardner, 2013). From this perspective, the younger generation, having breath from a digital environment where they depend on mobile devices and apps for most of their everyday tasks, are inherently competent and naturally fall in the path of automation when using VAs. By integrating the string of tasks listed as simple access to assistants, these devices become integrated, as well as contributing to the development of digital skills of VA (Kessler and Martin, 2017; Gunasinghe et al., 2020). This positive influence stands against

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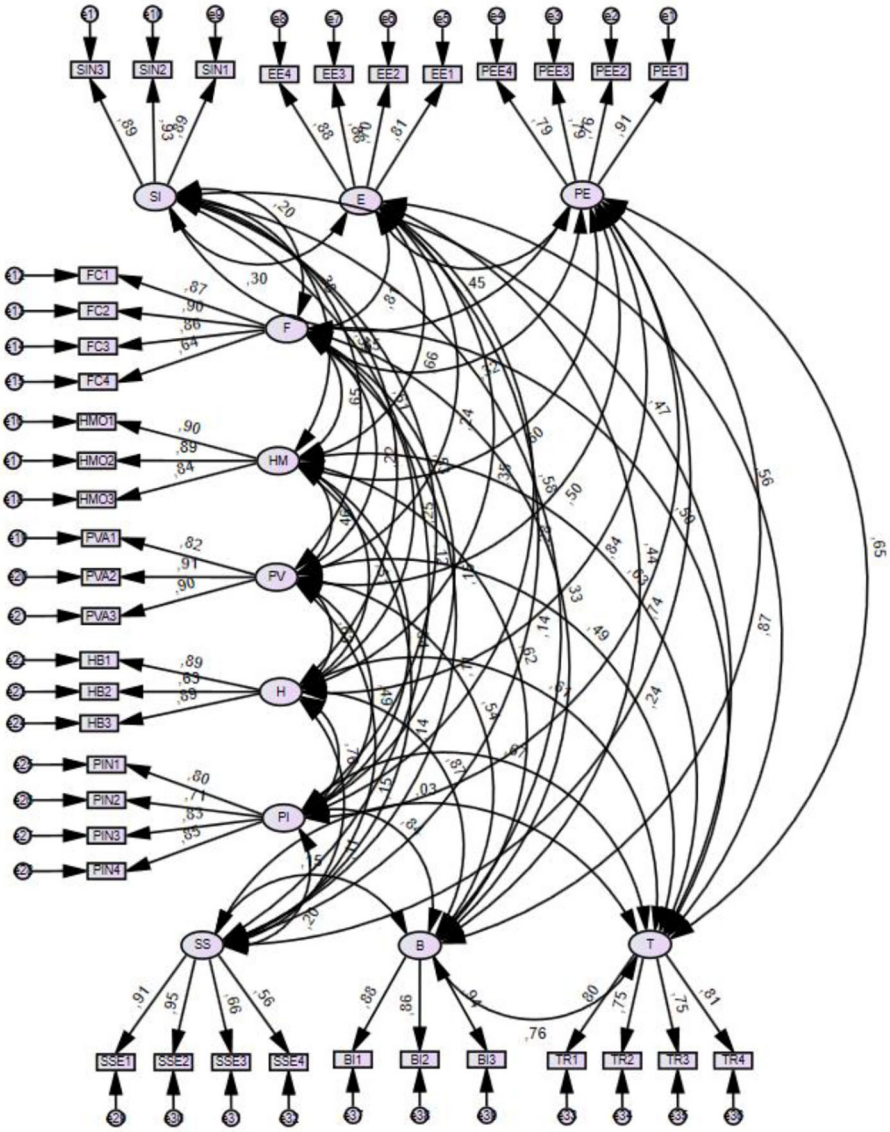

FIGURE 2
Measurement model.

other scholars' analysis with negative findings around the impact of HB in usage (He et al., 2022).

Our framework and data analysis supported that *privacy risks* (H9) do not impact user intention. In the VAs' area, the risks associated with security and privacy are aligned with third-party access to unauthorized, restricted information bands, and consequent data-breaches around personal information in the system (Han and Yang, 2018). One added benefit of a VA is listening to and storing requests; however, the security layer provides a perception risk in a manner that is not entangled with "trustworthiness" or "authorized access." Additionally, the compilation of personal information entrusted into the privacy of the system would not add a layer of risk when the service provider stores information according to set standards for security. This could be detrimental to the overall factors impacting adoption, but it is not a barrier in the use of an assistant device; the added risk is powerful among perceived situation or potential risks, but it isn't perceived or felt as such by users during their interactions who relied on the ease of use and its practicality.

This gap existing between the will to shield or share data is measured by trust. *Trust* (H9) changes toward the service and the provider of a platform. The service provided is established between individuals at the time of performing a task when the

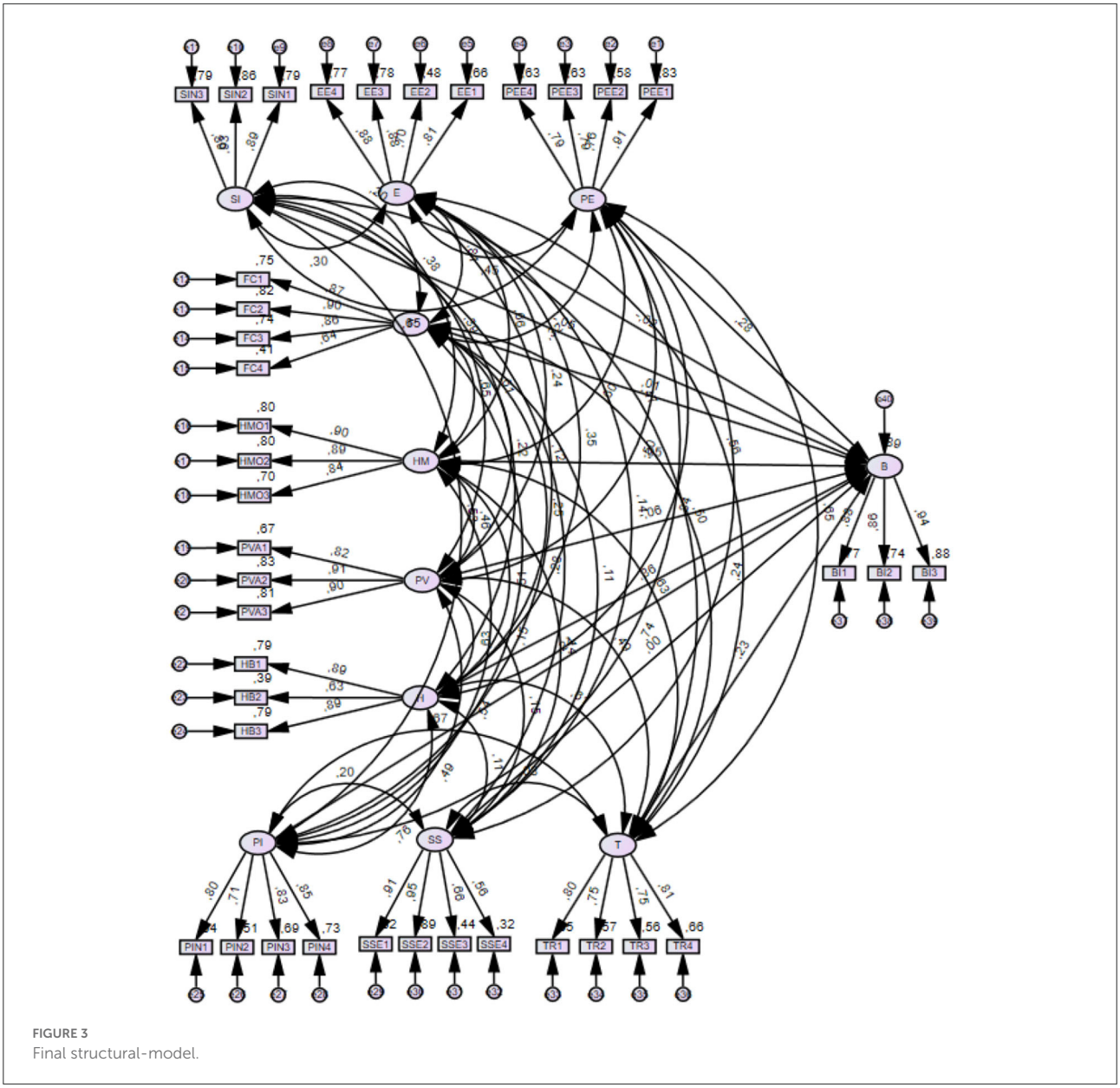

FIGURE 3
Final structural-model.

expectation is placed on the system responding to the present interaction and communicating the results fast and efficiently, in a reliable manner. On one hand, trust in the service provider links to credibility and established reputation. Some technology platforms providing service access to servers are Amazon, Google, and Apple—companies with a long-known trajectory and degree of trust that will eliminate initial user resistance toward enrolling in one of these service provider platforms. On the other hand, lack of trust will yield a lower adoption rate in the specific segment of VAs, due to underlying risks to privacy and trust, conducive to technology distrust (Cho et al., 2020; Zierau et al., 2020); accordingly, design of interface should be sensitive to this layer of risk and trust (Cho et al., 2020; Chen et al., 2021). Consistent with this line of thought, trust is a known factor in studies for user acceptance of VAs (Kuberkar and Singhal, 2020; Pitardi and Marriott, 2021; Vimalkumar et al., 2021).

Personal innovation influences behavioral intention, and for many researchers working in this variable, it is most promising in arising technologies, since leading into a role within a known process will cause an evolution into more immediate acceptance than other individuals that are lacking involvement with new technologies. This assertion reinforces the belief that innovative people are capable of remaining optimistic and positive when confronted with new technology developments (Dabholkar and Bagozzi, 2002). This is consistent with preliminary standards

TABLE 7 Results.

Guidelines	β	*t*-value	*p*-value	Decision
H1: Performance expectancy → Behavioral intention	0.136	1.368	0.171	Unsupported
H2: Effort expectancy → Behavioral intention	−0.141	−1.230	0.219	Unsupported
H3: Social influence → Behavioral intention	−0.008	−0.150	0.881	Unsupported
H4: Facilitating conditions → Behavioral intention	0.170	1.522	0.128	Unsupported
H5: Price/Value → Behavioral intention	−0.76	−1.461	0.144	Unsupported
H6: Habit → Behavioral intention	0.408	4.177	***	Supported
H7: Hedonic motivation → Behavioral intention	0.049	0.720	0.471	Unsupported
H8: Perceived privacy risk → Behavioral intention	0.002	0.573	0.958	Unsupported
H9: Trust → Behavioral intention	0.291	0.052	***	Supported
H10: Personal innovativeness → Behavioral intention	0.267	3.751	***	Supported

Measurement correlation-values: ***$p < 0.001$.

confirming PI as having a high degree of influence in a user's intention (Kasilingam, 2020).

Conclusions and implications

After the pandemic COVID-19 virus, many geographical areas showed an increase in VAs usage. There are few studies for reference after the global health crisis, and this model for analysis and study aims at filling this gap in the research of factors influencing introduction of new devices for virtual assistants. From a quantitative standpoint, there is a new methodology showing user intention around VAs' use and adoption in Spain. An underlying factor contributing to this context, arose from previous studies; based on AI introduction and a wide, all encompassing approach, to technology adoption (Wirtz et al., 2018, 2019); these changes have widened the scope in the theory and framework for analysis, to apply new filters for assessment of *trust, privacy risk*, and *personal innovation* in VAs. The information provided toward personal user experience can provide guidance for any development in the technological areas of health, business, home smart-systems (energy, security), and personalized bots-assistant companion. Considering that expanded use of the VA in these varied facets from industry to household, involve a massive potential for growth, this theoretical contribution and data analysis brings new light into personal innovation as a seminal variable for an integrated framework, with a focus on the interdependency of technology use and its context, limited to a national framework, the Spanish territory.

The above considerations are relative to the degree of technology development, skill, and competence around technology use as well as individual perceptions on the new applications (Alalwan et al., 2018). For the time-period framework, narrowed down to the years of global pandemic and defined by a health regulated environment, the study contributes data foreshadowing the novel role of consumer devices within a Spanish demographic, targeting device usage in diverse areas of daily life, from entertainment and home assistance to deliveries (Guzman, 2019). A second aspect under consideration is the effect of technology innovations as part of a context sensitive to added security and perceived risks; whether these devices make life easy without an added cost to privacy is a variable that opens a holistic sense into understanding the use of VAs as this field is evolving along AI. Personal innovation gains an edge for an integrated framework with essential notions established from behavioral intention. This notion is proposed by Dinev and Hart (2006) and proves to be productive in creating a cohesive base for analysis in line with a set of variables. In the area of VAs, personal innovation creates a filter valuable to system designers and business developers working in Vas as a means for retrofitting from clients, and to account for adoption with, an in-depth outlook into systems for prospecting of features and improvement processes (Kabra et al., 2017; Khalilzadeh et al., 2017). This is a valuable lesson obtained from the survey: it is important to have a customer centric approach, a user focus, along with a reputation for trustworthiness and low risk in bringing new features and generating innovations for an overall positive adoption rate. The information arising from the results represents a practical contribution looking forward into systems design and for businesses working in VA platforms. The data contrasted with an aligned set of variables will not only bring main factors that are relevant to user design to the discussion, but also highlight the need to integrate new features for increased trust, low risk, and greater innovation around digital assistants.

Limitations and future research

There are some limitations of the present study even after reaching our set of objectives. Mainly, the results should be taken with caution for the limited scope of demographic

data and only applied to the Spanish population. The same guidelines for ten factors of users' intention, can be extended for a cross-sectional approach to other geographical areas. Also, a cross-sectional study can be developed—an analytical approach from variables representing a synchronic set of standards for the data compiled in a specific timeframe—involving subjects and survey respondents' opinion evolution over time. Thus, results of the present analysis show that, indeed, *trust* leads to adoption, whereas *privacy risk* does not. Even though these factors are not new for studying users' adoption of the technological devices and smart technology, the context of application of the two factors leads researchers to open new paths for studies of continued use of VAs.

Finally, it could be appropriate to integrate new factors to the scope of variables and set of constructs, such as ergonomics, for dismantling an embedded bias around physical characteristics and their relation to mind processes, as these link to non-humans (for a technological viewpoint) with the aim of adding a layer of humanization to the process. This tendency to provide an animal form is known as anthropomorphism, which in turn, results in additional trust and satisfaction from a user, and even security, offering a more nuanced base for filtering of a subjective process. Prospective areas of development may bring a new insight on the link from intention to usage. Also, it may consider including other moderating variables for a study, such as gender, age, experience, and needs/desirable outcomes from use.

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.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MG: hypothesis proposal, data analysis, and manuscript preparation. JS: data collection. AA: manuscript revision. All authors contributed to the article and approved the submitted version.

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.

Publisher's note

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Factors affecting short-term rental first price: A revenue management model

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The aim of this paper is to conduct a revenue management study, generating a theoretical model that establishes the relationship between the factors of a Short-Term Rental apartment offered on the Airbnb marketplace or similar and its optimal rental price set when the property is first put on the market, considering not only the characteristics defined in the platform listing but also the sociodemographic characteristics of the area in which the apartment is located. The research process was structured in six phases as case study for the technology transfer model. First, research planning was conducted to estimate the time, cost, and suitability of the research topic. Second, the study design was determined to establish a technology transfer model focusing on the theory of mixed revenue management. Third, data collection about the city of Madrid was extracted from two technological databases, namely *SeeTransparent* based mainly on *Airbnb* (28 internal characteristics of the apartment) and *Deskmind Research* (9 sociodemographic variables of the area in which the apartment is located). Fourth, the data were prepared to create a new descriptive variable of the apartments based on geolocation. Fifth, the analysis of this study was applied to explore the correlation between the price charged per night, the 28 internal characteristics of the apartments, and the 9 sociodemographic variables of their surrounding areas. Sixth, with this integrated database, the information was transformed into multivariate inferential statistics through Exploratory Factor Analysis and Multiple Linear Regression, creating a technology transfer model (big data algorithm) that allows revenue managers to set the price of an apartment based on known information, prior to having a history of market reactions. This research process and model consider some of the factors affecting the psychological behavior of tourism consumers. Practical implications of the findings indicate

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that the size/capacity of the apartments used for Short-Term rentals largely determines the initial rental price set (72%). The equipment offered by the apartments has a moderate impact (18%), and the sociodemographic characteristics of the surrounding area have a minor influence (11%).

KEYWORDS

revenue management, short—term rental, dwellings for tourism use pricing, behavioral psychology, exploratory factor analysis, multiple linear regression, technology transfer model, first price

Introduction

The presence of marketplaces such as *Airbnb,* allowing so-called sharing economies to offer peer-to-peer rentals, has raised this market to a different level in terms of volume and number of listings.

Such marketplaces undoubtedly cover a large portion of the demand for overnight stays when traveling. Since the creation of *Airbnb* in 2008, the number of apartments available to rent for short stays has increased, and indeed this platform has become one of the biggest markets, with a strong presence today. In addition, many other companies have begun to offer this product, connecting landlords with short-term tenants, such as *VRBO*, *Wimdu*, *Homeaway,* and other marketplaces, as well as experts in traditional hotel accommodation such as *Booking* and *Expedia*. Even estate agencies and hotel companies such as *RoomMate*, *SpainSelect*, *GavirRentals*, and *MyCityHome.es* joined the market, as the sector became more professionalized, and progressively more short-term rental accommodation became available to the market.

The development of Short-Term Rental in the current economy as a model of revenue management for these properties, offering fully furnished real estate assets or apartments ready for immediate occupation, offers a significant area of study, in various fields. In this case, the research presented here also considers the psychological behavior of tourism consumers. For example, some research notes that Short-Term Rentals are putting a financial squeeze on housing for regular tenants and further increasing rent and property prices (Horn and Merante, 2017; Barron et al., 2018; Chen et al., 2019; Ayouba et al., 2020; Garcia-López et al., 2020; Koster et al., 2021a; Tood et al., 2021).

However, according to Levin et al. (2002), Sundararajan (2014), and Einav et al. (2016) Short-Term Rental (STR) home-sharing platforms, such as *Airbnb*, *HomeAway*, *VRBO*, and *CouchSurfing*, provide digital peer-to-peer (P2P) marketplace for landlords to rent out empty lodging spaces to third parties, thereby increasing availability and consequently adjusting the price as per the offer-demand rule, alleviating the suggested financial squeeze on housing by having a larger offer but reacting more dynamically to macroeconomic factors. Moreover, according to Brotman (2021), based on the results of their regressions, the motivation of property owners is also increasing, as they even consider building small annexes behind their primary residences to rent out to visitors as Short-Term Rentals.

Other authors state that, although home-sharing platforms provide major efficiencies and create economic benefits in certain aspects (Gárate Alvarez and Pennington-Cross, 2021), they also disrupt the existing property and hospitality industries and create disturbances in the neighborhood in which the lodgings are provided (Espinosa, 2016; Kim et al., 2017). However, such experiences forced the market to develop in terms of requiring more detailed contracts and regulations, imposing penalties for certain behaviors, and charging security deposits that also affect tenants' willingness to pay.

Undoubtedly, one important concern of landlords who offer their properties through these marketplaces is how to maximize their revenues. Hence, one of the most important issues in property management is ensuring the asset is correctly priced to meet demand at the best price while providing an experience at the destination (Ali et al., 2022) as well as maximizing the owner's income. To achieve optimal pricing and profitability for the landlord, it is important to determine which factors will affect this valuation, both directly and indirectly.

Many publications dealing with Revenue Management focus on optimizing pricing, based on experience and adjustments according to the market. Other studies compare Short-Term Rentals with other types of rentals. However, it would appear that no publications have yet tackled the issue of how professionals in this sector decide the starting price of a short term property rental. Interviews conducted with several professionals suggest that landlords largely tend to decide this starting price based on intuition. Interestingly, there does not appear to be empirical data available indicating the factors on which these professionals are basing their decision. Landlords do seem to adjust the price as they begin to gather historical information on the market's reaction; hence the method used during the initial period is largely intuitive and manual, with a significant time investment required.

This paper aims to provide a practical tool for professionals in the real estate sector, on how to decide the most suitable starting price for a residential real estate asset, and which factors affect this decision, reducing the time investment required when adding a new listing to the market. It contributes to the literature by using a technology transfer model to transform the big data gathered, enabling the effects of different internal or external factors on prices to be measured and modeled.

What are the main applications and uses of understanding the factors affecting the starting price of Short-Term Rentals considering a revenue management model?

By focusing on this analytical perspective, the research presented here aims to answer the following objectives:

- Identify the main applications of factors such as sociodemographic characteristics and property features that are quantitative indicators of Short—Term Rental apartments vs. Pricing, using a technology transfer model.
- Provide future guidelines to develop this technological model proposed here, to include qualitative indicators and correction factors on the grounds of seasonality and market trends.

To test the problems stated before, this research develops a systematic review of the literature to identify the main contributions made to date within this subject area. The results are analyzed by applying Yin's (2018) case study as a new technology transfer model with data collection from two technological databases and data analysis with multivariate inferential statistics through Exploratory Factor Analysis and Multiple Linear Regression, creating the technology transfer model (big data algorithm). A discussion and future lines of research in this area are then presented.

Following this introduction, section "Literature review" presents the theoretical framework. Section "Methodology development" sets out the methodology used in the study, and section "Analyze of results (Multivariate analysis)" describes the results, enabling revenue managers to set the price of an apartment on the basis of known information, prior to having a history of market reactions. Section "Discussion" presents the discussion, comparing it with similar studies, and section "Conclusion" states the final conclusions, implications, and limitations.

Literature review

Revenue management

Two of the key concepts in revenue management are Littlewood's rule (Littlewood, 1972) and expected marginal seat revenue (Belobaba, 1987). This notion was mainly created for airlines and considered seat availability, competition, as well as the expiration date of the plane ticket. In fact, American Airlines developed the world's first revenue management system in 1985 (Lentz et al., 2021), considering revenue management to be an essential instrument in terms of matching supply and demand by segmenting customers, based on their purchase intentions and assigning them in a way that would maximize the firm's revenues (El Haddad et al., 2008; Ivanov and Zhechev, 2012). Revenue management has been an area of interest in academia for many years (Tse and Poon, 2012), with research on topics such as pricing (Shoemaker, 2003, 2005), price fairness (Kimes and Rohlfs, 2007; Kimes and Wirtz, 2007; Kimes and Taylor, 2010), pricing research (Shy, 2008), and decision framing (Tversky and Kahneman, 1981). It has also benefited strongly not only from marketing management research but more profoundly from operations (Talluri and van Ryzin, 2005), as well as the impact on consumers (Choi and Mattila, 2004; Heo and Lee, 2010).

Revenue Management is widely understood to mean the management of pricing and external factors to maximize the profitability of an asset. Matsuoka (2022) states that Revenue Management aims to maximize financial performance by setting different prices for the same offerings. Cha et al. (2017) understood pricing to be a complex task that requires in-depth understanding. It entails, among other things, monitoring competition day by day, optimizing revenue and setting pricing strategies as per Cullen (2015) and Demirciftci and Belarmino (2022), integrating new technologies, such as artificial intelligence and robots as per Buhalis et al. (2019), using big data, as per Choi et al. (2018), and interpreting the right data in real time (Buhalis and Sinarta, 2019). Revenue management and pricing became particularly important as a tool and strategy in Yeoman's (2022) consideration of the hotel industry.

Organization support is crucial to maintain a collaborative workplace climate (Li and Srinivasan, 2019) and requires fairly advanced skills (Wang and Brennan, 2014). In this sense, training for managers and appropriate IT infrastructure for streamlined revenue management are essential elements (Selmi and Dornier, 2011). Innovation has emerged as the main driver of change in a business sector that needs to be flexible and resilient (Saura et al., 2022).

Revenue management is increasingly based on marketing, with tailored practices such as personalized pricing or personalized rooms (Tu et al., 2018). The integration between operations and marketing—as well as between strategy and tactics—is key for successful revenue management. Hotels adopt key performance indicators that go beyond room revenues, such as REVPar (Revenue per available room), which accounts for all outlets in the property, or GopPar (gross operating profit per available room), which accounts for expenses and cross selling (Ferguson and Smith, 2014). Ivanov and Zhechev (2012) provide a detailed overview of the specific revenue centers, including room division, F&B, function rooms, and spa and fitness facilities.

There is a vast body of literature on the subject of revenue management, an increasingly trending topic applied to many more markets. Vast numbers of articles such as those mentioned above allow pricing to be adapted based on events, in other words, competition strategy, expiration date, spikes in demand due to football matches, and a large number of different factors to be applied and considered continuously. However, this adaptation comes from a starting point, a defined unique price per unit, and yet it would appear that existing research has yet to tackle initial price-setting based on empirical evidence.

When asking revenue managers, in companies such as *MyCityHome.es*, how they set these starting prices, the most common answer is by experience, benchmarking, and personal impression, stating that they do not have a model to perform this calculation, and results are a little too arbitrary for such an important aspect in property revenue management.

Big data

Big data refers to the collection of a large amount of data that could be used in the future through the application of technology to learn about behaviors, yield statistics, and establish a decision-making model. The use of mobile applications and other technologies for tourism has seen important changes in the twenty-first century (Saura et al., 2017, 2021).

Elshawi et al. (2018) state that, recently, there have been huge advancements in the scale of data routinely generated and collected through almost all human activity, as well as the ability to exploit modern technologies to process, analyze, and understand such data. The intersection of these trends is known as Big Data Science. According to Ali et al. (2016), "In the modern world we are inundated with data" and "It is estimated that we are generating 2.5 quintillion bytes per day."

Information is becoming more and more accessible, and so the challenge for big data techniques is to transform this information into useful tools. In this particular case, the aim is to be able to model the data using SPSS and transfer all the knowledge acquired from these data using a simple algorithm or formula, bringing into play the concept of technology transfer.

Technology transfer model

Also known as transfer of technology (ToT), this is the process of transferring technology from one tech-owning entity to another. Soeder et al. (1990) define it as follows: "Technology transfer is the managed process of conveying a technology from one party to its adoption by another party."

Technology transfer does not have a universal meaning, according to Kremic (2003), and, in the words of Kutter (1991), it takes place "simply by moving a computer from a laboratory in Boston to a university in Manila" or relocating or exchanging personnel, as per NASA Aeronautics (1993). Others consider international technology transfer complete only when the host economy has absorbed, adapted, and resold the technology (Osman-Gani, 1999).

In order to achieve the goal of the technology transfer study, it is also considered as a process with a Setpoint-Comparator-Feedback loop and post-processing output as per Kremic's (2003) schema. The set of steps proposed in this paper to establish the Short-Term Rental starting price could be used as a technology transfer model or algorithm.

Short-term rental

There are three widely accepted definitions for the different types of rentals among professionals in the market. Bearing in mind that there are no precise or documented definitions, they can broadly be classified as follows:

Short-Term Rentals: apartment rentals by the day. Rental of the apartment for a period that can range from one night to several weeks. This type of rental can include Vacation Rentals, Tourism Rentals, Study Rentals, Exhibitions Rentals, and Workday Rentals. In terms of regulations, different regions have, indeed, defined the maximum term and placed certain limitations on the number of days the apartment can be rented. Koster et al. (2021b) summarize some of them: STR-hosts occupy the property for at least 50% of the time (O'Sullivan, 2016). San Francisco imposes a 14% hotel tax (i.e., a Transient Occupancy Tax) and a cap of 90 rental days maximum per year (Fishman, 2015). Amsterdam even imposes a maximum cap of 30 rental days per year as of 2019. In the region of Madrid, however, duration is not yet regulated, and so solutions such as a 5-day minimum stay or a maximum of 90 days have been put forward but rejected in the current regulations. The sample used in this paper recorded an average duration of 3.3219 nights per stay.

Season-Term Rentals: apartments rented by the month. This type of rental can be confused among professionals since it is unclear or at times difficult to differentiate from Short-Term Rentals. Nevertheless, typically, the general consensus within the property sector is that it refers to properties rented for between 4 and 12 months. Some countries such as Spain have restricted this type of rental to 12 months, as longer stays would be subject to the Spanish Urban Leases Act ("*Ley de Arrendamientos Urbanos*") (Jefatura del Estado, 1994).

Long-Term Rentals: apartments rented by the year. As mentioned previously, although there is no precise definition, there are, nonetheless, legal regulations that establish the duration of this rental period. Since this study was conducted in Madrid, Spain, the Urban Leases Act states that such leases will be no less than 6 months and up to 5 or 7 years, if the landlord is a company, unless otherwise agreed by both parties, for a longer

lease only. Season-Term Rentals, on the other hand, will never be longer than 12 months (Jefatura del Estado, 1994).

Taking this into consideration, the research presented in this paper defines Short-Term Rentals to be from 1 day to 4 months, Season-Term Rentals from 4 months up to 12 months, and Long-Term Rentals over 12 months.

Short-term rental vs. pricing: Property features

Surrounding sociodemographic variables

Different authors, such as Shokoohyar et al. (2020), have found that property location has a significant impact on the rental strategy chosen, underscoring the importance of that well-known refrain "location, location, location" in the property market. Authors such as Benítez-Aurioles (2018) and Gunter and Önder (2018) have focussed previously on geolocation, showing that listing prices are related to distance from the city center, and the response time of the host is negatively correlated with such bookings. Prices are influenced by sociodemographic variables in the surrounding area of the property, and Filippas and Horton (2018) noted that the demand for housing decreases when neighbors see a high turnover of people in their residential area.

As stated previously, this study considers up to 9 sociodemographic variables that may be influencing price.

- Resident population.
- Density of resident population.
- Socioeconomic Index (scale 0–10).
- % of second homes (Over total dwellings).
- No. of active businesses (shops).
- No. of Restaurants/Bars/Cafés.
- No. of Traditional hotels/residences.
- No. of Urban public transport stations.
- No. of Cultural venues (cinemas/theater...).

Internal property unit features

Adding to the previous paragraph, Shokoohyar et al. (2020) state that "properties with more bedrooms, closer to the historic attractions, in neighborhoods with lower minority rates and higher nightlife vibe are more likely to have a higher return if they are rented out through Short-Term Rental contract." Cui et al. (2018) assume that "higher-priced homeowners and higher-priced renters are more likely to live in properties with a greater number of bedrooms, near a major employment center, park, or school, as well as in a suburban location[. . .] school attendance with higher school quality."

As stated previously, this study considers up to 28 internal variables that may be influencing price. The pre-study variables established are as follows:

- Bathrooms.
- Bedrooms.
- Beds.
- Capacity.
- Available equipment (% Yes).
- Kitchen.
- Washing Machine.
- Heating / Air Conditioning.
- Child Friendly.
- Dryer.
- Pets Allowed.
- Internet.
- Pool.
- Parking.
- Gym.
- Hot Tub.
- Doorman.
- Suitable For Events.
- Wheelchair Accessible.
- Garden.
- Laptop Friendly.
- Workspace.
- Outdoor Grill.
- Patio or Balcony.
- Restaurant.
- Sauna.
- Spa and Wellness Center.
- Terrace View.

These are also the most relevant variables that major marketplaces like *Airbnb* and *Booking* request when completing their listings. This article sets out to demonstrate the relevance of these variables empirically, in this study.

In light of the above, the theoretical approach applied in this research, mixing sociodemographic and internal variables to determine Short-Term Rental prices (based on Yin's case study), contributes analytically to the subject of revenue management, seeking to provide complementary information. Other studies have focused on price-setting for Short-Term Rental holiday apartments. The study of Shokoohyar et al. (2020, mentioned earlier) is somewhat similar to the research presented here, showing how sociodemographic and internal variables influence rental prices, but using different methodological techniques such as logistic regression and applied to learn practices to predict the rental strategy with the highest rate of return for a given property. Most publications on Revenue Management, such as those mentioned earlier, focus chiefly on adapting the price of a given asset over time, on comparing calendar events and the competition that offers a similar product. However, the extant research seems to have largely neglected the issue of the optimal starting price. This initial price sets a course that can be adjusted over time. If the level of this initial price is set incorrectly, it could lead to a substantial loss in the potential profitability of the asset, as revenue

management corrections are carried out progressively on the basis of historical data.

Current research: *Airbnb* short-term rental apartments in Madrid

Information was gathered initially from several regions in Spain, but during the research process, the decision was made to concentrate solely on the city of Madrid, for the time being, due to several factors.

First, Madrid is a versatile city within this field of study: it offers Short-Term Rental apartments, as well as Vacation Rentals, Tourist Rentals, Study Rentals, Exhibitions Rentals, Workday Rentals, and so on, all included in the Short-Term Rental definition mentioned earlier.

Second, Madrid was also considered as a destination for the purposes of this article because its tourism demand is largely linear, contrary to other regions in Spain such as Marbella or the Balearic Islands, where demand is more seasonal and focused on summer holidays, or Baqueira or the Sierra Nevada where the peak tourist season is in winter.

Third, very reliable and accessible information has been compiled in Madrid, pertaining not only to sociodemographic and environmental factors but also to the internal features of the properties themselves. Other studies conducted previously in Madrid have also used the Deskmind Research (2022) and SeeTransparent Airbnb (2022) databases, which provide up-to-date information on this destination.

Fourth, the personal-professional background of the authors is more concentrated in Madrid. Indeed, they have working experience at an estate agency *MyCityHome.es*, which mainly focuses on Short-Term rentals and whose headquarters are in Madrid, justifying its selection as a destination.

Moreover, the choice of Airbnb Fast Facts (2022) seems appropriate, as its market share is 57.5%, compared with 36.5% held by *Booking.com* according to MyCityHome (2022). Furthermore, *Airbnb* focuses more on Short-Term apartment Rentals whereas *Booking.com* focuses more on hotel rooms. In addition, according to Zubair and Faiqa (2022), there is a certain level of intended user continuation.

In this context, the study makes three assumptions in this research:

- Assumption 1: the real rental price is taken to be the last price displayed in the Airbnb listing before the listing status changed from "available" to "reserved."
- Assumption 2: the measurable features of the apartments (quantitative variables, such as beds, bedrooms, and bathrooms) have been taken into account, disregarding the non-measurable features such as users' reviews, decoration style, or others (qualitative variables).
- Assumption 3: the effects of other variables such as seasonality and competitors have not been taken into consideration, since these variables should be subject to daily correction. The price studied in this paper should be considered a base price and subject to future studies and corrections. Therefore, the data take into consideration an average over the real yearly rental prices.

In light of the above, the final goal of this project is to develop a technology transfer model that establishes a correlation between the different features of a property used for Short-Term Rental in Madrid and the ideal starting price, taking into consideration not only the internal characteristics defined in the *Airbnb* listing but also the sociodemographic dimensions of the area where the apartment is located.

In this regard, two hypotheses have been formulated for statistical testing, based on Shokoohyar et al. (2020):

- Hypothesis 1: Price per night is influenced by the internal features of the apartment, considering that the price of the apartment is affected by the internal features of the property.
- Hypothesis 2: Price per night is influenced by the sociodemographic characteristics of the area, considering that the price of the apartment is affected by the sociodemographic elements of the surrounding environment.

Methodology development

The data used in this study were obtained from the *SeeTransparent* database for Short-Term Rentals about *Airbnb* and from the *Deskmind Research* database for the sociodemographic variables, to focus on revenue management in apartments for Short-Term Rental as a case study in the city of Madrid. The combination of these two sources represents a form of technology transfer to disseminate knowledge about big data and revenue management issues, such as internal factors (Hypothesis 1) and sociodemographic factors (Hypothesis 2) affecting the pricing of Short-Term Rentals for tourism.

In particular, the design of this technology transfer model is based on Yin's (2018) as one of the most popular case studies in social sciences and for its theoretical implications. This technology transfer model seems to be an appropriate methodological approach in this research in terms of establishing the relationship between the characteristics of a Short-Term Rental apartment offered through *Airbnb* or a similar marketplace and its optimal rental price, considering not only the characteristics defined in the platform listing but also the sociodemographic characteristics of the area in which the apartment is located. Yin's (2018) involves six stages that have

TABLE 1 Sample of *Airbnb* database for this research.

		Frequency
Valid	Without price (May21-Apr22)	481
	Without descriptions	13
	Valid cases	569
	Total	1,063

Source: Own elaboration.

TABLE 2 Average price per night for *Airbnb* properties (May 21–Apr 22) (in $).

***N* (cases)**		**569**
	Mean	**Standard deviation**
Nightly price (May21–Apr22)	121$	97$

Source: Own elaboration.

been applied in this research: planning, design, data collection, preparation, analysis, and sharing of information.

Plan

Research planning was conducted to estimate the time, cost, and suitability of the research topic. The initial plan was to identify a management model for revenue managers using technology transfer from a combination of databases.

Design

The study design was determined with a view to establishing a technology transfer model focusing on the theory of mixed revenue management and its practical implications for the marketing management of Short-Term Rental apartments. The application of revenue techniques and technological software boosts the profit management of these real estate assets.

Prepare

The dataset was mainly taken from *Airbnb,* compiling public information and data provided by the listing managers, data obtained through the big data research company, seeTransparent.com, for a sample of more than 1,048,576 day rentals, along with the internal historical data of *MyCityhome*, among others. The study analyses these technological database sources for apartments booked (with a nightly rate) through *Airbnb* between May 2021 and April 2022 (inclusive) focusing on the area of Madrid and the representative listings for this study. In total, 569 properties were selected (Table 1) with at least one booking in the research period. On average, these properties had been booked for 51% of the established period (187 days). Moreover, the internal features of each property are specified in the *Airbnb* database: booking price, day/month/year, rooms, beds, and equipment.

The information provided by the *SeeTransparent* database included the apartment coordinates. These coordinates can be used to geolocate each apartment. Through these coordinates, each apartment was linked to data about its surrounding environment. The *Deskmind Research* database, based on data compiled by the INE (National Institute of Statistics), provides sociodemographic information for each census section and was used here as a primary source to establish the characteristics of the apartment's surrounding area.

Prepare (univariate analysis)

The data for each apartment were correlated to the features within a 500-m radius of the apartment location, and the

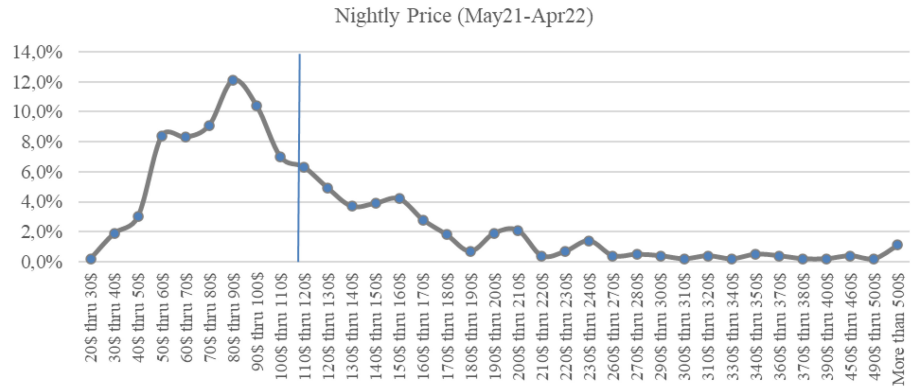

FIGURE 1
Nightly rate charged (May 2021–Apr 2022) (in $). Source: Own elaboration.

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TABLE 3 Between the nightly price with the 28 internal characteristics of the properties.

Equipment available in the properties (Description in *Airbnb*)	Correlation with Nightly price (May 21–Apr 22)		
	N	Pearson's Corr	Significance
Bathrooms	569	0.420**	0
Bedrooms	569	0.377**	0
Beds	569	0.367**	0
Capacity	569	0.360**	0
Available equipment (% yes)			
Kitchen	569	−0.01	0.819
Washing machine	569	0.066	0.117
Heating	569	0.128**	0.002
Air conditioning	569	0.103*	0.014
Child friendly	569	0.078	0.061
Dryer	569	0.180**	0
Pets allowed	569	0.001	0.981
Internet	569	−0.006	0.894
Pool	569	0.094*	0.025
Parking	569	0.069	0.101
Gym	569	0.079	0.059
Hot Tub	569	0.053	0.206
Doorman	569	0.029	0.497
Suitable for events	569	−0.005	0.897
Wheelchair accessible	569	−0.006	0.893
Garden	569	.c	.
Laptop friendly workspace	569	−0.019	0.653
Outdoor grill	569	.c	.
Patio or balcony	569	.c	.
Restaurant	569	.c	.
Sauna	569	.c	.
Spa and wellness Center	569	.c	.
View	569	.c	.
Terrace	569	.c	.

*Correlation is significant at 0.05 (bilateral). **Correlation is significant at 0.01 (bilateral). c, Not applicable as at least one variable is constant. Source: Own elaboration.

aggregated data from these census sections were linked to each property as a new descriptive variable.

First, the study began with aggregated data collection, working out the nightly rate charged to measure the market-adjusted price based on information from the *SeeTransparent* database and SPSS software (Table 2 and Figure 1).

Second, the average price per night was calculated for Short-Term Rental apartments booked from May 2021-April 2022. This average was $121 per night with a standard deviation of $97 (Table 2).

Third, the mean values and frequencies of all 28 internal characteristics (number of bathrooms, bedrooms, beds, capacity, kitchen, washing machine. . .view, terrace) (Table 3). of these 569 Short-Term Rental apartments were calculated. On average, each property has 1.26 bathrooms, 1.39 bedrooms, and 2.08 beds. Furthermore, the vast majority of them have a kitchen (97%), washing machine (90%), heating (89%), and air conditioning (82%).

Fourth, the study includes descriptions of the areas surrounding the 569 properties (within a radius of 500 m) taken from the other technological database used (*Deskmind Research*) indicating 9 sociodemographic features of these surrounding locations, such as resident population, the density of resident population, socioeconomic index, % of second homes, number of shops, restaurants, bars, hotels, public transport stations, and cultural venues (Table 4). These factors influence the growth of the market as well as the impossibility of renegotiating due to the common approach taken by governments to defend tenants' interests. The combination of the different databases allows the collection of multiple data sources and further geolocation analysis.

Analyze (bivariate analysis)

The analysis developed within this study was applied to explore the correlation between the nightly rate charged and the 28 internal characteristics of the apartments (Table 3). Pearson's coefficient is between 0.36 and 0.42 for bathrooms, bedrooms, beds, and capacity, indicating a moderate correlation.

The correlation between the nightly rate charged and the 9 sociodemographic features of the surrounding area is shown in Table 5. The highest values for Pearson's coefficients are found for the number of hotels/residences (0.103), public transport stations (0.099), and cultural venues (0.096). As regards the resident population (-0.084) and population density (-0.084), they present a negative correlation with the nightly rate.

Share/transferability (multivariate analysis)

The transferability of the algorithm refers to the degree to which the findings of this case study can be generalized in the context of Short-Term Rental apartments through multivariate inferential statistics such as Exploratory Factor Analysis (EFA) and Statistical Regression Technique (SRT). This technological algorithm can estimate a model in which the market-adjusted price could be established for a Short-Term Rental apartment if the location and internal features are known in advance.

The proposed technological algorithm was first used in an Exploratory Factor Analysis of the main factors (28 internal characteristics and 9 sociodemographic features of

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TABLE 4 Description of the area surrounding the 569 properties (500-m radius).

N (cases)	569	
Feature	**Mean**	**Standard deviation**
Resident population	38,276	12,512
Density of resident population	1,950	638
Socioeconomic Index (scale 0–10)	6.46	1.58
% of second homes (Over total dwellings)	14%	10%
No. of active businesses (shops)	8	9
No. of restaurants/bars/cafés	238	127
No. of traditional hotels/residences	9	12
No. of urban public transport stations	7	5
No. of establishments for cultural shows (cinemas/theaters...)	11	12

Source: Own elaboration.

TABLE 5 Correlation between the nightly price with the 9 sociodemographic features of the area.

Description of the area surrounding the 569 properties	**Correlation with**		
(500-m radius) (*Deskmind Research*)	**Nightly price (May 21–Apr 22)**		
	N	**Pearson's Corr**	**Significance**
Resident population	569	−0.084*	0.045
Density of resident population	569	−0.084*	0.045
Socioeconomic Index (scale 0–10)	569	0.054	0.201
% of second homes (Over total dwellings)	569	0.028	0.512
No. of active businesses (shops)	569	0.041	0.33
No. of Restaurants/Bars/Cafés	569	0.048	0.25
No. of Traditional hotels/residences	569	0.103*	0.014
No. of Urban public transport stations	569	0.099*	0.018
No. of cultural venues (cinemas/theater...)	569	0.096*	0.022

*Correlation is significant at 0.05 (bilateral). Source: Own elaboration.

the surrounding area) that most influence the market-adjusted price of a Short-Term Rental apartment when the location and internal characteristics are known in advance (37 variables in total, 28 + 9).

Analyze of results (multivariate analysis)

Exploratory factor analysis

Exploratory Factor Analysis (EFA) is reduced here to 12 common factors with different descriptive categories and a deep understanding of their influence on the nightly rate. As this subject has never been explored in this way before, EFA was chosen instead of Confirmatory Factor Analysis (CFA) for its validity and reliability. The validity of the new factors was then evaluated using Bartlett's Test of Sphericity, where $p < 0.05$ indicates that the matrix is adequate due to the high correlations between the variables. Reliability was confirmed using the KMO test (Kaiser–Mayer–Olkin), where a value of at least 0.6 indicates that partial correlations between variables are acceptable.

An Exploratory Factor Analysis was applied to condense these 37 items into a lower number of dimensions. Bartlett's Test of Sphericity ($p < 0.000$) and the KMO index (0.751 higher than 0.7) justify the application of factor analysis (Table 6).

Communalities indicate the amount of variance in each variable that is accounted for. In this EFA, all 38 variables are

TABLE 6 Bartlett's Test of Sphericity and the KMO index for this research.

KMO index and Bartlett's test of sphericity		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.751
Bartlett's test of sphericity	Approx. chi-squared	6156.398
	Df.	253
	p-value	0.000

Source: Own elaboration.

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TABLE 7 Communalities of this EFA.

Communalities	Initial	Extraction
Density of resident population	1	0.983
Socioeconomic index (scale 0–10)	1	0.947
% of second homes (over total dwellings)	1	0.943
No. of active businesses (shops)	1	0.622
No. of restaurants/bars/cafés	1	0.937
No. of traditional hotels/residences	1	0.949
No. of urban public transport stations	1	0.883
No. of cultural venues (cinemas/theater...)	1	0.951
Bathrooms	1	0.627
Bedrooms	1	0.828
Beds	1	0.778
Capacity	1	0.808
Air conditioning	1	0.801
Dryer	1	0.935
Gym	1	0.793
Heating	1	0.628
Hot tub	1	0.992
Internet	1	0.695
Child friendly	1	0.702
Pool	1	0.777
Washing machine	1	0.759
Doorman	1	0.961
Kitchen	1	0.717
Extraction method: principal component analysis		

Source: Own elaboration.

higher than 0.5, indicating a good explanation capacity for this model (Table 7).

Several iterations were conducted to reach the optimal number of factors. In particular, the total variance explained by these 12 factors/components is 82.721%, showing that the data are useful (Table 8).

The rotated component matrix (Table 9) determines factor composition. In this study, 12 factors are identified:

Multiple linear regression

Following EFA, Multiple Linear Regression was conducted to define an algorithm (technology transfer model) that explains the average rate charged based on 12 factors of the Short-Term Rental apartments related to the internal property features and the sociodemographic data of the surrounding area.

With an R of 0.754 and an adjusted R squared of 0.569, the model obtained is deemed to be reliable (Table 10).

Since the factors are independent of one another, standardized beta coefficients can be used to estimate the weight of each dimension (factor) in terms of the market-adjusted rental price (Table 11).

Discussion

Comparing findings with the existing literature, the research presented here is focused on the geolocation of the property with regard to its sociodemographic surroundings. In this regard, Benítez-Aurioles (2018) and Gunter and Önder (2018) also focus on geolocation, showing that listing price is related to distance from the city center and that the response time of the host is negatively correlated with such bookings.

Additionally, this study considers prices, influenced by the sociodemographic variables of the property's surrounding area, as positive. In this regard, Filippas and Horton (2018) focus on the decline in the demand for housing if the neighbors fear

TABLE 8 Total variance explained by factor analysis.

Component	Initial eigenvalues			Extraction eigenvalues			Rotation eigenvalues		
	Total	% of variance	% cumulative	Total	% of variance	% cumulative	Total	% of variance	% cumulative
Total variance explained									
1	4.17	18.128	18.128	4.17	18.128	18.128	3.863	16.797	16.797
2	3.232	14.054	32.182	3.232	14.054	32.182	2.977	12.945	29.7415
3	2.039	8.866	41.048	2.039	8.866	41.048	1.565	6.803	36.544
4	1.86	8.087	49.135	1.86	8.087	49.135	1.545	6.716	43.261
5	1.393	6.058	55.194	1.393	6.058	55.194	1.517	6.595	49.856
6	1.228	5.34	60.533	1.228	5.34	60.533	1.3	5.651	55.507
7	1.076	4.678	65.211	1.076	4.678	65.211	1.199	5.215	60.722
8	0.95	4.131	69.342	0.95	4.131	69.342	1.036	4.506	65.228
9	0.83	3.607	72.948	0.83	3.607	72.948	1.021	4.44	69.668
10	0.794	3.451	76.399	0.794	3.451	76.399	0.999	4.345	74.014
11	0.77	3.349	79.748	0.77	3.349	79.748	0.999	4.344	78.357
12	0.672	2.923	82.671	0.672	2.923	82.671	0.992	4.314	82.671

Source: Own elaboration.

TABLE 9 Rotated component matrix and factor labels.

Items involved in the factor	Contribution item- > factor	Factor label
Factor composition		
No. of cultural venues (cinemas/theater...)	24%	Surrounding area: Commercial equipment
No. of Traditional hotels/residences	23%	
No. of Urban public transport stations	22%	
No. of Restaurants/Bars/Cafés	20%	
No. of active businesses (shops)	7%	
Density of resident population	78%	Surrounding area: Population density
Socioeconomic Index (scale 0–10)	88%	Surrounding area: Socioeconomic level
% of second homes (over total dwellings)	86%	Surrounding area: Second homes
Bedrooms	27%	Properties for rent: Capacity
Capacity	26%	
Beds	25%	
Bathrooms	19%	
Gym	49%	Properties for rent: Sports equipment (Gym/pool)
Pool	45%	
Child friendly	41%	Properties for rent: Child friendly/internet
Internet	40%	
Washing machine	43%	Properties for rent: Basic appliances (washing machine, kitchen)
Kitchen	43%	
Heating	10%	
Air conditioning	58%	Properties for rent: Air conditioning and heating
Heating	32%	
Dryer	84%	Properties for rent: Complementary appliances: Dryer
Doorman	91%	Properties for rent: Complementary services: Doorman
Hot Tub	97%	Properties for rent: Complementary appliances: Hot tub

Source: Own elaboration.

TABLE 10 Summary of this technology transfer model.

Model	R	R-squared	Adjusted R-squared	Estimation standard error
1[b]	0.754[a]	0.569	0.559	32.00081

[a]Predictors: (Constant), Factors 1–12. [b]Dependent variable: Nightly price (May 21–Apr 22). Source: Own elaboration.

a high turnover or unfamiliar people in their neighborhood. In contrast, authors such as Yifei et al. (2022) found that location conditions have a limited impact on price in areas with established transportation networks.

Focusing on internal characteristics such as bedrooms, bathrooms, beds, and capacity, in this case, Shokoohyar et al. (2020) argued that "properties with more bedrooms, closer to the historic attractions, in neighborhoods with lower minority rates and higher nightlife vibe are more likely to have a higher return if they are rented out through a Short-Term Rental contract."

Looking at internal characteristics, Yifei et al. (2022) show that the quality of a property plays a key role in forming the listing prices. The research presented in this paper shows that the nightly rate charged presents a negative correlation between the resident population and population density. In this regard, Espinosa (2016) and Kim et al. (2017) show that Short Term Rental properties also disrupt existing property and hospitality industries and cause disturbance in the surrounding neighborhood.

Other authors, such as Mody et al. (2021) considered the impact on non-hosting residents' quality of life, finding that they perceived more positive than negative impacts on price. Similarly, the research takes into account data for *Airbnb* in Madrid, identifying the correlation between resident population and population density. In this regard, Martínez-Caldentey et al. (2020) state that tourist rentals arranged through platforms such as *Airbnb* have resulted in over-housing. The historic center of Madrid is an example of this since the *Centro* district is becoming practically a tourist resort, with the largest number of *Airbnb* listings concentrated there.

TABLE 11 Coefficients of the technology transfer model.

	Non-standard coefficients		Standard coefficients						
	B	**Standard error**	**Beta**	**t**	**Sig.**	**Beta^2**	**Factor weight**	**Main factors affecting the starting prices of this proposed technology transfer model**	
(Constant)	**110.391**	**1.397**		**79.04**	**0.00**				
Surrounding area: Commercial equipment	11.451	1.404	0.236	8.157	0.00	0.06	**9%**	**Surrounding area**	**11%**
Surrounding area: Population density	−3.347	1.382	−0.07	−2.421	0.02	0.00	**1%**		
Surrounding area: Socioeconomic level	1.969	1.383	0.041	1.424	0.16	0.00	**0%**		
Surrounding area: Second homes	2.734	1.4	0.056	1.952	0.05	0.00	**1%**		
Properties for rent: Capacity	35.595	1.575	0.655	22.599	0.00	0.43	**72%**	**Capacity**	**72%**
Properties for rent: Sports equipment (Gym/pool)	8.815	1.403	0.182	6.283	0.00	0.03	**6%**	**Property equipment**	**18%**
Properties for rent: Child friendly/internet	1.055	1.41	0.022	0.748	0.46	0.00	**0%**		
Properties for rent: Basic appliances (washing machine, kitchen)	1.665	1.422	0.034	−1.171	0.24	0.00	**0%**		
Properties for rent: Air conditioning and heating	8.818	1.374	0.185	6.42	0.00	0.03	**6%**		
Properties for rent: Complementary appliances: Dryer	8.577	1.417	0.175	6.054	0.00	0.03	**5%**		
Properties for rent: Complementary services: Doorman	2.354	1.457	0.047	1.615	0.11	0.00	**0%**		
Properties for rent: Complementary appliances: Hot Tub	2.927	1.387	0.061	2.111	0.04	0.00	**1%**		
a Dependent variable: Nightly price (May 21–Apr 22)					Sum:	0.60	100%		

Source: Own elaboration.

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All the factors studied in this research are factors that may be gathered in a kick off state of the commercialization of the asset and are not dependent on the historical data that may be gathered within time. They are specific to the asset and independent of market competition and calendar events that may also affect the pricing of the apartment.

Conclusion

This paper aimed to find a behavioral psychology study, generating a revenue management model that establishes the relationship between the factors of a property listed in the *Airbnb* marketplace, or similar, for a Short-Term Rental lease and its optimal rental price set when the property is first put on the market. Findings confirm that the price per night of apartments is influenced by both, the internal features of the property and the sociodemographic characteristics of the area. In this context, some theoretical and practical implications are drawn out in the next lines.

Theoretical implications

The original theoretical scope of this study was to make a comparison between Short-Term Rental and Long-Term Rental revenue. Nevertheless, during the development of the project, it became clear that this initial goal could not be achieved without establishing an empirical foundation to value the different rental models based on the existing literature and adding to it with these new studies. Therefore, based on Yin's approach, a technology transfer model for establishing the rental price of Short-Term Rental apartments was chosen as a new theoretical implication, narrowing this down to the internal characteristics of the property and sociodemographic variables of the surrounding area. Revenue managers usually set a starting price for Short-Term Rentals through experience, benchmarking, and personal impression, but they do not have a theoretical model to perform this calculation, and results are a little too arbitrary for such an important aspect of property revenue management.

The statistical relationships arising from Yin's methodological study and these theoretical developments between price and internal characteristics, and between price and sociodemographic variables, confirm the hypotheses mentioned above. "Hypothesis 1" states that the nightly rate is moderately affected by internal characteristics (refer to **Table 3**, where Pearson's coefficient sits between 0.36 and 0.42 for bathrooms, bedrooms, beds, and capacity). "Hypothesis 2" indicates that the nightly rate is slightly influenced by the sociodemographic variables of the property's surrounding area [refer to **Table 5**, where the highest values for Pearson's coefficients are found for the number of hotels/residences (0.103), public transport stations (0.099), and cultural venues (0.096)]. Regarding the resident population (-0.084) and population density (-0.084), this study found a negative correlation with the nightly rate.

With regard to the Exploratory Factor Analysis conducted, 37 variables were reduced to 12 common factors with different descriptive categories and a deep understanding of their influence on the rental price. In particular, the total variance explained by these 12 factors/components was 82.721%, validating the data (refer to **Table 8**).

Finally, Multiple Linear Regression was applied in order to define an algorithm (technology transfer model) that explains the average rental price based on 12 factors related to the internal characteristics of Short-Term Rental apartments and the sociodemographic features of their surrounding area. With an R of 0.754 and an adjusted R squared of 0.569, the model obtained has a strong predictive/explanatory capacity (refer to **Table 10**).

Practical implications

The practical implications of this research involve the implementation of a technology transfer model for revenue management in Madrid based on the main factors affecting the starting prices of Short-Term Rental apartments (refer to **Table 11**). Essentially, revenue management should be left to pricing decision-makers who are aware of consistent records regarding internal characteristics of the properties and the sociodemographic environment. In particular, the main practical implications of this proposed technology transfer model are:

a) The size/capacity of the properties offered largely determines the Short-Term Rental price (72%).
b) The equipment available in the property influences the Short-Term Rental price to a much lesser extent than its size/capacity (18%).
c) The characteristics of the surrounding area have an even lower impact on the Short-Term Rental price than the previous two factors (11%).

In short, this technology transfer model allows revenue managers and peers to estimate what the market-adjusted price should be for these Short-Term Rental apartments, whose location and internal characteristics are known in advance, as a starting point.

Limitations and future research

The model chosen achieves different levels of technological development and shows that certain factors significantly affect

the price. These factors are quantitative indicators of Short-Term Rental apartments. However, qualitative indicators, such as reviews of the tenant or tourist users have not been included in the model.

Moreover, the data were collected from April 2021 to May 2022 (inclusive). The COVID-19 pandemic may have affected the price, the commitment of the tenant, and their booking process due to travel restrictions and health requirements. Future lines of research will consider correction factors for this technological model on the grounds of seasonality and market trends. Seasonality and market trends will presumably also influence the rental price of Short-Term Rental apartments. Similarly, Long-Term Rental pricing could be studied and compared with Short-Term Rental for these kinds of fully furnished properties.

Data availability statement

The data collected for this study were extracted from two technological databases, namely *SeeTransparent*, based mainly on *Airbnb* (28 internal characteristics of the apartment), and *Deskmind Research* (9 sociodemographic variables of the surrounding area). Requests to access these datasets can be directed to the corresponding author/s.

Author contributions

DJ and DP-B conceptualized the theoretical framework, involved in data preparation, and prepared the first draft of the manuscript. DJ and JE performed the data analyses. DJ, DP-B, and JE revised and improved the multivariate analyses, performed and made important contributions linked to the theoretical literature. All authors read and approved the final version of the text.

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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Employee innovative behavior and workplace wellbeing: Leader support for innovation and coworker ostracism as mediators

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Introduction: Most previous studies focused on the antecedents of employee innovative behavior but rarely examined the outcomes of employee innovative behavior. Moreover, previous studies ignored the relationship between employee innovative behavior and workplace wellbeing. Based on social comparison theory and social exchange theory, this study introduces coworker ostracism and leader support for innovation as mediating variables to explore the "double–edged sword" effect of employee innovative behavior on workplace wellbeing.

Methods: Based on a sample of 319 employees from Chinese companies, this study used SPSS 26.0 and MPLUS 8.3 to examine the hypotheses.

Results: Empirical results demonstrate that (a) employee innovative behavior is directly and positively related to workplace wellbeing, (b) employee innovative behavior is indirectly and positively related to workplace wellbeing through leader support for innovation, and (c) the negative association between employee innovative behavior and workplace wellbeing via coworker ostracism is unsupported.

Discussion: The findings of this study enrich the literature by exploring the double-edged sword effect of employee innovative behavior on workplace wellbeing. The practical implications of this study are that leaders in organizations should give employees innovation support.

KEYWORDS

employee innovative behavior, workplace wellbeing, coworker ostracism, leader support for innovation, dual mediating model

Introduction

Employee innovative behavior refers to a complete process in the workplace, in which individuals generate, promote, and implement new ideas (Scott and Bruce, 1994). Research on employee innovative behavior proliferated at an increasing rate in the past several decades (Kang et al., 2016; Eva et al., 2019; Tian et al., 2020;

Wang H. et al., 2021). Employee innovative behavior is generally believed to be an important source of organizational competitive advantage, which is conducive to the development of an organization (e.g., Anderson et al., 2014; Shin et al., 2017; Eva et al., 2019). Thus, most studies focused on the antecedents of employee innovative behavior to explore how to facilitate such behavior but rarely examined its outcomes. In the literature on the outcomes of employee innovative behavior, most studies focused on the benefits of such behavior to individuals or organizations, and recently, the dark side of employee innovative behavior or creativity has been gaining attention (Janssen, 2003; Janssen et al., 2004; Aryee et al., 2012; Harari et al., 2016; Kim and Koo, 2017; Hammond et al., 2019; Ng and Wang, 2019; Nguyen and Le, 2019; Breidenthal et al., 2020; Coad et al., 2021; Dadaboyev et al., 2021). For example, Aryee et al. (2012) and Kim and Koo (2017) proved the existence of a positive correlation between employee innovative behavior and job performance. Ng and Wang (2019) found that employee innovative behavior has potential costs, which may cause psychological disengagement difficulties, and an important partner effect, which may cause stress among colleagues. Breidenthal et al. (2020) also found that a relatively high level of creativity may cause coworker envy, which can lead to coworker ostracism. Although previous studies have explored the possible positive or negative effects of employees' innovative behavior, no studies have integrated the analysis of the two different effects. Janssen et al. (2004) proposed a theoretical model to summarize the positive outcomes (e.g., improved performance, positive work attitude, constructive conflict, and workplace wellbeing) and negative outcomes (e.g., performance reduction, negative work attitude, destructive conflict, and work stress) of employee innovative behavior. Janssen et al. (2004) further suggested that researchers should develop models to explore the positive and negative outcomes of employee innovative behavior. Therefore, this study will respond to this call. In addition, with the advent of the digital economy era, social competition and work pressure increased, and workplace wellbeing attracted considerable attention from organizations (Salas-Vallina et al., 2017; Sorribes et al., 2021). Workplace wellbeing is considered to be beneficial to enterprises for retaining talents, creating a satisfactory work atmosphere, and promoting their sustainable development (Salas-Vallina et al., 2017; Nangoy et al., 2019). However, the relationship between employee innovative behavior and employee wellbeing has been largely ignored. Mustafa and Ramos (2018) proposed a conceptual model exploring how to mitigate the negative impact of employee creativity on wellbeing; however, they did not explore the mediating mechanisms nor did they conduct empirical tests. Furthermore, innovative behavior differs from individual creativity in that creativity is particularly concerned with coming up with novel ideas or solutions, whereas, innovative behavior further involves application-oriented components (Shalley et al., 2004; Hammond et al., 2011). Therefore, in the context of highly valued innovation and workplace wellbeing, examining the mechanism of how employee innovative behavior impact workplace wellbeing is of considerable significance. To fill this gap, the first objective of this research is to explore the direct relationship between employee innovative behavior and workplace wellbeing. In line with the call of Janssen et al. (2004), the second objective of our research is to explore the indirect positive effect and negative effect of employee innovative behavior on employees' workplace wellbeing.

To reveal the relationship between employee innovative behavior and workplace wellbeing, drawing on social comparison theory and social exchange theory, this study introduces coworker ostracism and leader support for innovation as mediating variables to explore the bright side and dark side of the effect of employee innovative behavior on employees' workplace wellbeing. This study chooses the two mediating variables for the following two reasons. First, coworkers and leaders play a vital part in the process of employees' innovative behavior (Chiaburu and Harrison, 2008; Sijbom et al., 2015a,b). Second, employees, coworkers, and leaders belong to an organizational ecosystem (Neves and Cunha, 2017), where they interact frequently, spend a significant amount of their time at work, and are bound to influence one another to a certain extent. Specifically, this study argues that coworker ostracism is an important mediating variable between employee innovative behavior and workplace wellbeing. Because in modern society, where innovation is encouraged and competition is fierce, "shooting the top bird" has become one of the most common phenomena in the workplace. According to social comparison theory, members of the same team tend to compare themselves with their coworkers to determine their status in the organization. Therefore, employees' outstanding innovative performance may cause their coworkers to reject them, which can adversely affect their wellbeing. Breidenthal et al. (2020) confirmed the dark side of creativity, that is, when employees demonstrate high creativity, they may cause jealousy and experience ostracism from coworkers, which may negatively affect their wellbeing. In addition, this study considers leader support for innovation as an important mediating variable between employee innovative behavior and workplace wellbeing. In a power hierarchy, employees rely on the leader for the information and support necessary to further develop after they implement innovative behaviors. A leader is a crucial party for employees to implement innovative behaviors (Kanter, 1988). Social exchange theory holds that individuals maintain an exchange relationship with others based on the principle of mutual benefit. This reciprocity principle, which is emphasized in social exchange theory, promotes the emergence of exchange. Employee innovative behavior is beneficial for not only promoting organizational performance but also improving the competitiveness of the organization. Consequently, according to social exchange theory, employees who engage in considerable innovative behavior are likely to receive innovation support from their supervisors, which can enhance their wellbeing. Furthermore, a leader has absolute power and status and is bound to exert a certain influence on

the members of his/her team. Accordingly, the leader can use his/her power to minimize phenomenon such as exclusion by coworkers, which is not conducive to the development of the team. Therefore, this study suggests that leader support for innovation may also have an impact on coworker ostracism.

Overall, this study integrates social comparison theory and social exchange theory to construct a serial mediation model of the influence of employee innovative behavior on workplace wellbeing, which uses coworker ostracism and leader support for innovation as mediating variables. This study may have several contributions. First, this study discusses the direct relationship between employee innovative behavior and workplace wellbeing, which can provide a new perspective on the adoption of employee innovative behavior as an antecedent variable, and expands research on the outcomes of employee innovative behavior. Second, based on social comparison theory and social exchange theory, this study introduces coworker ostracism and leader support for innovation as two mediating variables to discuss the indirect positive effect and negative effect of employee innovative behavior on employee workplace wellbeing, which can enrich the literature on the relationship between the two factors. Previous literature has paid limited attention to the dark side of employee innovative behavior. Drawing on social comparison theory, this study takes step to explore the negative impact of employee innovation behavior on employee wellbeing. More importantly, this study integrates, for the first time, the double-edged effect of employee innovative behavior on workplace wellbeing through the negative effect of coworker ostracism and the positive effect of leader support for innovation. Third, this study explores the chain-mediating path of "leader support for innovation–coworker ostracism" between employee innovative behavior and workplace wellbeing, further revealing the mechanism of the effect of employee innovative behavior on workplace wellbeing.

Theoretical background and hypotheses

Employee innovative behavior and workplace wellbeing

Employee innovative behavior refers to employees' creation of novel ideas or methods and their implementation in practice in the process of work. Employee innovative behavior involves three stages: generating innovative ideas, seeking coalitions of supporters, and implementing the innovative ideas in practice (Scott and Bruce, 1994). Workplace wellbeing refers to employees' positive psychological state and experience in the process of fulfilling their self-realization goals and is an important indicator of their mental health, which roughly includes three perspectives: subjective wellbeing, psychological wellbeing, and integrated wellbeing (Diener et al., 1985; Page and Vella-Brodrick, 2008). Terkel (1974) argued that work is the process of searching for bread and meaning every day as well as for cash and recognition. On the one hand, employee innovative behavior can generate high compensation and income to meet employees' material needs. On the other hand, employee innovative behavior may generate increased value for an enterprise and the society and meet employees' self-realization needs, thereby improving their workplace wellbeing. Accordingly, this study deduces that employee innovative behavior is directly and positively related to workplace wellbeing.

First, employees who exhibit considerable innovative behavior may be rewarded financially. Specifically, innovation may have corresponding rewards and meet the material needs of employees, thereby improving their workplace wellbeing. Studies confirmed the positive impact of income on happiness. Kollamparambil (2019) examined four dynamic data of national income in South Africa and found that income can determine the level of happiness. Rijnks et al. (2019) observed that absolute income and relative income can determine personal happiness. Second, innovative behavior means that employees' abilities and skills are improved in the process of continuous innovation, and corporate value and social value are enhanced to meet the spiritual needs of employees for self-improvement and self-value realization, thereby improving their workplace wellbeing. The constant realization of inner goals can help individuals maintain a stable sense of wellbeing (Schmuck et al., 2000). Page and Vella-Brodrick (2008) determined that self-improvement based on strength can reliably improve happiness. Meanwhile, Duan et al. (2020) reported that psychological meaning and perceived social value are positively correlated with workplace wellbeing. Moreover, in the context of Chinese collectivist culture, people pay considerable attention to their social value. Therefore, employees' innovative behavior can not only generate value for the enterprise and society but also enhance their happiness. Finally, according to the hierarchy of needs theory, human beings have five levels of needs: physiological, safety, social, respect, and self-realization, which transition from material to spiritual needs. Innovation, as a risky and valuable activity, is the affirmation of the innovative abilities of employees. Moreover, innovation can increase economic rewards for employees, generate substantial economic value for enterprises and society, and meet the material and spiritual needs of employees. Based on the above discussion, this study proposes the following hypothesis:

> *Hypothesis 1: Employee innovative behavior is directly and positively associated with workplace wellbeing.*

Mediating role of coworker ostracism in the relationship between employee innovative behavior and workplace wellbeing

Coworker ostracism is defined as the subjective feeling of being ignored, avoided, or excluded by coworkers in the workplace (Ferris et al., 2008). Rejection by coworkers in the workplace can lead to unpleasant and painful experiences for employees (Zhang and Shi, 2017). Drawing upon social comparison theory, individuals have an inherent drive to evaluate their abilities and perspectives, especially when assessment criteria are not defined, and they will attempt to compare themselves to others who are close (Festinger, 1954), such as coworkers. Coworkers have been considered particularly likely referents to be used in the workplace, especially when assessing performance in innovative activities (Mumford, 1983). Specifically, the successful performance of an employee (e.g., innovative behavior) triggers negative upward comparisons with coworkers, and such unfavorable comparisons with peers can lead to increased coworker envy and coworker ostracism (Breidenthal et al., 2020; Dadaboyev et al., 2021), thus reducing employees' workplace wellbeing.

On the one hand, employee innovative behavior has a correction effect on coworker ostracism. Employee innovative behavior is a type of breakthrough and change in existing situations or working conditions. Thus, coworkers may face the consequences of passively accepting the reform of the work content or work model brought about by other employees' innovation (Cheng and Hong, 2017), such as job crafting. However, studies showed that individuals prefer to maintain the *status quo* and stick to their routines rather than change (Van Dam et al., 2008; Hon et al., 2014; Röth and Spieth, 2019; Kashan et al., 2022). Coworkers may not accept the changes brought about by innovative behavior, because such changes may create increased work requirements (Janssen, 2003). From this point of view, employee innovative behavior may lead to coworker ostracism. Meanwhile, from the perspective of social comparison, employee innovative behaviors are prone to generate social comparison, unlike intra-role behaviors, which are specified in role regulations and recognized by formal reward systems (Dadaboyev et al., 2021). In this case, members in the same team tend to compare themselves with their coworkers to determine their own attributes, and coworkers engaging in considerable innovative behavior are equivalent to setting a good example for the team. By contrast, coworkers who are set in their ways and do not innovate will seem conservative and inactive, which can lead to lowered self-evaluations (Buunk and Gibbons, 2007). Thus, to mitigate the threat of contrast effects due to upward comparisons, individuals may motivate defensive ostracism (Liu et al., 2019; Henle et al., 2022). Specifically, employees who exhibit more innovative behavior compared with their peers are perceived to be outliers, which may cause their exclusion from the team's "one of us" classification system (Breidenthal et al., 2020). Moreover, when an employee engages in considerable innovative behavior, he/she will utilize substantial organizational innovation resources and thus may reduce the resources available to his/her coworkers (Graen and Uhl-Bien, 1995; Baer, 2012; Campbell et al., 2017), thereby resulting in coworker ostracism. Therefore, from the perspective of the social comparison mechanism and resource preservation, employee innovative behavior is a breakthrough in the current work balance and interpersonal relationship, which may lead to coworker ostracism.

On the other hand, coworker ostracism is associated with low levels of workplace wellbeing. Belongingness is a fundamental social need of humans, and human beings are born with the need to establish and maintain lasting and positive interpersonal relationships. If this basic need is not satisfied, then an individual may experience various negative effects, which may lead to psychological or behavioral disorders. A large number of empirical studies showed that coworker ostracism is associated with a variety of negative outcomes, including reduced voice behavior (Wen et al., 2018; Jahanzeb and Newell, 2020), increased stress (Sarfraz et al., 2019), increased job burnouts, and reduced OBSE, as well as organizational identification (Shafique et al., 2020). Coworker ostracism may make individuals feel that they are not accepted by the group and have no sense of belonging to the group (Janssen et al., 2004; Williams, 2007). Thus, they may face unpleasant experiences and perceive reduced workplace wellbeing. To sum up, this study holds that employee innovative behavior is positively related to coworker ostracism, whereas, coworker ostracism is negatively related to workplace wellbeing. Thus, this study proposes the following hypothesis:

> *Hypothesis 2: Coworker ostracism plays a mediating role in the relationship between employee innovative behavior and workplace wellbeing. In other words, employees' innovative behavior is indirectly and negatively related to their workplace wellbeing through coworker ostracism.*

Mediating role of leader support for innovation in the relationship between employee innovative behavior and workplace wellbeing

Leader support for innovation refers to leaders advocating innovation in the workplace, encouraging employees to actively present new ideas, improving production technology or working methods, and providing corresponding support (West, 2000). Amabile et al. (1996) argued that leader support for innovation will enable leaders to set clear goals for their subordinates,

actively interact with their subordinates, and support work-related innovation. Deci and Ryan (2013) proved that compared with controlling leaders, supportive leaders care more about and encourage their subordinates to actively express their ideas. According to the social exchange theory, parties engage in and maintain exchange relationships with others in anticipation of rewards (Homans, 1958; Blau, 1968), and the nature of this relationship is mutually beneficial (Emerson, 1976). Thus, when employees exhibit innovative behavior, leaders provide innovative support to employees based on the principle of reciprocity. As a result, employees see that when they are engaged in the organization, the organization likewise gives them feedback to nurture and maintain a mutually satisfying relationship, thereby enhancing employees' workplace wellbeing.

On the one hand, employee innovative behavior may lead to leader support for innovation. Innovation emphasizes the successful implementation of innovative ideas (Amabile, 1988; Staw, 1990; Unsworth et al., 2000; Hammond et al., 2011; Montani et al., 2018), and these ideas may provide leaders not only with valuable information about emerging work-related problems but also with a creative resolution of these problems emerging in leaders' domain of responsibility. Researches confirmed that members' creative performance is beneficial and vital to teams, enterprises, and large social groups (Janssen et al., 2004; Yuan and Woodman, 2010; Juliao-Rossi et al., 2020). Employee innovative behavior is recognized and encouraged by leaders because it is beneficial to organization survival in the modern competitive environment. Moreover, as a type of extra-role behavior (Cheng and Hong, 2017; Coetzer et al., 2018), employee innovative behavior is beyond the scope of employees' responsibilities. According to social exchange theory, individuals are satisfied with each other through the exchange (Homans, 1958). Employees who engage in considerable innovative behavior devote substantial amounts of time and energy and bear increased innovative risks and thus typically receive substantial support and resources from their leaders. As innovation can benefit an organization and leaders in terms of performance evaluation indicators (Eisenberger et al., 1990; Madrid et al., 2016), leaders will likely encourage and support employees who engage in considerable innovative behavior.

On the other hand, leader support for innovation can facilitate employees' workplace wellbeing. Existing studies confirmed that leader support can significantly positively predict employees' workplace wellbeing (Kim et al., 2018; Cohen and McKay, 2020; Hammer et al., 2021). Leader support for innovation can also improve employees' positive emotions and stimulate their enthusiasm for work, thereby enhancing their workplace wellbeing. In addition, leader support for innovation has a positive impact on employees' health (Hammer et al., 2013; Wang et al., 2013). Leader support for innovation means that leaders provide resource support and emotional care to their subordinates who show considerable innovative behavior (Akbari et al., 2021; Tan et al., 2021). When employees encounter difficulties in the innovation process, leaders will be understanding and will encourage them, which is conducive to reducing their insecurities and improving their workplace wellbeing. To sum up, this study proposes that employee innovative behavior is positively related to leader support for innovation, and leader support for innovation can improve employees' workplace wellbeing. Thus, we propose the following hypothesis:

> *Hypothesis 3: Leader support for innovation plays a mediating role in the relationship between employee innovative behavior and workplace wellbeing. In other words, employee innovative behavior is indirectly and positively related to workplace wellbeing through leader support for innovation.*

Chain-mediating role of leader support for innovation and coworker ostracism in the relationship between employee innovative behavior and workplace wellbeing

In a work team, the leader and coworkers mainly constitute the interpersonal work environment. On the one hand, employees who engage in considerable innovative behavior will attract the attention of their coworkers, because such action is novel and deviates from general workplace practices and procedures. On the other hand, employees who exhibit considerable innovative behavior tend to receive increased leader support for innovation. In addition, as the power holder and resource distributor in the team, a leader will have a significant influence on the attitude and behavior of each member in the team, and his/her attitude and behavior may also directly or indirectly intervene in the process of exclusion (Rhoades and Eisenberger, 2002). Previous studies suggested that when employees and coworkers are in conflict, leaders often take on the role of a third party to reduce the negative impact of the conflict on the participants involved (Jehn and Bendersky, 2003; Peterson and Harvey, 2009). Therefore, this study suggests that leader support for innovation may offset the negative impact of coworker ostracism when employee innovative behavior has an impact on workplace wellbeing.

As for the phenomenon of coworker ostracism in the workplace, existing studies found that organizational support can alleviate the negative impact of coworker ostracism, thereby enabling employees to achieve high performance and self-worth (Scott et al., 2014; Meng, 2016). For example, Janssen and Giebels (2013) confirmed that leaders alleviated tensions and conflicts with colleagues over creative behaviors. Ali et al. (2020)

found that spiritual leadership is negatively associated with workplace ostracism, both directly and indirectly *via* job social support. Therefore, leaders can relieve work pressure on employees through daily care and help and support other employees in the team to reduce their negative emotions of tension and jealousy (Lee and Duffy, 2019; Li et al., 2021). In addition, according to equity theory, leaders take steps to mitigate the effect of coworker ostracism to encourage innovative thinking. For instance, when employees engage in considerable innovative behavior, leaders will give them substantial encouragement and rewards and will tend to protect their rights and interests. Moreover, the innovation atmosphere in a team can promote cooperative behavior in innovation (Fredrickson, 2004). When employees' innovative behavior is encouraged and supported by leaders, and when employees receive certain material and spiritual rewards, an atmosphere encouraging and supporting innovation will be formed in the organization (Su et al., 2019). Thus, employees will regard their innovative coworkers as role models instead of exhibiting jealousy or rejection. Therefore, for employees who engage in considerable innovative behavior, leaders can adopt a series of measures to reduce ostracism by coworkers to improve their workplace wellbeing. Hence, this study proposes the following hypothesis:

> *Hypothesis 4: Leader support for innovation and coworker ostracism play a chain mediating role in the relationship between employee innovative behavior and workplace wellbeing. In other words, leader support for innovation is negatively related to coworker ostracism, and employee innovative behavior is indirectly related to workplace wellbeing through the chain mediating path of "leader support for innovation–coworker ostracism."*

The theoretical framework is presented in **Figure 1**.

Materials and methods

Sample and procedures

In this study, the snowball sampling approach was employed to collect the company sample (Hendricks and Blanken, 1992). First, 20 companies in China were identified through MBA alumni. Second, the human resource department directors of the companies were contacted to explain the purpose of the data collection. Third, 378 employees were recruited from the 20 companies to participate in the questionnaire survey. Several days before the administration of the questionnaire survey, a private email was sent to all the participants to emphasize that the research was anonymous and only for academic research purposes and further explains the research procedure.

Podsakoff et al. (2012) suggested that multi-wave data collection for the dependent and independent constructs may be beneficial for mitigating common method variance. Following this suggestion, a two-wave data collection procedure was implemented in this study. In Time 1, the participants were required to complete a questionnaire on the independent variable (employee innovative behavior), mediating variables (coworker ostracism and leader support for innovation), and demographic variables (age, gender, education, department, and number of years employed). After a month, in time 2, the same participants were required to complete a questionnaire on the dependent variable (workplace wellbeing). To match the responses of T1 and T2, participants were asked to fill in the last four digits of their phone numbers in the questionnaire.

At time 1, 378 questionnaires were collected, and at time 2, only 343 questionnaires were collected. Among 343 questionnaires, a total of 24 questionnaires were discarded owing to missing data; patterned responses, such as alternating between the options or clicking on the midpoint; or random responses (McKibben and Silvia, 2015), thereby leaving 319 valid questionnaires, with a response rate at 84.4%. The sample description is presented in **Table 1**.

Measures

The main variables in this study were employee innovative behavior, coworker ostracism, leader support for innovation, and workplace wellbeing. In addition to the control variables, each variable was measured on a five-point Likert scale ranging from 1 = "strongly disagree" to 5 = "strongly agree." The specific application is described below.

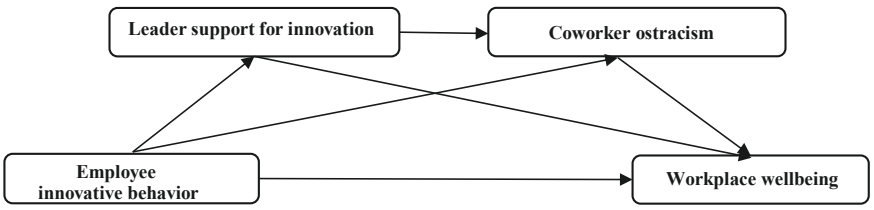

FIGURE 1
Theoretical model.

TABLE 1 Statistical characteristics of the sample.

Characteristics	Classification	Number	Ratio
Gender	Male	161	50.47%
	Female	158	49.53%
Age	18–25	98	30.72%
	25–29	113	35.42%
	30–39	94	29.47%
	40–49	13	4.08%
	≥50	1	0.31%
Education	High school or below	14	4.39%
	Junior college	37	11.60%
	Bachelor	230	72.10%
	Master or above	38	11.91%
Department	Management	82	25.71%
	Technical/R&D	114	35.74%
	Marketing	38	11.91%
	Finance	23	7.21%
	Others	62	19.44%
Working seniority	Less than 3 years	121	37.93%
	3–6 years	110	34.48%
	7–14 years	73	22.88%
	More than 15 years	15	4.70%

Employee innovative behavior

Employee innovative behavior was measured with a six-item scale developed by Scott and Bruce (1994). The items were (1) "I search out new technologies, processes, techniques, and/or product ideas"; (2) "I often generate creative ideas"; (3) "I often promote and champion ideas to others"; (4) "I investigate and secure funds needed to implement new ideas"; (5) "I develop adequate plans and schedules for the implementation of new ideas"; and (6) "Overall, I am innovative."

Coworker ostracism

Coworker ostracism was measured with the 10-item scale developed by Ferris et al. (2008). The items included (1) "I feel that my colleagues ignore me at work"; (2) "My colleagues leave the area when I enter"; (3) "My greetings are unanswered at work"; (4) "I involuntarily sit alone in a crowded lunchroom at work"; (5) "I feel that my colleagues avoid me at work"; (6) "I notice that my colleagues would not look at me at work"; (7) "I feel that my colleagues shut me out of the conversations at work"; (8) "I feel that my colleagues refuse to talk to me at work"; (9) "I feel that my colleagues treat me as if I am not there"; and (10) "My colleagues at work do not invite me or ask me if I want anything when they go out for a coffee break."

Leader support for innovation

Leader support for innovation was measured with a four-item scale adapted from Amabile et al. (1996) and Vincent-Höper and Stein (2019). The items were (1) "My supervisor encourages subordinates to contribute innovative ideas or suggestions for improvement"; (2) "My supervisor advises subordinates on how to develop and implement innovative ideas in the organization"; (3) "My supervisor attempts to create satisfactory conditions for the implementation of innovative ideas, such as financial resources and flexible scheduling"; and (4) "My supervisor praises and rewards innovative behavior at work."

Workplace wellbeing

Workplace wellbeing was measured with the five-item scale developed by Diener et al. (1985). The items included (1) "In most ways, I think my life is close to my ideal," (2) "I think my life conditions are excellent," (3) "I am satisfied with my life," (4) "So far I have gotten the important things I want in life," and (5) "If I could live my life over, I would change almost nothing."

Moreover, based on previous studies, the following control variables were selected: gender (1 = male, 2 = female), age (1 = 18–25 years, 2 = 25–29 years, 3 = 30–39 years, 4 = 40–49 years, 5 = 50 years and above), education (1 = high school or below, 2 = junior college, 3 = bachelor's degree, 4 = master's degree or higher), department (1 = management, 2 = technical/R&D, 3 = marketing, 4 = finance, 5 = others), and working seniority (1 = less than 3 years, 2 = 3–6 years, 3 = 7–14 years, 4 = more than 15 years). As the demographic variables may have a certain correlation with the behavior performance of the employees and an impact on employee innovative behavior, they were controlled in this study.

Data analysis and results

Reliability and validity tests

First, SPSS 26.0 was employed to test Cronbach's alpha of the four scales of employee innovative behavior, coworker ostracism, leader support for innovation, and workplace wellbeing (see Table 2). Cronbach's alpha of all the variables was larger than 0.7, thereby indicating that the reliability of the questionnaire was appropriate. Second, the average variance extracted (AVE) value of most variables was larger than 0.5 (see Table 2). Though the exception is employee innovative behavior (0.478), according to previous literature, as

TABLE 2 Reliability and validity of variables.

Variable	Load factor	Cronbach's α	KMO	CR	AVE
EIB	0.646–0.776	0.780	0.811	0.846	0.478
CO	0.665–0.819	0.922	0.949	0.935	0.592
LSI	0.715–0.824	0.775	0.772	0.857	0.600
WWB	0.676–0.855	0.838	0.848	0.890	0.619

EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

TABLE 3 Results of confirmatory factor analyses.

Models	χ^2	df	χ^2/df	$\Delta\chi^2$	CFI	TLI	RMSEA	SRMR
Four-factor model (EIB; CO; LSI; WWB)	450.800	269	1.676	/	0.947	0.941	0.046	0.053
Three-factor model (EIB + LSI; CO; WWB)	624.773	272	2.297	173.973	0.898	0.888	0.064	0.062
Two-factor model (EIB + WWB; CO + LSI)	1037.462	274	3.786	586.662	0.779	0.758	0.093	0.117
One-factor model (EIB + CO + LSI + WWB)	1937.589	275	7.046	1486.789	0.520	0.476	0.138	0.172

EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

the composite reliability (CR) of the constructs is well above the recommended level, the internal reliability of the measurement items is acceptable (Lam, 2012), thereby indicating that the aggregation validity of the questionnaire was appropriate. Third, MPLUS 8.3 was used to conduct confirmatory factor analysis (CFA). The fitting index of each model is shown in Table 3. The theoretical four-factor model (employee innovative behavior, coworker ostracism, leader innovation support, and workplace wellbeing) demonstrated a better fit with the data ($\chi 2$/df = 1.676, CFI = 0.947, TLI = 0.941, RMSEA = 0.046, and SRMR = 0.053) compared with the other models, thereby indicating that the theoretical four-factor model exhibited appropriate discriminant validity. Moreover, as shown in Table 4, the square root of the AVE of all the variables was larger than the correlation of all the remaining constructs in the rows and columns, thereby indicating that the discriminant validity of the questionnaire was appropriate.

Common method variance

As all the variables in this study were measured *via* the employees' self-evaluation, the problem of common method variance should be considered. Therefore, the Harman single-factor method was used for the testing, and unrotated principal component analysis was conducted for all the variables. The results showed that the first factor explained 22.96% of the cumulative total variance, which is less than 40% and meets the recommended criterion. Furthermore, CFA was conducted with the inclusion of the latent common factor model. The results revealed that the fitting effect of the latent common factor model ($\chi 2$/df = 1.734, CFI = 0.943, TLI = 0.936, RMSEA = 0.048, and SRMR = 0.065) was not as good as that of the four-factor model ($\chi 2$/df = 1.676, CFI = 0.947, TLI = 0.941, RMSEA = 0.046, and SRMR = 0.053), thereby indicating the absence of common method variance in this study.

Descriptive statistics and correlation analysis

Table 4 presents the descriptive statistics (mean and SD) and correlation analysis (Pearson's coefficient). The results showed that employee innovative behavior was positively correlated with workplace wellbeing (r = 0.469, $P < 0.01$) but negatively associated with coworker ostracism ($r = -0.125$, $P < 0.05$), and a non-significant correlation existed between coworker ostracism and workplace wellbeing ($r = -0.088$, $P > 0.05$). In addition, employee innovative behavior was positively associated with leader support for innovation (r = 0.416, $P < 0.01$), and leader support for innovation was positively associated with workplace wellbeing (r = 0.422, $P < 0.01$) but negatively associated with coworker ostracism ($r = -0.193$, $P < 0.01$). Among the results, the correlation between coworker ostracism and workplace wellbeing was unexpected. The hypothesis tests were further conducted.

Hypothesis tests

First, SPSS 26.0 was used for the hierarchical regression analysis to verify the research hypotheses, and the results are shown in Table 5.

Table 5 reveals that employee innovative behavior was positively related to workplace wellbeing (β = 0.624, $P < 0.01$, model 6), thereby supporting Hypothesis 1. Compared with model 6, the mediating variable coworker ostracism was added to model 7, which showed no significant effect on workplace wellbeing (β = 0.001, $P > 0.05$, model 7). However, the influence coefficient of employee innovative behavior on workplace wellbeing did not change (β = 0.624, $P < 0.01$), thereby indicating that coworker ostracism did not play a mediating role in the relationship between employee innovative behavior and workplace wellbeing; thus, Hypothesis 2 was unsupported. Compared with model 6, the mediating variable leader support for innovation was added to model 8, which demonstrated that leader support for innovation was positively related to workplace wellbeing (β = 0.317, $P < 0.01$). However, the influence coefficient of employee innovative behavior on workplace wellbeing decreased significantly (β = 0.464, $P < 0.01$), indicating that leader support for innovation played a partial mediating role in the relationship between employee innovative behavior and workplace wellbeing; thus, Hypothesis 3 was supported.

Second, PROCESS macro was employed for the bootstrap analysis. The sample size was set to 5,000, and the confidence interval was set to 95%. The non-parametric percentile method of deviation correction was selected for the bootstrap sampling,

TABLE 4 Means, standard deviations (SDs), and correlations.

Variables	1	2	3	4	5	6	7	8	9
1. Gender	–								
2. Education	0.132*	–							
3. Age	−0.045	0.223**	–						
4. Department	0.148**	−0.189**	−0.351**	–					
5. Working seniority	0.021	0.152**	0.807**	−0.295**	–				
6. EIB	−0.168**	0.102	0.173**	−0.204**	0.143*	(0.692)			
7. CO	−0.107	−0.157**	−0.147**	0.146**	−0.128*	−0.125*	(0.769)		
8. LSI	−0.024	0.025	0.103	−0.146**	0.136*	0.416**	−0.193**	(0.775)	
9. WWB	−0.044	0.105	0.238**	−0.184**	0.161**	0.469**	−0.088	0.422**	(0.787)
M	1.50	2.92	2.08	2.59	1.94	4.06	1.96	3.91	3.53
SD	0.501	0.636	0.889	1.440	0.892	0.569	0.794	0.699	0.805

$N = 319$; *$p < 0.05$, **$p < 0.01$. Values in parentheses are square roots of AVE. EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

TABLE 5 Hierarchical regression analysis results.

Variables	LSI		CO		WWB			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Gender	−0.015	0.075	−0.18*	−0.205*	−0.033	0.078	0.078	0.054
Education	−0.007	−0.041	−0.126	−0.117	0.053	0.011	0.011	0.024
Age	−0.046	−0.069	−0.072	−0.066	0.236**	0.207**	0.207**	0.229**
Department	−0.059*	−0.034	0.062	0.054	−0.06	−0.028	−0.028	−0.017
Working seniority	0.116	0.104	−0.011	−0.007	−0.078	−0.093	−0.093	−0.126
EIB		0.504***		−0.144		0.624***	0.624***	0.464***
CO							0.001	
LSI								0.317***
R^2	0.032	0.187	0.058	0.068	0.073	0.252	0.252	0.314
ΔR^2		0.155		0.01		0.179	0	0.061
F	2.069	59.684***	3.836**	3.293	4.937***	74.814***	0.001	27.820***

$N = 319$; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

and the results are presented in Table 6. The figure shows that the direct effect of employee innovative behavior on workplace wellbeing was 0.466, and its 95% CI was [0.318, 0.615] (excluding 0), thereby further supporting Hypothesis 1. In addition, the indirect effect of employee innovative behavior on workplace wellbeing through coworker ostracism was−0.002, with a 95% CI of [−0.019, 0.015] (including 0). Thus, the mediating effect of coworker ostracism was not confirmed, and Hypothesis 2 was unsupported. The indirect effect of employee innovative behavior on workplace wellbeing through leader support for innovation was 0.163, and the 95% CI was [0.084, 0.265] (excluding 0). Therefore, the mediating effect of leader support for innovation was confirmed, and Hypothesis 3 was further supported. The chain mediation path effect value of "employee innovative behavior → leader support for innovation → coworker ostracism → workplace wellbeing" was−0.004, and the CI was [−0.016, 0.007] (including 0). Therefore, Hypothesis 4 was unsupported.

In addition, to validate the model more completely, MPLUS 8.3 is used to construct a structural equation model. Figure 2 presents the standardized path coefficients of the model. In Figure 2, the direct effect of employee innovative behavior on workplace wellbeing is supported by

TABLE 6 Results of the chain mediation test.

Path	Effect	S.E	95% CI	
			Lower limit	Upper limit
EIB→WWB	0.466	0.076	0.318	0.615
EIB→CO→WWB	−0.002	0.008	−0.019	0.015
EIB→LSI→WWB	0.163	0.046	0.084	0.265
EIB→LSI→CO→WWB	−0.004	0.006	−0.016	0.007

EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

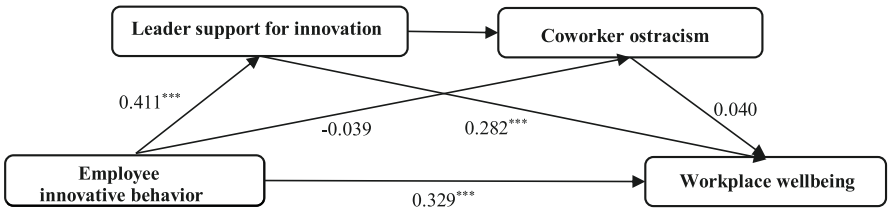

FIGURE 2
Results of the theoretical model using MPLUS. $N = 319$, $^{***}p < 0.001$. Standardized path coefficients are reported.

TABLE 7 Results of multiple mediating effect test.

Effects	Estimate	S.E	*P*	95% CI	
				Lower limit	Upper limit
Total effect EIB→WWB	0.623	0.081	0.000	0.465	0.775
Direct effect EIB→WWB	0.329	0.051	0.000	0.226	0.428
Direct effect EIB→CO	−0.039	0.073	0.591	−0.187	0.095
Direct effect CO→WWB	0.040	0.055	0.469	−0.082	0.136
Direct effect EIB→LSI	0.411	0.074	0.000	0.249	0.544
Direct effect LSI→WWB	0.282	0.061	0.000	0.152	0.391
Direct effect LSI→CO	−0.157	0.066	0.017	−0.283	−0.028
Indirect effect EIB→CO→WWB	−0.002	0.008	0.777	−0.027	0.007
Indirect effect EIB→LSI→WWB	0.164	0.047	0.000	0.085	0.271
Indirect effect EIB→LSI→CO→WWB	−0.004	0.006	0.536	−0.019	0.006

EIB, employee innovative behavior; CO, coworker ostracism; LSI, leader support for innovation; WWB, workplace wellbeing.

the regression coefficient and associated significance level (β = 0.329, $p < 0.001$). Furthermore, in Table 7, the total effect coefficient of employee innovative behavior on workplace wellbeing is significant (β = 0.623, $p < 0.001$), and the 95% CI is [0.465, 0.775] (excluding 0). The results suggest that employee innovative behavior is significantly positively related to workplace wellbeing. Thus, Hypothesis 1 is confirmed. Second, in Figure 2, employee innovative behavior has no significant effect on coworker ostracism (β =−0.039, $p > 0.05$), and coworker ostracism has no significant effect on workplace wellbeing (β = 0.040, $p > 0.05$). Furthermore, in Table 7, after controlling leader support for innovation, the indirect effect of "EIB→CO→ WWB" is not significant (β =−0.002, $p > 0.05$), and the CI is [−0.027, 0.007] (including 0). The results suggest that the mediating effect of coworker ostracism between employee innovative behavior and workplace wellbeing is not supported. Thus, Hypothesis 2 is not confirmed. Third, Figure 2 shows that employee innovative behavior is positively related to leader support for innovation (β = 0.411, $p < 0.001$), and leader support for innovation is positively related to workplace wellbeing (β = 0.282, $p < 0.001$). Furthermore, in Table 7, after controlling coworker ostracism, the indirect effect of "EIB→LSI→WWB" is significant (β = 0.164, $p < 0.001$), and the CI is [0.085, 0.271] (excluding 0). The results suggest that leader support for innovation plays a mediating role between employee innovative behavior and workplace wellbeing. Thus, Hypothesis 3 is confirmed. Finally, in Figure 2, employee innovative behavior had a positive effect on leader support for innovation (β = 0.411, $p < 0.001$), leader support for innovation exhibited a direct positive effect on coworker ostracism (β =−0.157, $p < 0.05$), but coworker ostracism has no significant effect on workplace wellbeing (β = 0.040, $p > 0.05$). The indirect impact of employee innovative behavior on workplace wellbeing by means of two chain-mediating variables, leader support for innovation and coworker ostracism, was unsupported. Furthermore, in Table 7, the indirect effect of "EIB→LSI→CO→WWB" is not significant (β =−0.004, $p > 0.05$), and the CI is [−0.019, 0.006] (including 0). The results suggest that the chain-mediating effect of "leader support for innovation–coworker ostracism" between employee innovative behavior and workplace wellbeing is not supported. Thus, Hypothesis 4 is not confirmed.

Discussion

Based on social comparison theory and social exchange theory, this study introduces coworker ostracism and leader support for innovation as mediating variables to explore the bright side and dark side of the effect of employee innovative

behavior on employees' workplace wellbeing. The empirical findings are described below.

First, the results show that employee innovative behavior is positively and directly related to workplace wellbeing. As employee innovative behavior is beneficial to enterprises' development, employees who engage in innovation will perceive self-goal satisfaction and self-value realization, which can improve their workplace wellbeing.

Second, coworker ostracism does not negatively mediate the relationship between employee innovative behavior and workplace wellbeing, employee innovative behavior is negatively correlated with coworker ostracism, and no significant correlation exists between coworker ostracism and workplace wellbeing. This finding may be attributed to the following reasons. First, most of the survey participants reported that they have not been ostracized by their coworkers, perhaps because the perceived coworker ostracism scale reported by the employees cannot accurately reflect actual coworker ostracism. Moreover, the items in the coworker ostracism scale developed by Ferris et al. (2008) describe coworker ostracism directly. However, in reality, coworker ostracism has the characteristic of concealment. Second, the popularity of team cooperation in enterprises makes the interests of employees and coworkers closely related. Thus, employees tend to try their best to maintain the harmony.

Third, employee innovative behavior indirectly affects workplace wellbeing through leader support for innovation. Innovation consistently benefits the development of enterprises; thus, employees will receive innovative support from leaders in the process of engaging in innovative behavior. Specifically, when employees engage in innovative behavior, their leader will provide resource support, encouragement, and praise, which can lead to high-quality leader–member exchange and enhance their workplace wellbeing.

Finally, the chain-mediating effect of leader support for innovation and coworker ostracism on the relationship between employee innovative behavior and workplace wellbeing is unverified, but the negative correlation between leader support for innovation and coworker ostracism is significant. The absence of the chain-mediating effect may also be attributed to the "hidden" phenomenon of coworker ostracism.

Theoretical implications

First, a new perspective is provided in this study by taking employee innovative behavior as an antecedent to explore the subsequent influence path at the individual level, thereby expanding research on employee innovative behavior as an antecedent. Previous studies on employee innovative behavior consistently regarded such behavior as an outcome variable and discussed the antecedents that may lead to employee innovative behavior from the perspective of the organizational level, individual level, and task characteristics (Janssen, 2000; Wu et al., 2011; Kang et al., 2016; Tian et al., 2020; Kim et al., 2021; Wang Y. et al., 2021; Elsetouhi et al., 2022). However, little attention was paid to employees' innovative behavior as an antecedent, and only few studies discussed the positive influence of employees' innovative behavior on organizational performance (Laforet, 2011; Aryee et al., 2012). In addition, some studies have started to focus on the dark side of employees' innovative behavior in recent years (Hammond et al., 2019; Ng and Wang, 2019; Nguyen and Le, 2019; Breidenthal et al., 2020; Dadaboyev et al., 2021), but the relationship between innovative behavior and employee wellbeing was ignored. Only one study presented a conceptual model of how to moderate the negative effects of employee creativity on wellbeing (Mustafa and Ramos, 2018). More importantly, to our knowledge, no research integrates the double-edged sword effect of employee innovative behavior on workplace wellbeing. This study takes employee innovative behavior as an antecedent and explores both the positive and negative effects of employee innovative behavior on workplace wellbeing, which will enrich the research on employee innovative behavior.

Second, based on social comparison theory and social exchange theory, coworker ostracism and leader support for innovation are introduced in this study as two mediating variables to reveal how employee innovative behavior affects workplace wellbeing. Although some studies presented the dark side of employee creativity (Janssen, 2003; González-Romá and Hernández, 2016; Ng and Wang, 2019; Breidenthal et al., 2020), few studies on employee innovative behavior considered coworkers' attitude and leaders' attitude toward employees' innovative behavior. As research showed that the role of coworkers and leaders cannot be ignored when exploring the outcomes of innovation, as they always play a crucial role in the process of employees' innovative behavior (Chiaburu and Harrison, 2008; Sijbom et al., 2015a,b). This study explored the double-edged sword effect of employee innovative behavior on workplace wellbeing using coworker ostracism and leader support for innovation as mediating variables. In addition, the chain-mediating effect of leader support for innovation and coworker ostracism is explored in this study, and the effect of leaders as a power distributor on coworker ostracism is examined. Thus, the current study enriches relevant research on the relationship between employee innovative behavior and workplace wellbeing.

Third, the mediating effect of coworker ostracism between employee innovative behavior and workplace wellbeing was unsupported in this study. This finding may be due to the strong "concealment" of coworker ostracism in the context of Chinese collectivist culture. In fact, coworker ostracism is an anti-regulatory behavior involving ambiguous and low-intensity individual intentions

that is difficult to identify compared to other interpersonal maltreatment such as bullying and aggression (Ferris et al., 2017; Naseer et al., 2018). Especially in the context of Chinese Confucian culture, which emphasizes that "harmony is the most valuable," people generally repress their grievances instead of expressing them directly to others. Therefore, coworker ostracism may manifest in implicit and imperceptible ways.

Practical implications

In this era, when innovation has become a general trend, enterprises should pay attention to follow-up support for employees' innovative behavior and avoid discouraging their enthusiasm for innovation to enhance the innovation vitality of the enterprise and realize sustainable development.

First, enterprises should pay attention to the outstanding innovation performance of their employees. Innovation is the key to the core competitiveness of an enterprise. When employees engage in innovative behavior, leaders should give them innovation support as much as possible in terms of both innovation resources and emotional encouragement, which is not only conducive to improving employees' workplace wellbeing but also beneficial to promote organizational development.

Second, enterprises should help their employees overcome the obstacles they may encounter in the process of innovation to avoid the tragedy of "dying on the way" to innovation. Innovation, which means change or breakthrough, may threaten the interests of certain individuals in the organization and thus is hindered. Therefore, when employees actively explore and strive for innovation, leaders should support and encourage them.

Finally, enterprises should create a harmonious atmosphere of organizational innovation and teamwork. A harmonious working atmosphere has become an important factor in attracting job seekers and retaining employees. Therefore, enterprises should adopt measures to create a harmonious atmosphere to avoid coworker ostracism in the workplace.

Limitations and future research

First, a two-wave design in the survey was used to reduce CMV in this study. However, all variables came from a single source and were employee self-reported, which limits the conclusions that can be made regarding causality. Thus, multiple resources can be adopted to reduce the threat of a CMV in subsequent research. Researchers can collect the data from multiple sources. For example, employees evaluate their perceived workplace wellbeing, coworker ostracism, and leader support for innovation, whereas leaders evaluate their innovative behavior.

Second, coworker ostracism in this study was measured with the scale developed by Ferris et al. (2008), which defines coworker ostracism as the subjective feeling of being ignored, avoided, or excluded by coworkers in the workplace. Given that coworker ostracism manifests in implicit and imperceptible ways. The coworker ostracism scale should be developed further for future studies.

Third, to thoroughly explore the reactions of coworkers and leaders to employee innovative behaviors, a qualitative investigation can be chosen in future research, including interviewing employees or using a recall paradigm. These methods could be used to ask participants to describe recent incidents in which they were rejected by coworkers and supported by leaders for innovation at work. Furthermore, to avoid the limitations of memory distortion and recall bias, details of incidents of coworker ostracism and leadership innovative support could be collected qualitatively or quantitatively in real time using experience sampling methods.

Lastly, this study chooses coworker ostracism and leader support for innovation as mediating variables. Future research can consider other mediators, such as work alienation and repercussions. Work alienation is a negatively dissociate state of the individual concerning the product or process of work, coworker jealousy and disconnection triggered by employees' innovative behavior may lead to alienation from a person's job (Shantz et al., 2015). However, employees may cope with alienation by being "innovative" so that they can create situations at work that are meaningful to them (Mitchell, 1984). Therefore, it would be meaningful for future research to clarify the mixed effects involved. Moreover, although the results show that employee innovative behavior has a positive influence on leader support for innovation, future research could investigate the acceptance of different leadership orientations (mastery orientation vs. performance orientation) on employee innovative behavior. In addition, future research may consider the effects of moderating variables, such as innovative style, organizational context (Janssen et al., 2004), task interdependence (Dadaboyev et al., 2021), and LMX (Nelson, 2017; Breidenthal et al., 2020). For instance, employees with a high-quality LMX relationship may be more ostracized by their coworkers and be more supported by their leaders. Moreover, individual characteristics should be considered, like extraversion, agreeableness, or conscientiousness (Howard et al., 2020).

Data availability statement

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

Ethics statement

As a protection of all participants, all subjects read informed consent before participating in this study and voluntarily made their decision to complete surveys. The protocol was approved by an Institutional Review Board at Xiangtan University of China.

Author contributions

XC and MX: investigation. XC: data analysis and writing—original draft preparation. HW (1st author): supervision and writing—review and editing. HW (3rd author): writing—revising manuscript. All authors read and agreed to the published version of the manuscript.

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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Paths out of poverty: Social entrepreneurship and sustainable development

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Poverty reduction in rural areas is an important development goal concerned by the international community, but the traditional poverty-reduction methods have certain drawbacks. Social entrepreneurship, with its innovative way to solve social problems, has gradually become a new sustainable development path to solve rural poverty. Using the case study method, this paper analyzes the social entrepreneurship process of 9 enterprises and the process mechanism of solving the rural poverty problem based on the identification and development of social opportunities. Our analysis suggests that social entrepreneurship is the process of identification, development and realization of social opportunities. Multidimensional rural poverty creates different social opportunities, including social opportunities in social, economic and ecological poverty. Enterprises integrate farmers into their value chain to develop and realize social opportunities, which is a sustainable means of poverty alleviation. In theory, we propose a conceptual framework for the sustainable development of social entrepreneurship and enriches the research on the process of realizing social opportunities in social entrepreneurship. In practice, we provide a sustainable development ideas for rural areas.

KEYWORDS

rural poverty, social entrepreneurship, social opportunity, sustainability, case study

Introduction

Rural poverty is the most prevalent type of human poverty in the world. Poverty alleviation in rural areas is a major global challenge. It is not only an economic issue but also a social issue related to inclusive development (Steiner and Teasdale, 2019). Traditional approaches to reducing rural poverty include government assistance, non-profit organization assistance, and corporate social responsibility. However, these approaches have problems, such as lack of capital, motivation and core competitiveness

(Doherty et al., 2014). Therefore, how to deal with the shortage of external assistance and economic development in rural areas is still the key to reducing rural poverty. As an innovative way to solve social problems, social entrepreneurship plays an important role in solving the lack of external support and economic development difficulties in rural areas (Atahau et al., 2022).

Social entrepreneurship can integrate the efficiency, innovation and resources of traditional for-profit companies with the passion, values and mission of non-profit organizations, to identify and develop social opportunities based on social needs, thereby pursuing social, economic, and ecological values (Zulfiqar et al., 2021; Koehne et al., 2022). Rural areas are generally considered as the ideal location in which to build and operate social enterprises. Poverty here includes social, economic and ecological aspects (Khan et al., 2014; Liu et al., 2017), forming a variety of entrepreneurial opportunities (Alvarez and Barney, 2014). Then, how to identify and develop social opportunities to alleviate rural poverty is a challenge for social entrepreneurship.

However, the existing literature does not answer the above questions well. First, the mechanism and output of social enterprises in rural poverty alleviation remain ambiguous. As a rapidly developing academic field, some scholars have gradually begun to pay attention to the definition, value orientation and wider role of social entrepreneurship in solving social problems (Ranville and Barros, 2021). They argued that social entrepreneurship, which focuses on those at the bottom of the pyramid, is an effective way to address social problems such as poverty, uneven distribution of health resources and unemployment (Galaskiewicz and Barringer, 2012; McMullen and Warnick, 2016). However, social entrepreneurship in a rural context remains mostly unexplored (Steiner et al., 2021). Ghauri et al. (2014) found that social entrepreneurship is an effective way to eliminate poverty, but they were unable to clearly reveal its deep operating mechanism. Moreover, the sustainable way of solving problems by social entrepreneurship is worth exploring. Second, the types and realization processes of social opportunities in the context of rural poverty are still unclear. Opportunities have been widely discussed in the theoretical research of business entrepreneurship, but ignored in the field of social entrepreneurship (Davidsson, 2015). Effective opportunity identification is the premise of entrepreneurship, and opportunity development is the source of organizational competitive advantage. However, the existing research lacks systematic research on social opportunities in the context of rural poverty, and does not take into account the particularity of social entrepreneurship.

This research is guided by the following research question: How does social entrepreneurship solve rural poverty from the perspective of social opportunity? In answering this question, through literature review, we theoretically clarify the research status of social entrepreneurship and social opportunities in rural context. Then, we use case study method to explore the little-understood context of the process of social entrepreneurship (Yin, 2014). We analyze the process of identifying, developing and realizing the social opportunities of nine enterprises and reveal the mechanism of social entrepreneurship in the process of reducing rural poverty. In terms of identification of social opportunities, based on the sustainability theory, we refine the types of social opportunities from three dimensions: social poverty, economic poverty, and ecological poverty. In terms of the exploitation and realization of social opportunities, our study combines the value chain theory and explains the specific role of social entrepreneurship in rural poverty by revealing farmers' value chain participation in the process of social entrepreneurship and the compatible ways of achieving social, economic and ecological benefits. We then propose an effective sustainable development framework for social entrepreneurship to promote the rural economy.

Our research contributes to entrepreneurship literature in two important ways. First, we enrich the research of social entrepreneurship from process perspective, and provide effective ways for social entrepreneurship to solve the problems of rural poverty. Second, we systematically study the types and realization process of social opportunities, which plays an important role in promoting the boundary expansion of entrepreneurship theory.

Literature review

Rural poverty and social entrepreneurship

Since 1980, poverty has been on the agenda of major international organizations (such as the United Nations, the World Bank, the International Monetary Fund). Narrowing the gap between urban and rural areas, eliminating extreme poverty, and achieving common prosperity are the ideals that human beings are constantly pursuing. In recent years, farmers have been forced to adapt to new challenges, such as market changes (Lans et al., 2013), information technology and biotechnology development, but rural poverty has not been adequately addressed (Rodriguez-Pose and Hardy, 2015). Poverty was initially considered to be an economic phenomenon, in which individuals or households were unable to meet basic living standards. Gradually, scholars have discovered that poverty is a multidimensional concept (Liu et al., 2017). Rural poverty is mainly discussed from three aspects of society, economy and ecology (Namara et al., 2010; Khan et al., 2014; Liu et al., 2017). Specifically, rural poverty issues include social exclusion, poor access to services and infrastructure, vulnerability to natural disasters, and an aging population caused by the migration of

young people (Namara et al., 2010; Farmer et al., 2011; Alkire and Fang, 2019).

However, the actions of governments, commercial enterprises, and non-profit organizations often fail to effectively solve such problems (Ganapati and Reddick, 2018; Li et al., 2018); this has become known as a "triple failure" problem. Social entrepreneurship is an activity that maintains its operations by selling products or services in an innovative way, based on a clear social goal. It takes into account the efficiency, innovation and resources of business entrepreneurship, as well as the enthusiasm, values and mission of non-profit organizations, in order to provide innovative solutions for social poverty (Austin et al., 2006; Neck et al., 2009) and help communities meet complex social, economic and environmental challenges (Steiner and Teasdale, 2019).

To be sure, social entrepreneurship has a positive impact on rural issues (Steinerowski and Steinerowska-Streb, 2012), but few articles focus on its role in the rural context. Most of the existing studies focus on the definition, influencing factors, performance, legitimacy and other aspects of social entrepreneurship (Janssen et al., 2018; Stirzaker et al., 2021; Chen et al., 2022). However, social entrepreneurship is a complex activity, and scholars have paid insufficient attention to its process. In terms of research context, the research focuses on the results of social entrepreneurship in solving a wide range of social problems. The research on the particularity of social entrepreneurship to solve rural problems is not deep enough. In addition, the goal of social entrepreneurship is to use appropriate capabilities to ensure economic success, positive environmental impacts and social benefits. That is, sustainable entrepreneurship pursues the triple bottom line of economic, social and ecological goals (Belz and Binder, 2017). However, due to its special nature between business and charity, it is worth thinking about how social entrepreneurship can solve rural poverty in a sustainable way.

The role of social opportunity in social entrepreneurship

Social opportunity is an entrepreneurial opportunity in the context of social entrepreneurship. Entrepreneurial opportunity refers to the mismatch between the demand and the corresponding product or service supply, which is the core of business entrepreneurship and social entrepreneurship (Shane and Venkataraman, 2000; Mair and Marti, 2006; Davidsson, 2015). The identification, development and utilization of entrepreneurial opportunities is an important aspect of the entrepreneurial process, which is also applicable to the field of agricultural entrepreneurship (Lans et al., 2013; Belz and Binder, 2017). It provides an unsaturated market for products or services and requires innovation or improvement of existing products or services (Singh, 2001).

The meaning and function of opportunities are different in the two entrepreneurial contexts. However, scholars pay more attention to opportunities in the business field. In an organization with a business mission, the entrepreneurial opportunity is often considered an opportunity to make money, with market response at its core. Therefore, it is difficult to apply to opportunities in the context of social entrepreneurship (Corner and Ho, 2010; Lehner and Kansikas, 2012). There are social opportunities in social evils and social problems (Lumpkin et al., 2013). Entrepreneurs should comprehensively consider factors such as social and moral environments and recognize that social entrepreneurship is an effective way to solve social problems. It is important that business activities be legal and socially beneficial (Brooks, 2009). Opportunity identification in the context of social entrepreneurship, which reflects the entrepreneur's ability to detect value creation (Perrini et al., 2010) and the entrepreneur's willingness to solve these social problems (Lumpkin et al., 2013), is the starting point and core of the social entrepreneurship process. Unfortunately, social entrepreneurship is still a relatively new concept in the academic field, and the research on opportunity identification in the field of social entrepreneurship is relatively scattered and unsystematic. For example, some scholars focus on the opportunity identification behavior of youth when preparing for social entrepreneurship (Zulfiqar et al., 2021). Moreover, the research on the types and realization process of social opportunities in the rural context is insufficient; multi-dimensional rural poverty provides different social opportunities, which needs to be summarized.

Research design

Methods

Quantitative and qualitative research are the two basic research methods (Creswell and Creswell, 2017). Qualitative research is a practice-oriented method, especially the case study method. It can describe the phenomenon of things (cases) and analyze the reasons in detail according to the actual development of enterprises, which is conducive to excavating the general rules and constructing new theories. In the field of social entrepreneurship research, most studies use qualitative research methods. For example, Cherrier et al. (2018), based on the ethnographic case of social risk in India, studied the possibility of institutional complexity providing opportunities for social entrepreneurs and identified strategic countermeasures to deal with institutional complexity. Munoz and Kibler (2016) used the fuzzy set method to explore the relationship between institutional complexity and social entrepreneurship.

This paper adopts the case study method for the following three reasons. First of all, this paper mainly discusses the

mechanism and process of social entrepreneurship to alleviate rural poverty, which is still in its initial stage. Compared with quantitative methods that are conducive to testing theories, the case study method is more suitable for answering "how" and "why," which helps this research to complete theoretical construction (Yin, 2014). Second, there are multiple constructs such as social opportunities and social entrepreneurship, each of that contains multiple subdivided dimensions. The case study method can be used to describe the dimensions and the relations of different constructs in a detailed way, which is helpful to reveal the relationships hidden behind the evolving and complex phenomena. Third, social entrepreneurship is an effective way to solve social problems, but there is little mature theoretical guidance on how to reduce rural poverty. Case study is a more appropriate research method to explore contextualization, which can develop rural real-life cases into a conceptual framework supported by existing literature (Pervez et al., 2013). We can improve the reliability and validity of the study by using multi-case replication logic, and make the conclusion testability and empirical validity (Eisenhardt, 1989; Yin, 2014).

Case selection and collection

Different from the statistical sampling principle in empirical studies, the selection of case study objects is mainly based on theoretical sampling (Glaser and Strauss, 1967), that is, the case selection should be consistent with the research theme, rather than representative of the whole. In this way, theoretical insights can be obtained through the connection between constructs (Eisenhardt and Graebner, 2007). This selection criterion based on case specificity rather than generality is known as "exploratory logic" (Yin, 2014).

Since research on social entrepreneurship is still in its infancy, given the research purpose, time, cost and difficulty of collection, there are three types of case sources: (1) case studies and papers, ensuring that their information is clear, accessible, and verified; (2) the official website of social entrepreneurial organizations, marketing materials and statistics provided by enterprises, and news reports; and (3) the website of the Trickle Out Africa Project and Business Call to Action (BCtA). Trickle Out provides an open case study platform for users, researchers and decision makers, and its public information comprises data on nearly 4,000 companies in 19 countries; the BCtA website provides a database of high-quality, inclusive business models across sectors and regions in 70 countries.

After screening, this paper identified a total 9 representative cases of rural social entrepreneurship, such as Nuru Energy, Drishtee and Tekera Resource Centre (**Table 1**). These cases come from various industries (agriculture, medical, education, energy, tourism, etc.) and countries (China, India, Bangladesh, etc.). Compared with homogeneous enterprises, heterogeneous enterprises provide a more solid theoretical foundation and improve the external validity of the research (Santos and Eisenhardt, 2009).

Coding and analysis

After data collection and collation, the research drew lessons from Corbin and Strauss's (2008) grounded theory coding method and used the software Nvivo to code and analyze the cases. New concepts and ideas are abstracted from the data and logical argumentation is carried out under the idea of verification or falsification (Jantunen and Gause, 2014).

The steps are as follows: (1) Open coding. Frist, we coded the cases from A to I (e.g., Xingeng Workshop-A, Drishtee-B), and conceptualized the information content. Then, after 130 initial concepts were obtained, they were combined and eliminated preliminarily to obtain 101 valid concepts. Finally, the concept was categorized to form 23 conceptual sub-categories. (2) Axial coding. This paper analyzed the potential relationships between the sub-categories and gradually integrated the main categories. (3) Selective coding. The research summarized the main categories as core categories or theoretical dimensions, and systematically associate them with other categories, thereby constructing a systematic theoretical framework. When coding, we constantly compared, analyzed and modified categories with similarities and differences, so as to improve theoretical accuracy and realize theoretical innovation (Kroeger et al., 2014). Due to the complexity of the coding process, refer to Ausrød et al. (2017), the research only shows the coding results, as shown in **Table 2**. Moreover, there are many first-order codes, so we have listed the typical concepts and the number of items.

Explanation of core constructs

Based on the existing literature, this paper selected and clarified the measure methods that best match the case data, so that the core constructs emerged from the cases. Their definition and explanation are as follows:

Rural social opportunity

The rural social opportunity is the social opportunity in the rural context. The essence of social entrepreneurship is the process of identifying, exploiting and realizing social opportunities. With the rapid development of the global economy and the modernization of agriculture, rural development and construction have lagged far behind the demand for rural transformation, and social imbalances often coexist with unmet social needs.

There are still many poverty issues that have social, economic and ecological aspects (Namara et al., 2010;

Khan et al., 2014; Liu et al., 2017), including low population density, isolated communities, a lack of large town centers, and a lack of effective public transportation and sound infrastructure (Steiner and Teasdale, 2019). These provide a large number of development opportunities for social enterprises (Littlewood and Holt, 2018; Steiner and Teasdale, 2019). Moreover, opportunities for entrepreneurship may differ according to various issues (Alvarez and Barney, 2014).

Drawing on the dimensions of rural poverty and multidimensional poverty assessment methods (Bourguignon and Chakravarty, 2003; Khan et al., 2014), the research summarized three types of rural social opportunities in social, economic and ecological poverty, including job creation, education service, medical service, fair trade, low-price service, microcredit, ecological technology, ecological resource and ecological protection.

Value chain participation

The identification and development of opportunities seems to be related to the active participation of stakeholders and the mobilization of resources (McDermott et al., 2018). Studies have shown that although the economic development in rural areas is terrible (Pateman, 2011), when people believe that inequity is great or the pain is severe, they are more inclined to act quickly, and the resulting community cohesion has prompted a high level of trust and active citizen participation in rural communities. In the process of developing social opportunities, more and more social enterprises have developed a collaborative approach between service users and providers to meet existing challenges (Boyle and Harris, 2009), including farmers in their enterprise value chains.

The enterprise value chain includes the process of obtaining raw materials from the original supplier until the final product is delivered to the user (Shank and Govindarajan, 1993). The participation of farmers can be divided into three types: as suppliers participating in the enterprise's procurement link, as employees participating in the manufacturing, marketing and service links, or as consumers of the enterprise.

TABLE 1 Cases of rural social entrepreneurship.

Case	Country	Founder	Date of establishment
Xingeng workshop	China	Zhu Bingzhao	2006
Drishtee	India	Nitin Gachhayat	2000
Tekera resource center	Uganda	Brigitte	2006
Acceso El Salvador	El Salvador	Clinton Giustra Enterprise Partnership	2013
Bancalimentos	Colombia	Olga Bocarejo	2015
CD finance	China	Liu Dongwen	2008
Grameen Veolia Water	Bangladesh	Muhammad Yunus	2008
Njobvu cultural village lodge	Malawi	Several Villagers	2002
Fargreen	Vietnam	TrangTran	2015

First, social enterprises establish supply and marketing cooperative relationships with farmers, purchase their products directly, and build convenient, smooth, efficient, and stable circulation channels and docking platforms between the agricultural product market and the market (Barrett et al., 2012) to return more income to farmers. Second, allowing social enterprises to participate in the manufacturing, marketing and service links means that farmers are included as employees in the workforce and thus can directly participate in the daily operations of the enterprise. This can reduce social isolation (Steiner and Teasdale, 2019) and promote the employment of rural surplus labor, which is obviously a win-win strategy. This requires companies to be able to transform their values from instrumentalists into values that include equality and social justice (Tobin et al., 2016). Furthermore, in modern society it is no longer possible for farmers to be completely self-sufficient, and every aspect of life requires one to purchase goods and receive services from business operators. Social enterprises regard farmers as customers at the end of the value chain, provide farmers with better services, popularize technology, and disseminate knowledge to meet their urgent needs in terms of spiritual, material, and cultural aspects.

Sustainable social entrepreneurship

Social enterprise, which integrates the elements of business and charity (Austin et al., 2006; Mair and Marti, 2006), is an ideal hybrid type of organization that combines aspects of multiple organizational forms. Therefore, the challenge for social enterprise is to balance their mixed goals, i.e., achieving sustainable commercial development, meeting the needs of "transactional" customers, and achieving social goals. With conflicting goals, hybrid enterprises may struggle to achieve financial sustainability, and research is called to reconcile these conflicting goals. According to the theory of sustainable development, sustainable rural social entrepreneurship should identify, develop and utilize opportunities to provide goods and services with social, economic and ecological benefits (Belz and Binder, 2017). In particular, with regard to economic sustainability, enterprises have different sources of income, i.e., providing high-quality services, which can reduce their dependence on national funds and other donations, and it is more conducive to independent sustainable development.

Reliability and validity

In order to ensure the reliability and validity, the following measures were taken in this study: (1) The reliability and validity of research design. This study follows the reproducibility principle of multiple case studies (Yin, 2014) to compare

TABLE 2 Data coding and analysis.

Typical concepts (no. of items)	Conceptual sub-categories	Conceptual categories	Aggregated theoretical dimensions
Lack of equal employment opportunities (4)	Job creation	Social opportunities	Rural social opportunity
Lack of necessary skills; low level of education (3)	Education service	in social poverty	
Limited (or no) basic medical services (6)	Medical service		
Limited access to markets for agricultural products (4)	Fair trade	Social opportunities	
Food insecurity; Lack cheap and safe supplies (2)	Low-price service	in economic poverty	
Few pledges; high agricultural risks (4)	Microcredit		
Lack of ecological planting technology (4)	Ecological technology	Social opportunities	
Inadequate utilization of ecological resources (5)	Ecological resource	in ecological poverty	
Waste recycling; straw burning pollution (5)	Ecological protection		
Buy their crops; optimize quality management (3)	Farmers participate in procurement link	Farmers as suppliers	Value chain participation
Make handicrafts; make reusable bags (3)	Farmers participate in manufacturing link	Farmers as	
Sell handicrafts; provide a retail platform (3)	Farmers participate in marketing link	employees	
Tour guide; technical guidance (3)	Farmers participate in service link		
Provide convenient medical services (5)	Farmers as consumers	Farmers as consumers	
Public welfare consumption; cross-subsidy (5)	Profit model	Economic benefit	Sustainable social
Product development; production (3)	Profitable products		entrepreneurship
Activity income; service charges (4)	Profitable services		
Expansion of trade; expansion of service network (3)	Market expansion		
Youth education Fund; experience sharing platform (4)	Provide high-quality education services	Social benefit	
Build employment platform; create jobs (2)	Create local employment opportunities		
Skills training; to meet the demand for skilled labor (2)	Rural human capital development		
Improve income; return to social life (6)	Improve the quality of life		
Health education seminar; affordable medical expenses (4)	Improve medical conditions		
Reduce emissions; green production (4)	Improve the ecological environment	Ecological benefit	
Carry out a series of lectures on ecology (3)	Promote ecological education activities		
Reshape rural charm; promote local culture (4)	Develop rural resources and local culture		
Convert organic waste into organic fertilizer (3)	Strengthen waste management		

and verify the research conclusions, thus enhancing the persuasiveness. (2) The reliability and validity of case selection. The nine social enterprises belong to different regions and industries, which helps ensuring that information covers a certain theoretical breadth, and improving the scalability and external validity of research design. It is conducive to compare whether there are differences in the exploitation and realization of social opportunities in different poverty circumstances, so as to enhance the external validity of the research conclusions. (3) Reliability and validity of data collection. The case database was established to incorporate data from different sources for triangulation verification, so as to form an accurate and complete data chain. (4) Reliability and validity of data encoding. The researcher first determined the coding standard, then coded the first case, adjusted the coding rules after comparison, and finally coded the eight cases to ensure the uniformity of the coding standard. (5) Theory construction. After the theoretical dimensions were initially determined, other social enterprises were selected for the theoretical saturation test. By encoding and analyzing this part of data in turn, the extracted categories and main categories have been included in the existing categories, and no new categories have been extracted. This showed that the main category was well developed, and its structural dimension had a good theoretical saturation, so the sampling was stopped.

Results

Identification, exploitation and realization of social opportunity

The process of identifying social opportunity

Social opportunities in social poverty

Rural social poverty is an unfair condition, a phenomenon caused by the imbalanced distribution of resources between urban and rural areas, low levels of farmers' knowledge and skills, and loss of health (Khan et al., 2014; Liu et al., 2017). In this situation, three types of social opportunities have been created: job creation, education service, and medical service.

Farmers are often socially excluded because of their low levels of education and lack of necessary skills (Munoz and Steinerowski, 2012). This provides an educational service-oriented opportunity for social enterprises to realize the development of human capital for farmers and reduce the unequal opportunities stemming from differences in personal background and living conditions, so that all people can enjoy equal dignity and the ability to live (Nussbaum, 2009). In addition, the community is always looking for new strategies and income sources, that is, developing new non-agricultural income-generating activities on their farms (Alsos et al., 2011), hoping to increase local employment opportunities for young people and reduce their outward migration (Steiner and Teasdale, 2019). This provides social enterprises with job creation opportunities, replacing traditional charity subsidies with farmers finding work, allowing them to rely on their own labor force to obtain a secure income and realize their self-worth. Furthermore, disease is currently an important cause of rural poverty (Liu et al., 2017), while rural towns and villages have limited (or no) basic medical services. Most rural medical problems involve a lack of chronic disease care, a shortage of health workers, the failure to adequately address prevention issues, a lack of infrastructure for comprehensive care, etc. (Humphreys and Wakerman, 2008). Therefore, medical service-oriented social opportunities inspire social enterprises to provide farmers with affordable and high-quality medical services.

Social opportunities in economic poverty

Rural economic poverty usually means that farmers do not have a stable income and cannot meet their basic consumption needs. Poverty can be reduced by increasing agricultural income or reducing expenditures (Banerjee et al., 2015; Koch, 2015). This creates three social opportunities for social entrepreneurship: fair trade, low-price service, and microcredit social opportunities. There are limited opportunities for agricultural products to enter the market (Perez et al., 2013), and their purchase prices are volatile (Dethier and Effenberger, 2012). However, farmers often lack the ability to cope optimally with agricultural production and trading activities. Fair trade opportunities encourage social enterprises to establish supply and marketing partnerships with the poor, provide vulnerable farmers with a stable and fair source of income, and protect them from market fluctuations. In addition, due to remote geographical locations and low consumption levels, rural commodity markets are small and fragmented, and middlemen are asking high prices from rural consumers, which often prevents rural households from obtaining enough product information (Zaefarian et al., 2015) or buying the goods they need from a more competitive (low-price) market (Vachani and Smith, 2008). There is a greater demand for affordable basic necessities and services in rural areas, which in turn provides social enterprises with low-price, service-oriented social opportunities. Furthermore, for rural families, limited funding is a key obstacle (Duong and Izumida, 2002; Duong and Thanh, 2014). However, farmers are often excluded from the trajectory of financial institutions due to low pledges, high agricultural risks, the high lending costs of financial institutions, and low credit records, resulting in serious asymmetry between financial services and financial needs in rural areas. This offers a microcredit-type social opportunity to provide villagers with personal or commercial loans at a reasonable interest rate.

Social opportunities in ecological poverty

Poor natural conditions in rural areas (Namara et al., 2010), coupled with an irrational use of resources, environmental pollution and other human activities, often lead to ecological poverty. This in turn gives rise to three types of social opportunities: ecological technology, ecological resource, and ecological protection.

First, rural areas lack technologies related to clean energy and waste disposal (Chauhan and Saini, 2015). Eco-technological social opportunity requires enterprises to solve a series of rural problems scientifically and efficiently using advanced technological means. Second, one of the causes of rural poverty is the inadequate utilization of rural ecological and cultural resources. The diversification of traditional agriculture into non-agricultural enterprises is an important corporate strategy (Dias et al., 2019). Relying on agricultural production, developing agricultural resources and the local culture by means of tourism is an effective means of sustainable agricultural development (Gao and Wu, 2017), one that provides opportunities for social enterprises to develop ecological resources. Third, rural environmental pollution is one of the main problems hindering rural development. Pollution comes from waste discharged during agricultural production, such as livestock manure, plant straw, wood chips, straw, and residual pesticides (Pindado and Sanchez, 2017). This serious problem provides social enterprises with opportunities for ecological protection, which can support the natural environment by protecting local land and fully protecting biodiversity (Steiner and Teasdale, 2019) to promote the application of a circular economy and sustainable agricultural development.

The process of exploitation and realization social opportunity

How does social entrepreneurship solve the problem of "social poverty"?

The problem of social poverty has created social opportunities for job creation, education services, and medical services. Taking Xingeng Workshop as an example, the founder realized that giving money could not permanently alleviate poverty. The company produces specialty handicrafts and brings farmers into the sales chain to obtain economic and social benefits. In addition, they create ecological value by recycling Tetra Pak packaging materials, recycling environmentally

friendly products and conducting training courses on ecological education and rural development.

How does social entrepreneurship solve the problem of "economic poverty"?

The issue of economic poverty has led to fair trade, low-price service, and microcredit social opportunities. A typical example of identifying and exploiting low-price service-oriented social opportunities is Bancalimentos. The company created a circular economy, acquired organic waste and recyclable materials, sold them as raw materials to the local recycling industry, bought large quantities of food, medicines and other household items at economic returns, and sold them to villagers at affordable prices. As a result, they indirectly achieve the purpose of increasing the income of the poor while reducing environmental waste pollution.

How does social entrepreneurship solve the problem of "ecological poverty"?

The problem of ecological poverty gives rise to the social opportunities of ecological technology, ecological resource development and ecological protection. A typical example of identifying and developing ecological resource-development social opportunities is Njobvu Cultural Village Lodge. They hire local villagers to participate in the service link of the value chain and carry out interesting Malawian cultural activities. While enjoying high-quality accommodation services, tourists can observe traditional pastimes such as dancing, cooking, and basket weaving. Through this project, tourism development has provided a source of income for villagers and directly improved orphan care, local schools, clinics and bridges. It has also reduced poaching in Liwonde National Park, which encourages communities to protect this precious natural resource.

Through grounded theoretical analysis of 9 cases, the research explored the internal mechanism of social entrepreneurship to solve rural problems (**Figure 1**); that is, by identifying and developing social opportunities, social enterprises include farmers in their value chains, allowing them to participate in the procurement, manufacturing, marketing and service or consumer's links. This allows enterprises to create social value, economic value and ecological value in order to solve the problem of rural poverty.

In fact, the best way to help poor farmers is not to donate money, goods or other free assistance directly to them, as traditional poverty-alleviation subjects do, as this may generate spiritual poverty. In contrast, social enterprises use the means of integrating farmers into the entire social value chain to ensure that farmers can create social, economic, and ecological values with dignity through their labor and intelligence. In addition, the development of poverty-alleviation value chains as a poverty-reduction strategy can be used to counter the failure of institutions such as the government (Thorpe, 2018). This is the best way to truly benefit the livelihood of small farmers.

Sustainable development framework for social entrepreneurship

Through the generalization and reasoning of the internal mechanism of social entrepreneurship to solve the problem of rural poverty, and taking into account the constraints of second-hand data and geographical location, this study summarizes the conceptual framework of sustainable development for social entrepreneurship rather than utilizing an empirical model (**Figure 2**).

Sustainable social entrepreneurship is the process of identifying, developing, and utilizing opportunities. The goods or services they provide have social, economic, and ecological benefits, which is in line with the triple bottom line principle (Belz and Binder, 2017). The entire process of social entrepreneurship includes the impact of the two levels of society and enterprise, which is in line with the multilevel attributes of social enterprises (Le Pennec and Raufflet, 2018).

At the social level, multidimensional rural poverty often puts farmers in a difficult position, and they lack resources and skills. Compared with other groups, they are more likely to fall into the intergenerational poverty cycle (Lichter et al., 2015). However, many poverty issues coexist with the urgent needs of villagers, generating numerous development opportunities waiting to be discovered by social enterprises.

At the enterprise level, when a social enterprise recognizes a social opportunity, it often takes a series of actions to creatively use and combine resources to meet social needs (Mair and Marti, 2006). We find that in the process of solving rural poverty, the strategic action taken by social enterprises is to integrate farmers as suppliers, employees, and target customers into the value chain of the enterprise, and create social, economic and ecological value with (or for) them (Ebrahim et al., 2014; Dohrmann et al., 2015; Saebi et al., 2019).

This is a sustainable way of solving the problem of rural poverty, that is, to solve problems at the social level as the guideline and to take the strategy of the enterprise level as the promotion point. Social enterprises include farmers in the value chain, mobilize people to actively participate in poverty alleviation, and combine rural external and internal resources to improve rural predicaments in education, employment, medical care, and green energy. This will have long-term rather than short-term positive impacts on many aspects of economy, society and ecology, and in the end fulfill the mission of solving rural poverty.

Discussion

This paper explores the contribution of social entrepreneurship to rural poverty alleviation from the perspective of social opportunity. We analyze the process of social entrepreneurship based on the identification,

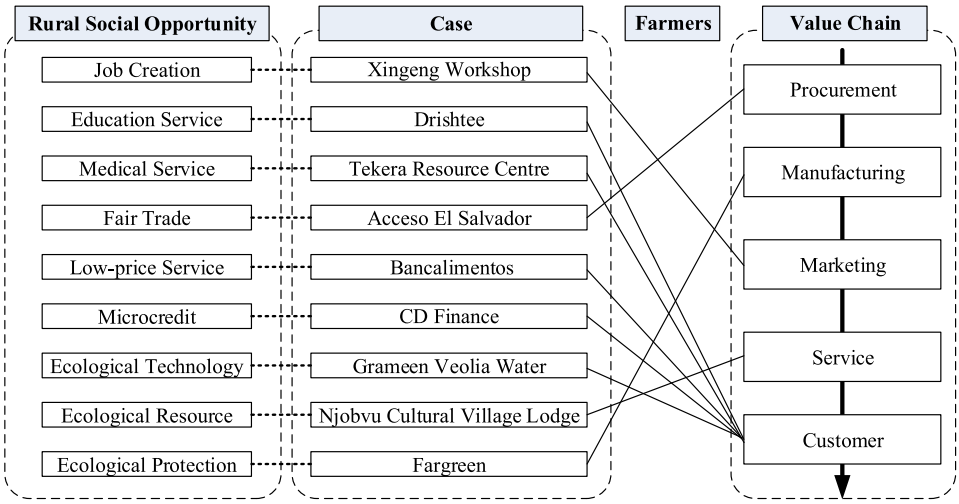

FIGURE 1
The internal mechanism of social entrepreneurship to solve rural problems.

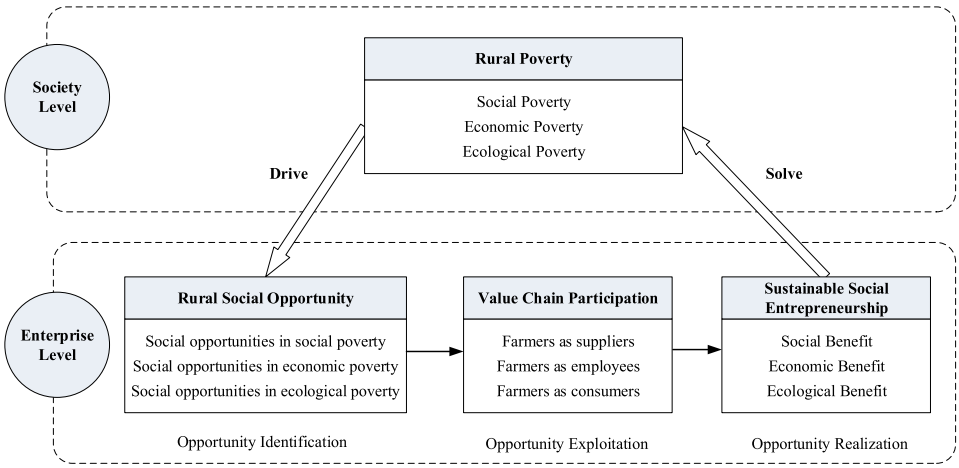

FIGURE 2
Sustainable development framework for social entrepreneurship.

development and realization of social opportunities. We then summarize the types of social opportunities, the ways in which addressing rural poverty works, and the resulting social, economic and ecological outcomes.

First, our research enriches the social entrepreneurship theory from process perspective, clarifies the connotation of social opportunities and reveals the realization process of social opportunity and its special value in social entrepreneurship. Social opportunities arise from three types of poverty: social poverty, economic poverty, and ecological poverty. Based on these factors, we summarize nine typical social opportunities in rural poverty. There are human capital, property rights, and financial capital that can be exploited in different types of social opportunities. If entrepreneurs are unaware of the potential for value creation in various opportunities, their effectiveness in participating in poverty initiatives may be limited (Alvarez and Barney, 2014). In terms of opportunity development and realization, we introduce the theory of enterprise value chain and believe that farmers' participation in different value chain links is the primary means of realizing social opportunities. Companies can use their expertise to develop affordable products or services to address the unmet needs of the poor (Zaefarian et al., 2015), or empower them by treating them as suppliers, producers or consumers of the company (Boyle and Boguslaw, 2007). This finding highlights the importance of exploitation of social opportunities in the entrepreneurial process and also responds to the call of scholars to study opportunities in rural areas (Tabares et al., 2022). Based

on the value chain theory, we make the complex approach of poverty alleviation more actionable. In addition, we can clearly show that social entrepreneurship may have several goals when solving problems. For example, Xingeng Workshop has the dual goals of promoting farmers' employment and protecting the rural ecological environment. Consistent with traditional entrepreneurial theory centered on opportunities (Shane and Venkataraman, 2000; Zahra et al., 2008), we believe that the discovery and development of opportunities are crucial to any research work related to new business concepts, and we must find answers by studying entrepreneurial opportunities. However, we also believe that in the context of social entrepreneurship, opportunity is special valuable (Zulfiqar et al., 2021), which determines that the core of social entrepreneurship is social value creation rather than economic value. Therefore, our findings extend the research paradigm of social entrepreneurship beyond the framework of business entrepreneurship, and we believe it can contribute to this emerging research field.

Second, we analyze the mechanism of social entrepreneurship to solve rural poverty, and fill in the research gap of rural context in the field of social entrepreneurship. Most entrepreneurship research has an urban focus (Tabares et al., 2022), and the social entrepreneurship literature has also largely ignored rural entrepreneurial activities, especially in underdeveloped countries, where theoretical and empirical studies are still limited. Our study therefore focuses on the countryside and finds that rural social entrepreneurship plays a key role in alleviating extreme poverty. Social entrepreneurship can integrate both social and entrepreneurial dimensions, and social opportunity is the primary medium and focus of poverty. At the social level, one must focus on difficult social issues and grasp the urgent needs of people at the bottom of the pyramid (Goyal et al., 2015). At the enterprise level, social enterprises must establish clear social goals (such as improving education and health, reducing social exclusion, etc.), engage in business activities in innovative ways, and maintain their operations by selling products or services (Galaskiewicz and Barringer, 2012; McMullen and Warnick, 2016). These are two aspects of social enterprises' sustainable solution to social problems. During the implementation process from the social to the enterprise level, social enterprises must begin by identifying social opportunities. By identifying and developing social opportunities, the social level and enterprise level can be combined to focus on specific rural poverty problems, so that solutions can be implemented and poverty problems solved. This double-sided research complements existing social entrepreneurship research and helps to further understand how social entrepreneurship is integrated with rural poverty or other social issues.

Third, we have constructed a sustainable development framework for social entrepreneurship aimed at helping to find a sustainable solution to rural poverty. From a sustainable livelihood perspective, the framework proposes a multi-dimensional measurement approach with the goal of improving the livelihoods of vulnerable individuals and communities in rural areas. We argue that sustainable livelihoods are multi-dimensional, as poverty can be manifested in many ways and affected by many factors, not just income (Tabares et al., 2022). Therefore, social entrepreneurship needs to take into account social, economic and ecological benefits. Traditional poverty-reduction methods often assume that the poor cannot help themselves and need charity, and so direct public investment, subsidies, or other charities are used to meet unmet needs; however, this impact is often limited and short-term (Austin et al., 2006). On the other hand, the market-based approach recognizes that poverty does not necessarily eliminate one's participation in business and market transactions (Zaefarian et al., 2015). In fact, in order to meet their basic needs, individuals must trade with cash or labor. Therefore, in rural areas, compared with other helping entities, social enterprises see farmers as suppliers, employers, and consumers, which seems to better help communities control and address complex social, economic, and environmental challenges (Steiner and Teasdale, 2019). This can fill the gap between what the private sector is willing to produce and what the government and charity can provide, and it is an effective mechanism for creating value for (or with) farmers (Saebi et al., 2019). This also helps to solve the triple failure problem of government, non-profit organizations and commercial enterprises, and fundamentally promotes the development of entrepreneurship theory.

Conclusion, implication and limitations

Conclusion

This study uses a case study method to analyze the identification, development and realization of social opportunities in the process of social entrepreneurship under the rural context. We try to reveal the mechanism of social entrepreneurship to solve the rural poverty, and propose a conceptual framework for the sustainable development of social entrepreneurship. We find that social entrepreneurship is a process of identifying, developing and realizing social opportunities, and the economic value, social value and ecological value created by social entrepreneurship correspond to the solution of rural economic, social and ecological poverty. This is the essential process of social entrepreneurship promoting rural development. We also find the role of social opportunity in addressing rural poverty at both the social and corporate levels. There are three types of social opportunities driven by rural poverty at the social level, including opportunities in social, economic and ecological poverty. At the enterprise level, after identifying social

opportunities, enterprises engage farmers in different parts of their value chain to develop and realize opportunities, which is a sustainable means of addressing poverty.

Implication

This study is of great significance both theoretically and practically for social entrepreneurship in solving the rural poverty. Firstly, this paper extends the theoretical research on the process perspective in the field of social entrepreneurship and answers how promoting poverty alleviation in rural areas. This study integrates rural poverty issues at the social level with actions at the enterprise level, fills the gap of social entrepreneurship theory in the rural field. From the perspective of social opportunities, we put forward the sustainable development framework of social entrepreneurship, which complements and improves the sustainability of social entrepreneurship. In practice, this paper provides concrete and sustainable ideas for solving rural poverty through social entrepreneurship. In addition, it has certain guiding significance to solve the problem of insufficient external support from the government, commercial enterprises and non-profit organizations.

Secondly, this paper enriches the research on the realization processes of social opportunities in the rural context. At present, the research on opportunity recognition in the field of social entrepreneurship is scattered. Moreover, the existing research on social opportunities focuses on the research paradigm of commercial enterprises and ignores the particularity of social opportunities. We summarize the rural social opportunities in social poverty, economic poverty and ecological poverty. It provides ideas for enterprises to identify social opportunities effectively, and also fills the gap of research. Also, we find that farmers' participation in the value chain is an important means of social opportunity development. It not only helps to explain the mechanism process of social entrepreneurship to solve rural poverty, but also helps to guide the practice of social entrepreneurship, and provides a new solution path for enterprises to realize social, economic and ecological value. The introduction of value chain lines also helps to visualize solutions to the complex problem of rural poverty. By taking farmers as suppliers, employers and consumers, social entrepreneurship not only neatly solves the obstacles to the sustainable development, but also helps rural areas to fundamentally control and deal with complex social challenges.

Limitations

While our study offers some important insights, it also has limitations that open the way for future research. First, our research limits the sources of social opportunities to the three dimensions of poverty, and there are further sources and types of social opportunities waiting to be explored. Second, due to time and resource constraints, our study is limited to a conceptual framework rather than utilizing an empirical model. Nonetheless, we believe that theoretical generalizations of the mechanisms emerging in this study are possible. Future research can use multi-source data such as interviews and panel data to conduct more rigorous empirical tests and develop it into a successful model. In addition, the universality of the model remains to be further examined in different contexts. Future research could focus on a certain region or country and propose more targeted poverty solutions.

Data availability statement

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

Author contributions

XZ: designing. YS and YG: writing. YD: method. All authors contributed to the article and approved the submitted version.

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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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Cross-level research on the impact of self-serving leadership on employee innovation behavior: The roles of workplace anxiety and team psychological safety

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Employee innovative behavior is significant in maintaining an organization's sustainable development. This study explored the impact of team psychological safety and workplace anxiety on the association between self-serving leadership and employee innovation behavior by synthesizing social information processing theory, conservation of resources theory, and ego depletion theory. We conducted a hierarchical linear model analysis using three-wave paired data collected from 86 leaders and 392 employees. The research results showed that self-serving leadership is negatively correlated with employee innovation behavior. Meanwhile, team psychological safety and workplace anxiety mediated this relationship. In addition, team psychological safety mitigates the impact of workplace anxiety on employee innovation behavior and the indirect impact of self-serving leadership on employee innovation behavior *via* workplace anxiety. These findings have a number of theoretical and practical implications in the domains of self-serving leadership and employee innovation behavior.

KEYWORDS

self-serving leadership, team psychological safety, workplace anxiety, employee innovation behavior, cross-level

1. Introduction

Innovation is crucial to the survival and prosperity of an organization (Hjalager, 2010). As the direct implementer of innovation activities, employees' innovation behavior determines the innovation level of an enterprise (Shalley et al., 2004). Therefore, managers and researchers have begun to pay closer attention to employees' innovative behavior. As an important situational factor in the organization, one of the important functions of leadership is to promote innovative behaviors in employees and obtain sustainable organizational competitive advantages (Zhang X., 2010). Leadership is an important predictor of employee innovation behavior (Liden et al., 2014). A large number of studies focus on the link between positive leadership and employee innovative behavior, such as transformational leadership (Pieterse et al., 2009), empowering

leadership (Zhang X., 2010), ethical leadership (Yidong and Xinxin, 2013), and inclusive leadership (Carmeli et al., 2010). However, leadership has positive and negative effects, with negative leadership impacting employees' behavior more than positive leadership (Jiang and Gu, 2016). Researchers found that leaders do not always benefit the organization (Rafferty and Restubog, 2011) and sometimes utilize organizational resources to seek their own interests (Camps et al., 2012). As a result, self-serving leadership began to attract the attention of scholars.

As a prevalent form of leadership in organizations (Decoster et al., 2021), self-serving leadership refers to leaders who put their interests above the needs of their subordinates and organizational benefit (Camps et al., 2012). As an emerging field of leadership research, there is a growing body of research on self-serving leadership, and the impact of self-serving leadership on organizations requires researchers to pay more attention. Existing research reported that self-serving leadership has a series of detrimental effects on employees and teams (Schyns and Schilling, 2013), such as causing psychological harm and negative moods in subordinates (Camps et al., 2012), inhibiting employees' willingness to cooperate (Decoster et al., 2014), reducing employees' contentment with supervisors and organizational citizenship behavior toward leaders (Ritzenhöfer et al., 2019), motivating subordinates' tendency to quit (Ritzenhöfer et al., 2019), showing counterproductive work behavior (Mao et al., 2019b), triggering deviant behaviors (Zhou et al., 2021), and also weakening team creativity (Peng et al., 2019). However, whether self-serving leadership impacts employees' innovative behavior needs to be proven. As a typical form of destructive leadership (Schmid et al., 2019), self-serving leadership can trigger negative emotions and uncertainty in employees (Camps et al., 2012), making them feel insecure and thus inhibiting their innovative behavior. In addition, employees are nested within a work team (Zhang Z.-X., 2010), and their innovative behavior can be influenced by a high-level construct (i.e., self-serving leadership). Since self-serving leadership can affect individual employees and the team, we infer that self-serving leadership should be a multilevel variable.

Meanwhile, according to leadership theory, leadership can influence employees' innovative behavior through both individual and team factors (Xu et al., 2020). Unfortunately, existing studies mainly focus on self-serving leadership at the individual level, ignoring the impact of team-level characteristics of self-serving leadership, and have not clarified how the high-level construct of self-serving leadership influences the innovation behavior of subordinates, including at the individual level (e.g., attitude, cognition, and emotion) and team level (e.g., psychological safety atmosphere). Therefore, this study will be helpful in systematically exploring the cross-level impact of self-serving leadership on employee innovation behavior.

According to the theory of social information processing, social cues from leaders affect employees' interpretations of the work environment, resulting in their perception and understanding and then affecting their subsequent behaviors (Salancik and Pfeffer, 1978). Team employees depend on the information gathered by team leaders to form perceptions of the team environment and adjust them accordingly (Gu et al., 2016). Self-serving leadership is detrimental to employees' wellbeing (Mao et al., 2017), making them feel that the organization cannot protect their interests and instilling a profound fear in them (Peng et al., 2019). In addition, self-serving leaders usually ignore the wellbeing of employees (Camps et al., 2012). They do not recognize employees' efforts, resulting in the decline of common psychological safety (Peng et al., 2019). However, the sense of team psychological safety can effectively help employees coordinate interpersonal relationships, and members can freely express their opinions and ideas without worrying about a negative impact on their work status or reputation (Roussin and Webber, 2012). Therefore, members can openly discuss and exchange information related to tasks, promoting their cooperation and learning (Roussin et al., 2014) while daring to express their opinions (Patterson et al., 2004) to stimulate members' innovative behavior (Carmeli et al., 2010).

This study brought team psychological safety into our study framework and explored the association between self-serving leadership and employee innovation behavior, as well as examined its behavioral effects on the relationship between the two. As the controller and distributor of resources, leaders' selfish behaviors damage the interests of subordinates, and trigger anxiety among employees (Mao et al., 2019a), thus inhibiting employee innovation behavior (Samma et al., 2020). Based on this notion, the present study also explored the mediation effects of workplace anxiety on self-serving leadership and followers' innovation behavior.

In addition, we believe that team psychological safety is a significant moderator of workplace anxiety and employee innovation behavior. According to self-depletion theory, team psychological safety, as a work resource at the team level (Halbesleben et al., 2014), reduces members' interpersonal risk relating to their expressions of anxiety—team members do not worry that expressing their concern will lead to a denial of their ability or degradation of their image by team leaders and colleagues. As a result, employees save their limited self-control resources and have more resources to invest in follow-up work, thus stimulating more innovative behaviors at work (Amabile, 1993). By studying the interaction of team psychological safety and employees' anxiety in the workplace context, this study provides a new perspective for organizations on alleviating the detrimental effect of workplace anxiety on employee innovation behavior.

Our research integrated social information processing theory, resource conservation theory, and ego depletion theory to investigate the effect of egoistic leaders on employees' innovative behavior. This study's innovation lies in studying the impact of self-serving leadership on employee innovation behavior and discussing the mediating mechanism and

boundary conditions of the relationship, which enriches the theoretical research results of self-serving leadership. The questions explored in the research are as follows. Q1: How does self-serving leadership impact employee innovation behavior? Q2: What is the mediating mechanism in the impact of self-serving leadership on employees' innovative behavior? Q3: What are the boundaries for the relationship between self-serving leadership and employee innovation behavior?

To answer these questions, SPSS 23.0, AMOS 24.0, HLM 6.08, and R 3.6.3 were adopted to carry out statistical analysis on the collected questionnaires. First, the reliability of model variables was analyzed using Cronbach's α. Second, the validity of model variables was analyzed using CFA. Then, the common method bias of the variables was tested. Third, the basic statistical information and correlation relationships of variables were judged using descriptive statistics and correlation analysis. Finally, a hierarchical linear model (HLM) was used to test the hypothesis. Additionally, the Monte Carlo method was adopted to test the effects of mediating and moderating.

There are three reasons why the hierarchical linear model (HLM) was adopted in this study. First, from the theoretical perspective, the important influence of team leaders as "atmosphere engineers" on employee behavior is discussed (Kozlowski and Doherty, 1989). Studies showed that self-serving leadership can exist at the team level (Peng et al., 2019). Second, in terms of data collection, we collected the questionnaire data through cluster sampling. Individuals are nested within work groups. In other words, the data were nested. Therefore, the model was designed as a hierarchical linear one (Bryk and Raudenbush, 1992); this method has also been adopted in other studies (for a similar approach, see Table 1).

This study is structured as follows: In Section 2, we review relevant literature and hypotheses. Section 3 presents the methodology. The results are reported in Section 4. The discussion and theoretical and managerial contributions, as well as limitations of the present study and future research on self-serving leadership, are presented in Section 5.

2. Literature review and hypotheses development

2.1. Self-serving leadership and employee innovation behavior

Self-serving leaders put their own interests above those of their followers and the organization for which they work (Camps et al., 2012), which adversely affects employees' wellbeing, causes harmful and long-term consequences for the organization (Haynes et al., 2015), and has many adverse effects on employees (Haynes et al., 2015). However, employee innovation behavior is referred to as the process in which employees inspire novel and valuable ideas in workplace contexts and attempt to put them into practice (Shi, 2012), including the generation, promotion, and realization of innovative thinking (De Vries et al., 2016). Since employee innovation behavior exceeds the prescribed role expectations, it belongs to out-of-role behavior (Wang and Chang, 2017). Existing research showed that individual factors, such as personality (Raja and Johns, 2010; Saura et al., 2021), self-efficacy (Wang et al., 2014), perceptions of differences in order atmosphere (Ma and Su, 2020), employees' positive perceptions of their companies' support (Saura et al., 2022), and emotions (George and Zhou, 2007), as well as organizational situational factors, such as innovation climate (Baer and Frese, 2003) and leadership, influence employees' innovative behavior. However, as an important component of an organization, leadership is a key factor in stimulating employees' innovative behavior (Choi et al., 2015; Shen et al., 2019).

According to social information processing theory (Salancik and Pfeffer, 1978), the surrounding social environment largely influences people's attitudes and behaviors: people decide what kind of attitude and behavior they have to adopt by processing and interpreting specific social information. For example, leaders are the primary source of information for employees (Jiang and Gu, 2016). Thus, team members interpret the information that self-serving leaders provide and adjust their perceptions and behaviors accordingly. Therefore, we expect that team leaders exhibiting self-serving behaviors will harm team members' innovative behaviors. The main reasons are as follows.

First, when team leaders are self-serving, team members fear that the leader will steal their benefits (Mao et al., 2019a), putting the team members' work performance at risk of not being recognized by the leader (Mao et al., 2017), causing members to exhibit negative emotions and experience a sense of uncertainty (Camps et al., 2012). Uncertainty affects team members' cognition, emotions, and behaviors. It also reduces team members' sense of control and predictability in the environment, causes them to lose their sense of security, and triggers a sense of uncertainty (Hogg, 2007), leading to stress and work distractions (Mao et al., 2019a), which ultimately detaches employees from work and makes them unwilling to innovate (May et al., 2004). Meanwhile, the expectations of innovation are uncertain, implying high risks and the possibility of failure (Carmeli et al., 2010). In the absence of a sense of security, employees become less willing to take responsibility and increase their risk-averse behavior (Mao et al., 2019a), leading to a decline in employee innovation behavior.

Second, self-serving leaders who prioritize their own interests above the organization's interests and others make employees vulnerable to the infringement of their interests (Mao et al., 2017). As a result, team members trust their leaders less (Decoster et al., 2021) and produce fewer positive work outcomes (Lau and Liden, 2008), such as cooperative behaviors (Coleman, 1990) and organizational citizenship behaviors (McAllister, 1995). In addition, it prompts employees

TABLE 1 Relevant previous studies adopted HLM analysis.

References	Team level	Individual level
Hsiung (2012)	Authentic leadership; Procedural justice climate	Positive mood; Leader–member exchange; Employee Voice behavior
Li et al. (2017)	Differentiated empowering leadership	Trust in leaders; Chinese traditionality; In-role performance; Extra-role performance; Counterproductive work behaviors
Tourigny et al. (2019)	Ethical leadership; Corporate social responsibility	Organizational trust; Taking responsibility; Organizational citizenship behavior
Zhang and Song (2020)	Humble leadership; Error management climate	Psychological safety; Work wellbeing
Liu et al. (2022)	Humble leader behavior; Team cognitive diversity; Team potency; Team performance	Organization-based self-esteem; Individual performance
Meng et al. (2022)	Transformational leadership	Meaningfulness in work; meaningfulness at work; work engagement

Source: The authors.

to take actions to restore the imbalance between their efforts and expected returns (Carlsmith et al., 2002) and reduce the willingness of members to provide services for the organization (Haynes et al., 2015), such as a willingness to cooperate and extra-role behaviors that are beneficial to the organization but not within the organization's formal salary assessment (Decoster et al., 2014), such as innovative behavior. In addition, when faced with a self-serving leader, the members may think that they are not valued (Camps et al., 2012), which leads to the perception that their work is unimportant and worthless to the organization. As a result, they will pay less attention to their work and thus reduce their innovative behaviors.

Based on social learning theory (Bandura, 1977), employees observe the leader's behavior and learn from it. Thus, employees will learn self-serving behaviors by imitating a self-serving supervisor, forming self-serving values, and then guiding their behaviors (Haynes et al., 2015). Hence, self-serving leadership promotes an unhealthy organizational climate in which each member's interests above others are acceptable, causing team members to adopt a self-serving code of conduct (Vardaman et al., 2014). Under these self-serving values, there will be less knowledge exchange (Peng et al., 2019) since employees tend to hide knowledge to avoid personal loss. This reduced sharing increases the cost of knowledge acquisition for employees and hinders the free flow of knowledge (Zhao, 2020). Since this behavior is not conducive to employees acquiring new knowledge, it reduces employee innovation behavior. In sum, we hypothesize the following:

H_1: Self-serving leadership is negatively related to employee innovation behavior.

2.2. The cross-level mediating effect of team psychological safety

Team psychological safety is defined as members' common perceptions that taking an interpersonal risk in a team environment is safe. They believe they can express what they think and feel and that the team would not refuse, embarrass, or punish anyone who dares to state their opinions; the basis of this belief is trust and mutual respect between members (Edmondson, 1999). Leadership behavior is the key premise of psychological safety (Ortega et al., 2014). For example, Edmondson (2003) believes that the behaviors of team leaders can trigger team members' awareness of interpersonal risks, thus affecting their psychological safety. Meanwhile, leaders' different attitudes toward tasks and members have distinct influences on shaping team atmosphere and psychological states (Qing et al., 2012). Therefore, when team leaders shape the image of openness and fallibility, they can effectively promote a psychologically safe atmosphere for the team (Edmondson and Roloff, 2009). Meanwhile, leaders who prioritize the interests of their team members create an atmosphere of psychological safety within the group (Hu et al., 2018). On the contrary, when leaders lack sympathy or exploit members, it causes psychological insecurity among members (Jiang and Gu, 2016).

Social information processing theory posits that leadership behavior is an important information source that affects team members' behavior in the work environment. How team members interpret information helps them understand their work environment and shapes their behavior (Salancik and Pfeffer, 1978). In other words, team members use cues from their leaders to test their interpretations of the team environment and adjust their perceptions (Gu et al., 2016). Specifically, self-serving leaders will occupy organizational resources (Rus et al., 2010), sacrifice others' interests to achieve their goals, shift blame, and use deceptive means to satisfy their interests (Schilling, 2009). As a result, their interests threaten team members (Mao et al., 2017). Through the interpretation of this information, team members believe that leaders do not recognize their contributions, making them feel as if the leaders are taking advantage of them and inducing fear of exposing mistakes within the team. Therefore, employees tend to cover up their errors or even blame each other, which leads to the alienation of interpersonal relationships among employees (Du et al., 2015). It makes them realize that the team environment

cannot bear the risks of interpersonal communication, which leads to a shared psychological insecurity among team members (Peng et al., 2019).

Social information affects individual behavior everywhere. Innovation is a risky activity with unpredictable outcomes (George, 2007). Employees can be encouraged to put forward new ideas or viewpoints when the working environment tolerates the risk of undertaking innovative activities (West, 1990). In addition, employees can improve their innovative skills (Edmondson, 1999), increase work input, and fully engage in originality through active collaboration and creative problem-solving (Brown and Leigh, 1996). Psychologically safe work environments include trust and encourage employees to take risks without fear of adverse effects on their work status or workplace reputation (Roussin and Webber, 2012). In this work environment, team members do not have to worry about being criticized, blamed, or punished by other members for presenting a different point of view; they tend to express their true thoughts, ask questions, and frankly discuss mistakes in their work. In addition, team members can seek help and feedback from other members (Ortega et al., 2014), enabling the free exchange of task-related information and thus promoting cooperation and learning among members (Roussin et al., 2014).

Previous studies showed that team psychological safety can promote exploratory and exploitive innovation (Nemanich and Vera, 2009). The higher the team's psychological safety, the more innovative their behaviors are (Vinarski-Peretz and Carmeli, 2011). Based on the above analysis, self-serving leadership inhibits employee innovation *via* team psychological safety. In sum, we hypothesize the following:

> H_2: Team psychological safety cross-level mediates the relationship between self-serving leadership and employee innovation behavior.

2.3. The cross-level mediating effect of workplace anxiety

Workplace anxiety includes feelings of tension and apprehension about achieving job tasks (Muschalla and Linden, 2012). There are two types of anxiety: trait and state. This study considers workplace anxiety as state anxiety in an organizational context, an unabiding emotional status. It includes cognitive anxiety and physiological arousal (Endler and Kocovski, 2001) and reflects general feelings of work-related anxiety (Spielberger, 1972), often occurring when employees feel threatened and experience stress at work (Cheng and McCarthy, 2018).

Based on the conservation of resources theory, people tend to strive to maintain, protect, and obtain resources that contribute to realizing their personal goals. Therefore, individuals with more resources are more likely to obtain the preservation and appreciation of those resources and are less affected by the loss of those resources. On the contrary, individuals with fewer resources are more vulnerable to the harmful effects of actual or potential losses (Hobfoll, 1989). As a competitor for the resources available to employees (Mao et al., 2019a), self-serving leadership may induce employees' workplace anxiety and impede their innovative behavior. Self-serving leaders put their benefits above the interests of the organization and others, affecting subordinates' perceptions of available resources (Mao et al., 2019a), threatening subordinates' feelings of interest deprivation, and thus triggering subordinates' stress responses (Hobfoll, 1989). Therefore, self-serving leaders impact the psychological status of employees (Brotheridge and Lee, 2002). If employees believe that the final work result is less than their expectations, they tend to adopt relatively negative resource processing motivation, which is manifested explicitly as negative emotions and increased workplace anxiety (Ye et al., 2021); this acts as a self-help signal when their survival is threatened (Cheng and McCarthy, 2018).

Workplace anxiety is detrimental to employee innovation behavior. First, innovation needs to change the routine and the status quo, which will affect the interests of some employees. It requires employees to be willing to take risks, know-how to communicate and cooperate with others, and invest numerous resources (Agarwal, 2016). According to the conservation of resources theory, anxiety consumes more cognitive resources than any negative emotion (Ferris et al., 2008). Therefore, it reduces employees' investment of cognitive resources in innovation and negatively affects their innovation behavior.

Second, according to attention control theory, when there is a threat-related stimulus, anxiety will significantly reduce the individual's attention to control—anxious members will allocate their limited attention to the source of the threat (Eysenck et al., 2007). Therefore, when leaders threaten employees' interests and cause intense anxiety, they will pay more attention to how to weaken the leaders' threat to their interests, thus reducing their attention to work and innovative behaviors. Finally, compared with calm employees, anxious employees think less efficiently, thus impeding their innovative behaviors (Eysenck et al., 2007). In conclusion, leaders' self-serving behaviors increase employees' workplace anxiety, while employees' workplace anxiety inhibits their innovative behaviors. In sum, we hypothesize the following:

> H_3: Workplace anxiety is cross-level and mediates the relationship between self-serving leadership and employee innovation behavior.

2.4. The cross-level moderating effect of team psychological safety

Based on the theory of self-depletion, the ability of employees to exercise self-control is a depletable resource (Baumeister et al., 1998), and individual self-control consumes specific control resources (Baumeister et al., 2007). Ego depletion of control resources after employees perform self-control tasks (Muraven and Baumeister, 2000) depletes available resources in another area (Ren et al., 2014). As a result, the performance of subsequent self-control tasks worsens (Baumeister et al., 2007), resulting in many adverse consequences (Klotz et al., 2018). In addition, team psychological safety is a kind of social support and work resource at the team level (Halbesleben et al., 2014); it is an opportunity perceived by employees or an actual supportive behavior (Hobfoll, 2002).

Although the literature on psychological safety mainly focuses on employees' perceptions of taking interpersonal risks, such as asking questions or making mistakes (Edmondson, 1999), we can also consider emotional expression in this context (Grandey et al., 2012). A team with better psychological safety has mutual respect and trust among its members. Employees perceive trust and support from colleagues and have a positive relationship with them (Banks et al., 2014). They believe that expressing their emotions will not cause difficulties or embarrassment for other members (Edmondson, 1999). They do not worry about voicing their anxiety, even if team leaders and colleagues might think less of them. They even believe bold expressions to be beneficial, which effectively reduces the psychological pressure of expressing their anxiety and makes their psychological state more stable, thus reducing the impact of negative emotions (Wei et al., 2019).

In a team that is better at psychological safety, individuals are less concerned about the interpersonal risks associated with expressing their anxiety, thus saving their limited self-control resources. At the same time, as an organizational support resource, team psychological safety gives employees a chance to replenish psychological resources (Througakos et al., 2008) so that team members can compensate for resource loss caused by anxiety (Grandey et al., 2012). This enables employees to have more resources to invest in follow-up work, which is conducive to employee involvement (Lin and Johnson, 2015). In addition, employees actively coordinate various resources to meet work challenges and inspire more innovation at work (Amabile, 1993).

In addition, as a negative emotion, anxiety consumes employees' cognitive/emotional resources (Weiss and Cropanzano, 1996), reducing their cognitive/emotional input into innovation. Furthermore, when people feel uninhibited (Grandey et al., 2012), they experience a reduced loss of self-control resources, effectively improving their subsequent work performance (Througakos et al., 2008). However, in an environment with low team psychological safety, team members will have a higher interpersonal risk perception. As a result, they may suppress their emotions, resulting in more consumption of self-control resources and poor performance in subsequent tasks (Goldberg and Grandey, 2007). Negative emotions (including workplace anxiety) can reduce the quality of interpersonal relationships between team members (Tse and Dasborough, 2008), leading employees to believe that freely expressing their concerns may bear uncertain interpersonal risks.

As a result, employees who suffer from workplace anxiety will suppress their emotions to avoid unnecessary interpersonal issues in the team. However, the inhibited expression will consume self-control resources, leading to employees' lack of self-control in follow-up tasks. This action will harm employee work engagement (Lin and Johnson, 2015) and inhibit innovative behavior. In summary, we hypothesize the following:

> H_4: Team psychological safety cross-level moderates the relationship between workplace anxiety and employee innovation behavior. Thus, the relationship is stronger when the team's psychological safety is lower.

2.5. Moderated mediation effect

Combined with H_3 and H_4, we propose that team psychological safety moderates self-serving leadership through the influence of workplace anxiety on employee innovation behavior. Specifically, when team psychological safety is high, members are more likely to have positive interpersonal relationships (Banks et al., 2014). In other words, team members are less concerned about interpersonal risks, including negative impressions of themselves, arising from workplace anxiety caused by self-serving leadership. Thus, high levels of team psychological safety can effectively relieve employees' fear of a negative impact (Moake et al., 2019); self-control of resource consumption provides relief. In addition, as an organizational support resource, team psychological safety can help replenish the resource depletion caused by the anxiety of team members (Grandey et al., 2012). As a result, team members can put more resources into their work, stimulating innovative behaviors (Amabile, 1993).

In contrast, when the team lacks psychological safety, team members worry that revealing their negative emotions caused by the leader's self-serving behavior will lead to too many interpersonal risks. Therefore, they attempt to suppress their feelings and reinforce self-control. At the same time, the workplace anxiety of team members caused by the self-serving leadership forces employees to allocate their resources to the source of their stress, thereby reducing team members' focus on work (Eysenck et al., 2007). Moreover, this focus results in the reduction of resource input in follow-up work (Weiss and Cropanzano, 1996) because employees use simpler cognitive strategies and produce mediocre ideas (Sun et al., 2018), thus

inhibiting the innovative behaviors of team members (Zhang et al., 2014). Therefore, we propose the following:

> H_5: Team psychological safety moderates the mediation of workplace anxiety on the relationship between self-serving leadership and employee innovation behavior. The mediating effect for teams with low psychological safety is stronger than for teams with high psychological safety.

Figure 1 illustrates the hypothesized model.

3. Method

3.1. Procedure and samples

Data were collected from staff on active duty at different organizations in China *via* mail. To obtain as large a sample as possible, this study adopted the non-probability sampling method, combining convenience sampling and snowball sampling methods, to collect research data. Through social relations, researchers found participants who were willing to participate in our questionnaire survey, such as friends, classmates, and recently graduated students. We then asked them to be team contacts and explained to them the study's purpose, methods, and requirements, as well as tasked them with inviting their supervisors and colleagues to participate. The contacts chose their own time to distribute the questionnaires based on the situation of the enterprises, and they collected the questionnaires uniformly after they were completed.

The study was conducted in two main ways. First, paper-based questionnaires were distributed in batches, either in person or by mail. The questionnaires were delivered in sets, and the researchers placed the questionnaires for each team leader and their subordinates in a single envelope, which contained one questionnaire description, five questionnaires for team employees at time point T1, five questionnaires for team employees at time point T2, and one questionnaire for the team supervisor at time point T3. Team leader and employee questionnaires were marked T1, T2, and T3 on the envelope cover at different time points. Both team leader questionnaires and team employee questionnaires were reserved for coding matching. Second, electronic questionnaires were distributed. We informed the contact person of the filling requirements in advance, especially the time interval and questionnaire code, to ensure that the questionnaires at the three-time points could be matched and classified as the T1, T2, and T3 questionnaires. After filling it out, the contact person sent it to the researcher through the network.

To ensure the validity of the questionnaire and avoid the ideological burden of participants in the process of filling out the questionnaire, we briefly trained the contact individuals before the distribution of the questionnaire, ensuring the anonymity and academic nature of the survey. We also stressed the confidentiality and anonymity of the questionnaire to the respondents in the questionnaire filling instructions. At the same time, the double-sided tape was attached to each envelope, which was placed and sealed by the subjects themselves after filling out the questionnaire. Meanwhile, the subjects were told that there were no right or wrong answers. In addition, to improve the recovery rate of the questionnaire, we provided a reward of RMB ¥10 (about USD $1.43) to each participant.

The data of this research collection adopted three phases and the supervisor–subordinate pair to eliminate common method variance (Podsakoff et al., 2003, 2012). We considered an interval of 2 weeks between the three phases to be suitable (for a similar approach, see Eva et al., 2020). At Time 1 (T1), we requested subordinates to assess their perceptions of leadership and offer demographic information. We distributed 540 questionnaires to 108 teams, and 466 valid questionnaires were collected from 102 teams. At Time 2 (T2), which took place 2 weeks later, subordinates assessed workplace anxiety and team psychological safety. We distributed 466 questionnaires at T2 and received 418 questionnaires from 96 teams. Finally, at Time 3 (T3), which took place 2 weeks after Time 2, the supervisors evaluated the subordinates' innovation behaviors and the team's background information. A total of 418 questionnaires were distributed to 96 team leaders at T3, and the questionnaires of 88 team leaders and 405 employees were returned. After matching the three-wave questionnaires, we excluded the questionnaires that had teams with <3 members, answers with regularity, and vacancy as primary variables. The final sample used for this study consisted of 86 supervisors and 392 subordinates. The effective feedback rates of team leaders and employees were 89.58 and 72.59%, respectively. Each supervisor evaluated an average of 4.56 subordinates. Of the 392 employees, 58.2% were female, and 78.8% of participants had a bachelor's or junior college degree. The participants' ages were 25 years old or below (11%), 26–35 years old (68.4%), 36–45 years old (15.8%), and 46 years or older (4.8%). Regarding tenure, 56.4% were with the company for 5 years or less, 30.6% for 6–10 years, 8.7% for 11–20 years, and 4.3% for 21 years or more. In addition, participants reported working with their supervisor for 2 years or less (47.4%), 3–5 years (33.4%), 6–10 years (15.8%), and 11 years or more (3.3%). The average team size of the 86 teams in this study was 6.90.

3.2. Measures

Since Western countries created the measurements adopted in our research, we adopted the back-translation procedure (Brislin, 1970) to maintain consistency between the Chinese and English scales. Unless demographic variables were included, all items used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

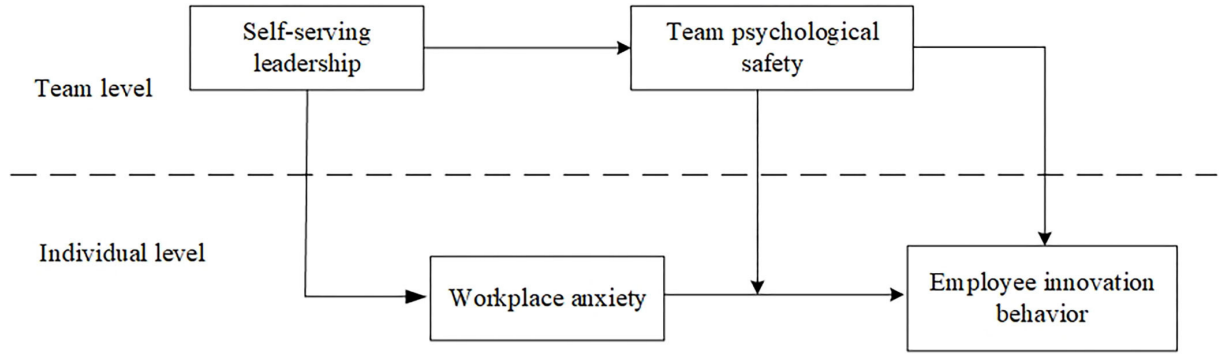

FIGURE 1
Theoretical model.

3.2.1. Self-serving leadership

A four-item scale for measuring SL was developed by Camps et al. (2012). Sample items include "My superior does not show consideration for their followers, only for themselves." Cronbach's α for this section in the present study was 0.93. Given that SL was a team-level construct, we adopted within-group reliability (ICC1), group mean reliability (ICC2), and within-group agreement indices (rwg) to evaluate the viability of aggregating the individual-level data on SL to the group-level. ICC1, ICC2, and rwg were 0.56, 0.85, and 0.81, respectively. The results exceeded the acceptable standards of 0.12, 0.47, and 0.70 (James, 1982), justifying the aggregation of SL.

3.2.2. Workplace anxiety

A two-item scale for measuring WA was developed by Kouchaki and Desai (2015) and adopted to measure WA. Items are "I feel anxious at work" and "I feel nervous at work." Cronbach's α for this section in the present study was 0.92.

3.2.3. Team psychology safety

A seven-item scale for measuring TPS was developed by Edmondson (1999). Sample items include "Members of this team can bring up problems and tough issues." Cronbach's α for this section in the present study was 0.90. ICC1, ICC2, and rwg of TPS were 0.50, 0.82, and 0.90, respectively, above the thresholds. The result justified the aggregation of TPS.

3.2.4. Employee innovative behaviors

A six-item scale for measuring EIB was developed by Scott and Bruce (1994). Sample items include "At work, they search out new technologies, processes, techniques, and/or product ideas." The Cronbach's α for this section in the present study was 0.94.

3.2.5. Control variables

According to other research (Sun et al., 2018), age, gender, education, tenure, and time working with their current direct supervisors were controlled for in our analyses. In addition, because team size can affect the interaction of team members (Wheelan, 2009), team size was considered as a control variable.

4. Results

4.1. Confirmatory factor analysis

Before verifying hypotheses, we conducted confirmatory factor analyses (CFAs) using Amos 24 to assess the distinctness of these variables. The results presented in Table 2 indicate the proposed hypothesized measurement model that yielded an acceptable fit (χ^2 = 324.20, df = 146, CFI = 0.97, TLI = 0.96, RMSEA = 0.06). This result showed that the distinctiveness of the four variables of the hypothesized model (self-serving leadership, workplace anxiety, psychological safety, and employee innovation behavior) was supported.

4.2. Common method variance

To reduce the possibility of common method variance (CMV), we conducted time-lagged and multi-source experiments to collect data (Siemsen et al., 2009). We evaluated CMV using the Harman single factor test in SPSS 23.0, resulting in 39.09% in the first unrotated factor. Because the value was below 40%, we concluded that the research was effectively free of common method bias (Ashford and Tsui, 1991). Moreover, we introduced one common factor based on a four-factor model. If the new model's (i.e., adding the common factor) fit index improved significantly in contrast with the hypothesized model, then this indicates the existence of CMV. The results indicated that the fit indexes of the new model (CFI = 0.98, TLI = 0.98,

TABLE 2 Confirmatory factor analysis and model comparison.

Model	χ^2	df	CFI	TLI	RMSEA
1.Four factors: SL; TPS; WA; EIB	324.20	146	0.97	0.96	0.06
2.Three factors: SL + TPS; WA; EIB	1,516.15	149	0.76	0.72	0.15
3.Three factors: SL; TPS; WA + EIB	800.07	149	0.89	0.87	0.11
4.Two factors: SL; TPS + WA + EIB	2,120.05	151	0.65	0.61	0.18
5.Two factors: SL + TPS + WA; EIB	2,009.45	151	0.67	0.63	0.18
6.One factors: SL + TPS + WA + EIB	3,294.38	152	0.45	0.38	0.23
Common factor	232.92	127	0.98	0.98	0.05

SL, self-serving leadership; TPS, team psychological safety; WA, workplace anxiety; EIB, employee innovative behavior.

and RMESA = 0.05) were not significantly better (both were <0.02) (Williams et al., 1989). Thus, the influence of CMV was not severe in this study.

4.3. Descriptive statistics and correlations

Table 3 lists the means, standard deviations, and correlations among the study variables. We found a negative relationship between WA and EIB ($\beta = -0.31$, $p < 0.01$) and SL and TPS ($\beta = -0.52$, $p < 0.01$).

4.4. Hypothesis testing

We used HLM 6.08 to test our hypotheses in this study. When examining the main effect and the mediating effect, both team-level and individual-level variables were processed using grand-mean-centered analysis, as recommended by Hofmann and Gavin (1998) and Enders and Tofighi (2007). When testing for interaction effects, team-level variables were processed by grand-mean centering, and individual-level variables were processed by group-mean centering. Table 4 provides the results of the regression. First, two null models were tested to confirm whether workplace anxiety and employee innovation behavior have significant variance across groups. The Null Model 1 results revealed that the between-group variance of workplace anxiety ($\tau 00$) was 0.41 and the within-group variance (σ^2) was 0.99, $\chi^2_{(85)} = 245.81$, and $p < 0.001$, manifesting that 29.29% of the variability in workplace anxiety can be attributed to the groups. Similarly, the Null model 2 results revealed that the between-group variance of employee innovation behavior ($\tau 00$) was 0.40 and the within-group variance (σ^2) was 0.34, $\chi^2_{(85)} = 550.50$, and $p < 0.001$, confirming that 54.05% of the variability in employee innovation behavior can be attributed to the groups.

Subsequently, we tested the first hypothesis. We included control variables and self-serving leadership in the null model 2. As indicated in Model 4, self-serving leadership was negatively correlated with EIB ($\gamma = -0.35$, $p < 0.001$). This finding supported H1.

We tested H_2 and H_3 following the study of Baron and Kenny (1986). First, the independent variable (SL) is correlated with the dependent variable (EIB), which was proved by H_1. Second, there should be a significant relationship between the independent variable (SL) and the mediator (TPS), as SL and TPS are both team-level variables. A single-level regression analysis was conducted using SPSS 23.0, with SL as the independent variable, TPS as the dependent variable, and team size as the control variable. There was a relationship between SL and TPS ($\gamma = -0.36$, $p < 0.001$). Third, the mediator (TPS) is significant in predicting the dependent variable (EIB) (Model 6, $\gamma = 0.60$, $p < 0.001$); finally, after adding the mediator variables TPS and WA into the model, the impact of the independent variable on the dependent variable becomes significant or non-significant. As indicated in Model 7, the effect of SL on EIB decreased from −0.35 (see Model 4) to −0.16 but was still significant, indicating that TPS has a partially mediating effect between SL and EIB. Therefore, this finding supported H2.

Similarly, the same procedure was adopted to verify H3: First, SL was related to EIB, which was proved by H_1; secondly, as shown in Model 2, there was a relationship between the independent variable (SL) and the mediator (WA) ($\gamma = 0.42$, $p < 0.001$). Third, the mediator (WA) is significant in predicting the dependent variable (EIB) (Model 5, $\gamma = -0.10$, $p < 0.01$). Finally, after adding the mediator variables WA and TPS into the model, the association of the independent variable with the dependent variable becomes significant or non-significant. As indicated in Model 7, the effect of SL on EIB decreased from −0.35 (see Model 4) to −0.16 but was still significant, indicating that WA has a partial mediates effect between SL and EIB. Therefore, H3 was supported.

We further tested the cross-layer indirect effect of team psychological safety and workplace anxiety by following the recommendations of Preacher and Selig (2012) and using bootstrap analysis. In addition, we used R 3.6.3, and Monte Carlo repeated sampling was set to 20,000. The results showed that the mediating effect of self-serving leadership on employee

TABLE 3 Means, standard deviations, and correlations.

	M	*SD*	1	2	3	4	5	6
Individual-level								
(1) Gender	0.42	0.49						
(2) Age	2.15	0.66	0.13*					
(3) Education	3.13	0.46	0.02	−0.16**				
(4) Tenure	1.61	0.82	0.05	0.62**	−0.16**			
(5) Work with leader	1.75	0.84	0.03	0.39**	−0.16**	0.53**		
(6) WA	2.69	1.18	−0.03	−0.05	0.05	−0.06	−0.03	
(7) EIB	3.71	0.86	0.06	0.03	0.03	−0.01	−0.01	−0.31**
Team-level								
(1) Team_size	2.10	0.53						
(2) SL	1.92	0.88	−0.06					
(3) TPS	3.70	0.63	0.16	−0.52**				

n = 392 individuals, N = 86 teams. For gender, male = 1, female = 0. For age, 25 years or younger = 1, 25–30 years = 2, 36–45 years = 3, 46 years or older = 4. For education, Junior high and below = 1, Senior High School (Vocational high School) = 2, Junior college and Undergraduate = 3, Graduate degree = 4. For employee tenure, ≤5 years = 1, 6–10 years = 2, 11–20 years = 3, ≥21 years = 4. For the times work with supervisor, ≤2 years = 1, 3–5 years = 2, 6–10 years = 3, ≥11 years = 4. For Team size, ≤4 people = 1, 5–9 people = 2, 10–14 people = 3, more than or equal to 15 people = 4. *$p < 0.05$, **$p < 0.01$. SL, self-serving leadership; TPS, team psychological safety; WA, workplace anxiety; EIB, employee innovative behavior.

TABLE 4 HLM results for hypothesis testing.

Variable	WA			EIB						
	Null model 1	M1	M2	Null model 2	M3	M4	M5	M6	M7	M8	M9
Intercept	2.69***	2.69***	2.69***	3.71***	3.71***	3.71***	3.71***	3.71***	3.71***	3.71***	3.71***
Individual-level											
Gender		−0.03	−0.05		0.02	0.04	0.02	0.01	0.02	0.01	−0.00
Age		−0.07	−0.06		0.07	0.07	0.06	0.07	0.07	0.07	0.06
Education		0.1	0.05		0.09	0.11	0.10	0.1	0.11	0.10	0.13
Tenure		0.00	−0.00		−0.04	−0.05	−0.04	−0.06	−0.06	−0.06	−0.03
Work with leader		0.02	0.01		0.01	0.02	0.02	0.05	0.04	0.05	0.04
WA							−0.10**		−0.08*	−0.09*	−0.06
Team-level											
Team-size		−0.24	−0.21		0.19	0.15	0.16	0.07	0.07	0.06	0.08
SL			0.42***			−0.35***			−0.16*		
TPS								0.60***	0.43***	0.55***	0.59***
Cross-level interaction variable											
WA∗TPS											0.19*
Variance decomposition											
Within-group variance σ^2	0.99	1.00	1.01	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.32
Between-group variance $\tau 00$	0.41	0.41	0.27	0.40	0.4	0.31	0.35	0.27	0.24	0.25	0.27
Chi-square	245.81	235.69	183.90	550.50	538.50	431.83	485.50	387.45	352.38	365.22	409.04
Deviance	1,201.45	1,213.47	1,197.76	843.64	860.13	845.72	856.55	836.23	832.77	831.61	830.01

The regression coefficients are all non-standardized coefficients under robust standard errors. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. SL, self-serving leadership; TPS, team psychological safety; WA, workplace anxiety; EIB, employee innovative behavior. WA*TPS denotes the interaction item for WA and TPS.

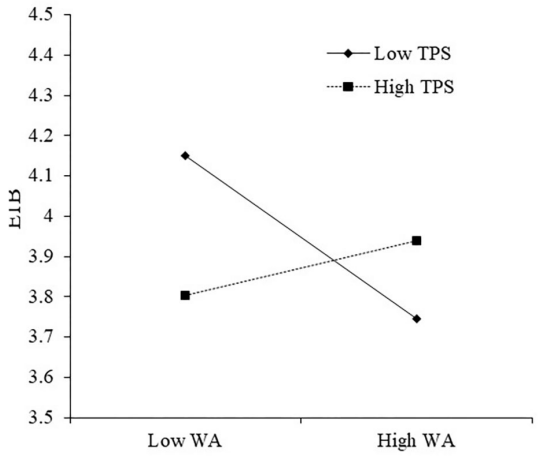

FIGURE 2
Moderating role of TPS on the relationship between workplace anxiety and employee innovative behaviors.

innovation behavior *via* team psychological safety was −0.17, with a 95% CI [−0.29, −0.07], which did not include 0. Thus, this finding supported H_2. Similarly, the mediating impact of self-serving leadership on employee innovation behavior through workplace anxiety was −0.22, with a 95% CI [−0.44, −0.05] and did not include 0. This result supported H_3.

Next, we examined H_4, which states that the impact of workplace anxiety on employee innovation behavior is moderated by team psychological safety. As presented for Model 9 in Table 4, the interaction between team psychological safety and workplace anxiety is significant to employee innovation behavior ($\gamma = 0.19$, $p < 0.05$). This finding indicated that the impact of workplace anxiety on employee innovation behavior is moderated by team psychological safety. We then used Aiken and West's (1991) recommendations to clarify the form of the interaction at two levels of team psychological safety. Figure 2 shows the impact of workplace anxiety on employee innovation behavior under M + SD and M – SD of team psychological safety. The interaction plot indicates a more robust relationship (simple slope = −0.17, $t = -2.44$) between workplace anxiety and employee innovation behavior when team psychological safety is low. However, when team psychological safety is high (simple slope = 0.06, $t = 1.25$), the influence of workplace anxiety on employee innovation behavior is not significant. However, the slope difference is significant (Δslope = 0.23, $p < 0.05$). Thus, H_4 was supported.

Finally, we used R3.6.3 to test H5 and determine whether the mediated relation between self-serving leadership and EIB *via* workplace anxiety is moderated by psychological safety. Table 5 demonstrates that when team psychological safety is high, the mediating effect of workplace anxiety between self-serving leadership and EIB was 95% CI [−0.02, 0.06], including

TABLE 5 Moderated mediation testing.

Dependent	TPS	Effect	SD	Low 95% CI	High 95% CI
EIB	High	0.02	0.02	−0.02	0.06
	Low	−0.05	0.03	−0.11	−0.01
	Difference	0.07	0.04	0.01	0.16

SL, self-serving leadership; TPS, team psychological safety; WA, workplace anxiety; EIB, employee innovative behavior. WA*TPS denotes the interaction item for WA and TPS.

0. However, when team psychological safety was low, the mediating effect of workplace anxiety was 95% CI [−0.11, −0.01], excluding 0. In addition, the between-group difference was 95% CI [0.01, 0.16], excluding zero. These results indicated that moderated mediation was supported. Therefore, these results supported H5.

5. Discussion

Employee innovation behavior is key for organizational innovation, and how to motivate employee innovation behavior has garnered wide attention from numerous researchers and organizations. Leadership style plays a critical role in predicting employee innovation behavior (Zhang X., 2010); however, only a few studies explored the influence of self-serving leadership on employee innovation behavior. Therefore, some scholars recommend exploring the influence of self-serving leadership on employees' innovative behavior (Yang et al., 2020).

This study integrated the theories of social information processing, conservation of resources, and ego depletion in 392 employees from 86 teams as research samples to investigate mainly questions (Q1: How does self-serving leadership impact employee innovation behavior? Q2: What is the mediating mechanism in the impact of self-serving leadership on employees' innovative behavior? Q3: What are the boundary conditions for the relationship between self-serving leadership and employee innovation behavior?). To answer the above questions and respond to the advice of Li et al. (2021), this study constructed a cross-level model of two factors explaining the association of self-serving leadership with employee innovation from the perspectives of team psychological safety (team climate) and workplace anxiety (employee emotion).

The results showed that self-serving leadership has a significant detrimental influence on employee innovation behavior. As Liu et al. (2012) demonstrated, negative leadership influences employees' innovation negatively.

Next, based on social information processing theory (Salancik and Pfeffer, 1978), the social information formed by the leadership impacts the working environment and then affects the individual's attitude and behavior. From the perspective of social information processing, team psychological safety, as a kind of working environment, is an important

intermediary mechanism between the impact of leadership on individual behaviors or attitudes (Zhang and Guo, 2021). According to this argument, we found the mediating role of team psychological safety in the relationship between self-serving leadership and employees' innovative behavior. As Yi et al. (2017) demonstrated, team psychological safety plays a mediating role between leadership and employee behavior.

Furthermore, psychologists believe that emotions play a critical role in predicting human behavior (Ashkanasy and Humphrey, 2011). In work scenarios, various work events trigger organizational members' emotional responses, which affect their work attitudes and behaviors (Weiss et al., 1999). Meanwhile, according to the conservation of resources theory, state anxiety consumes more cognitive resources than any other negative emotion (Ferris et al., 2008). It reduces employees' investment of cognitive resources in innovation and negatively affects their innovation behavior. The results confirm the mediating effect of workplace anxiety between self-serving leadership and employees' innovative behavior.

Finally, team psychological safety can apply to employees' perceptions of interpersonal risks and emotional expression (Grandey et al., 2012). Based on this argument and ego depletion theory, this research proposed that team psychological safety is a kind of social support and work resource at the team level (Halbesleben et al., 2014). Members can boldly express their emotions, effectively relieving the psychological pressure of expressing their anxiety and making their psychological state more stable, thus reducing the impact of negative emotions (Wei et al., 2019). Empirical results also support our hypothesis.

5.1. Theoretical contributions

The study has several theoretical contributions. First, this study constructed a conceptual model indicating that self-serving leadership impacts employee innovation behavior. It explored the trickle-down effect of self-serving leadership on employee innovative behavior from a new perspective. Employee innovative behavior as a kind of extra-role behavior (Wang and Chang, 2017), most studies pay attention to the effect of positive leadership on innovative behavior; however, there are not enough studies exploring the effect of negative leadership on employees' innovative behavior. Meanwhile, previous scholars who studied self-serving leadership mostly explored the effects of such leadership on subordinates' behaviors, such as counterproductive behaviors (Mao et al., 2019b), deviant behaviors (Zhou et al., 2021), and organizational citizenship behaviors toward leaders (Ritzenhöfer et al., 2019). Those research neglected the effects of self-serving leadership on employee innovative behaviors. This study emphasizes the antecedents of innovative employee behavior. The findings further revealed that the more self-interested the leader, the greater the likelihood of inhibiting innovative employee behavior. Specifically, this study points out that the self-serving behavior of leaders will elicit employees' insecurity and the perception of being underappreciated. Therefore, employees are less willing to take responsibility and focus on their work, which will prompt employees' risk-averse behavior and thus inhibit their innovative behavior. Accordingly, the influence process of self-serving leadership on employees' innovative behavior is revealed, and the role of negative leadership on individual innovative behavior is explored in depth in organizational situations, which is a useful addition to previous studies.

Second, previous studies showed that team-level leaders can impact employee innovation behavior through individual and team paths (Li et al., 2021). This study tests the cross-level indirect effects of two factors on the association of self-serving leadership with employee innovation based on the perspectives of team psychological safety (team climate) and workplace anxiety (employee emotion). Based on social information processing theory, the work environment of team members is an important information source that affects the effectiveness of their behaviors (Salancik and Pfeffer, 1978). Team members shape their shared perceptions of team atmosphere through social information clues such as how leaders distribute team benefits, thus becoming information sources affecting the effectiveness of their subsequent behaviors. In addition, according to the conservation of resources theory, since leaders meet their needs by exploiting employee interests, they can be seen as a threat to employees. This situation creates a stress response in subordinate employees, leading to an adverse psychological state. As a result, members spend a considerable amount of time and energy dealing with negative emotions, reducing their energy and resources to devote to innovation. The results of this study help unearth the "black box" of the association between self-serving leadership and employee innovation behavior and effectively explain the underlying mechanisms of this relationship.

Finally, psychological safety can affect team members' shared perceptions of their environment. As an organizational support resource, team psychological safety is beneficial to reducing members' perceptions of suffering from negative interpersonal interactions during emotional expression and provides employees with an opportunity to recover their psychological resources. Team members can make up for resource loss caused by anxiety (Grandey et al., 2012) so that employees have more resources to invest in the follow-up work, thus influencing their attitudes and behaviors. Therefore, this study applied ego-depletion theory to team psychological safety (a moderating variable in the theoretical construction that plays a positive role in improving team communication and cooperation) and analyzed the moderating role played in the link between workplace anxiety and employee innovation behavior. The results showed that team psychological safety negatively moderates the effect of workplace anxiety on employee innovation behavior. Specifically, a

team lacking psychological safety can aggravate the loss of self-control resources caused by workplace anxiety. In addition, it can deplete employee resources for investing in follow-up work, thus exacerbating the adverse impact of workplace anxiety on employee innovation behavior. This finding helps clarify workplace anxiety's boundary condition affecting employee innovation behavior. Further, to some extent, it enriches the theory of team psychological safety research and leadership. It demonstrates that research situations involving team and individual interactions affect employee behavior and work results, improving the relationship between the factors' characteristics.

5.2. Managerial contributions

This study also has some implications for enterprise management practices. We found that self-serving leadership negatively impacts subordinates' innovation behavior and has a particular warning effect on leaders' daily management. If the team leader cannot effectively restrain their self-serving behaviors, employees will experience workplace anxiety. At the same time, self-serving leadership will adversely impact the team's psychological safety environment, reducing employees' innovative behaviors at work. Therefore, we recommend the following.

First, the organization's top managers must recognize the negative impact of leaders' self-serving behaviors and actively take measures to curb them. Moreover, organizations should emphasize the ethical character of leadership in team leader selection and avoid appointing individuals with self-serving behavior tendencies as team leaders. The study indicated that the power of leadership is directly proportional to selfish behavior (Bendahan et al., 2015). Thus, top managers should take measures to minimize the adverse influence of power, improve the constraint and oversight systems for exercising power, and prevent power from being abused to advance vested interests.

Second, this study confirmed that workplace anxiety has an important mediating effect on the link between self-serving leadership and employee innovation behavior, which provides insights for organizations so that they can mitigate the harmful effects of self-serving leadership. Therefore, it is necessary to strengthen the attention and management of employees' workplace anxiety, implement employee care plans (such as providing psychological counseling services, increasing micro-breaks at work, and so on), and promote the recovery of employees' psychological resources. Furthermore, a positive and open corporate culture and atmosphere can improve the psychological state of employees more effectively (Cheng and McCarthy, 2018). Therefore, organizations should abandon the concept of "profit first and opportunistic," initiate corporate social responsibility, and build a positive corporate culture.

Finally, team psychological safety serves as a partial mediator in the association of self-serving leadership with employee innovation behavior. The results showed that improving a team's psychological safety and promoting subordinates' innovation behaviors are feasible. The organization could build an inclusive corporate environment. Studies showed that leadership inclusiveness promotes team psychological safety (Hirak et al., 2012). Therefore, managers should accept criticism with an open mind, tolerate the different opinions of subordinates, and make employees believe that leaders will not retaliate or take personal revenge. Moreover, organizations should develop a system to encourage employees to make bold suggestions so that employees can muster up courage to take "interpersonal risks." In addition, they should encourage all team members to dare to speak their minds and give timely praise and affirmation to those who provide constructive feedback, thus improving team psychological safety.

5.3. Limitations of this study and future research direction

Our research has several limitations. First, we based this research on the Chinese context; in different cultural contexts, employees' understanding of self-serving leadership may be different (Yang et al., 2020), which limits the generalizability of our research conclusions. Therefore, future research should consider using samples from Western cultural contexts to test this study's reliability. Second, the measurement of self-serving behavior is sensitive. Therefore, self or subordinate reporting causes deviation. Therefore, future studies could use different methods (such as in-depth interviews and other qualitative research methods) to collect data on self-serving leadership, further exploring the mechanism and boundary conditions under which self-serving leadership is related to employee innovation behavior. Third, this study mainly focused on the individual and team levels and did not consider the influence of organizational variables on the research model. Future research could incorporate organizational variables such as corporate culture and organizational ethical climate into the research model for careful consideration of the systematic impact of each factor on innovation behavior. Fourth, although this study adopted two independent sources (direct leaders of the work team and team members) and two-time points to obtain research data, we can eliminate the potential impact of common method bias on research results to some extent (Podsakoff et al., 2003). However, in essence, this research was a cross-sectional study. Thus, we cannot make causal inferences from the results of this study. Although top-down processes are more likely to occur in a work team, team members also influence leaders, which is a bottom–up process (Kozlowski and Klein, 2000). Future research could adopt an experimental or longitudinal

study design to explore the relationship between variables in this study. Finally, for the measurement of workplace anxiety, we chose a two-item scale developed by Kouchaki and Desai (2015), which has the advantage of being concise. Some other studies on workplace anxiety usually used the eight-item scale provided by McCarthy et al. (2016), which provides a more comprehensive assessment of employees' anxiety in the workplace by including dimensions of job performance, job competency, job outcome, and performance evaluation. In future studies, we will use other well-established scales to measure workplace anxiety more precisely to further ensure the accuracy of the study results.

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

LL and ZW: conceptualization and funding acquisition. LW and ZW: data collection. ZW: formal analysis and writing–original draft preparation. LL and LW: writing–review and editing. All authors contributed to the article and approved the submitted version.

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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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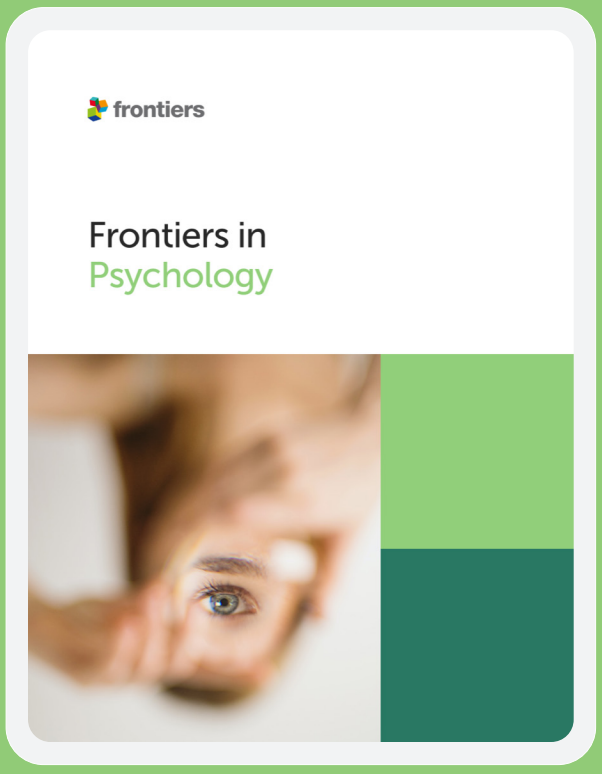

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