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Collectivism culture and green transition: An empirical investigation for the rice theory

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With growing concerns worldwide on global warming, emissions reduction has become a major challenge for many countries. China, as the largest carbon emitter, has played a key role in achieving global green transition. Using panel data from 2004–2017 on 31 Chinese provinces, this study examines the relationship between the collectivism culture and green transition. My results reveal that places with a stronger collectivism culture tend to make more green investments, and the results remain valid after a battery of robustness tests. In addition, the heterogeneity analysis indicates that the positive effects of collectivism culture on green investments are more pronounced if the province governor is advanced in age, well educated, and holds a long tenure. Additionally, such effects are more conspicuous in those provinces with more serious pollution, greater levels of collectivism, and more developed markets. This study fills a theoretical gap in the field of research on green investments from a cultural perspective. Therefore, this study has important implications for promoting green development and achieve carbon peaking and neutrality.

KEYWORDS

collectivism culture, green transition, the rice theory, environment governance, emerging markets

1 Introduction

Global warming caused by carbon emissions has become an issue of worldwide concern (Chen et al., 2022), and it poses a serious threat to human development (Yu et al., 2022). The main reason for the increase of such emissions is human activities (Pachauri and Meyer, 2014; Tong et al., 2022; Wang et al., 2023). At the 2015 Paris Climate Conference, China, as the largest carbon emitter (Kang et al., 2022), proposed as its 'Intended Nationally Determined Contributions' to reach peak carbon emissions around 2030, pledging that it would do its utmost to achieve this goal (Chen, 2022). In 2020, China put forward the goal of 'peak carbon emissions and carbon neutrality', which drew widespread attention both at home and abroad. The government and the public have increasingly high requirements for environmental protection (Tian et al., 2022a). However, some projections regarding the country's greenhouse gas emission trends under its current policies indicate that emissions will peak at 113–118 million tonnes in 2030. Judging from its current national carbon reduction policies, there is a likelihood that China will miss this goal, for which stronger policy measures will be needed (Elzen et al., 2016). Thus, it is clear that China is still facing a huge challenge regarding carbon emission reduction.

As global economic growth and carbon emissions increase as a result of consumption and production processes, the role of investment in promoting and controlling carbon emissions becomes particularly important. From 2016 to 2030, Asia will need to invest

roughly \$1.7 trillion per year, or about \$26 trillion cumulatively regarding the issues of eradicating poverty, sustaining growth, and addressing climate challenges. Of these estimated investments, approximately \$14.7 trillion is needed for electricity, \$8.4 trillion for transportation, \$2.3 trillion for telecommunications, and \$0.8 trillion for water and sanitation (Sachs et al., 2019). Countries are focusing on building efficient energy systems to move towards a low-carbon economy (Tian et al., 2022b; Tao et al., 2022). This transition will require green financing and the pricing of externalities. However, carbon pricing will not be sufficient to address environmental sustainability challenges. According to International Monetary Fund estimates, carbon pricing levels are not commensurate with the requirements to mitigate global environmental problems (Lagarde and Gaspar, 2019). Public investment in the form of green financing plays a key role in reducing greenhouse gas (GHG) emissions, creating efficient energy systems, and building robust climate markets (Mazzucato, 2016).

Among the various macroeconomic factors deemed to be affecting carbon emissions, previous studies have specifically mentioned green investments (Krushelnytska, 2017), which are investments into industrial pollution controls in a bid to mitigate environmental pollution (Li et al., 2020). Studies have demonstrated that green investment is a key factor in reducing carbon emissions and promoting sustainable growth. Furthermore, research has considered green investments mainly from the corporate perspective (Wan et al., 2021; Liu et al., 2022a; Liu et al., 2022b). Many factors, including external and internal ones, can influence green investments. Market competition is a major external factor (Rui and Lu, 2021), whereas internal factors include enterprise properties (Huang and Lei, 2021), managerial characteristics (Jang et al., 2017; Jia et al., 2021), and corporate culture (Fiordelisi et al., 2019). On the government side, research indicates that administrations could promote green investments by setting environmental regulations (Huang and Lei, 2021) and providing subsidies (Jung and Feng, 2020). However, relatively little research has been conducted on the impact of culture on green investments.

Collectivism culture is characterised by mutual protection among individuals through the formation of close team relationships and individuals' loyalty to the collective interest. According to Hofstede (1980) and Bhagat (2002), individual goals in collectivism culture are established in the interest of the team as a whole. When an individual's opinion diverges from that of a larger community, they tend to avoid any conflicts that could arise from the expression of a different opinion. As a result, individuals are less likely to voice their own interests. However, in an individualistic culture, relationships between people are more tenuous and individuals are given the responsibility of looking after themselves and their own families. Employees' value and their organisation's perception of them can be reflected through the allocation of resources; as a result, employees will pay attention to achievement and personal gain in their work. These two cultures, collectivism and individualism, can influence people's tendency to engage in environmental behaviour in different ways. On the one hand, the former tends to prompt people to consider the impact of individual behaviour on others. Therefore, the behaviour of collectivists tends to be driven by social norms, and these people

are shown to be more willing to share scarce resources. On the other hand, the latter tends to promote contractual relationships based on the principle of exchange, on the basis of which people calculate profits and losses before engaging in a certain behaviour. Individualists place greater importance on the relationship between their action and their needs and beliefs. With individualism, one tends to focus one's attention on the immediate benefits relative to the costs (Yuan, 2020). However, extrinsic benefits could be scant in the short term relative to perceived costs.

Recent developments in rice culture and its methodology (Talhelm et al., 2014, 2018) have enabled people to measure the differences between collectivist and individualist cultures. The rice theory suggests that people in areas with a longer history of rice cultivation are more collectivist than those in wheat-producing areas. The reason for this is that growing rice requires more intensive irrigation and labour than growing wheat. Therefore, a rice farmer needs more cooperation with family members and agricultural workers living in the vicinity.

In this study, I use the rice theory to examine collectivism culture and its impact on government green investments. Specifically, I argue that provincial governors with collectivist tendencies make more green investments than those with individualist leanings. I empirically examine the impact of provincial leaders' collectivist tendencies on green investments in China. Examining Chinese provincial administrative regions over the period 2004–2017, I determined whether collectivist governors made more green investments. I used the scale of rice cultivation to measure the degree of collectivism culture in the governor's birthplace. Specifically, I constructed a proxy variable for collectivism culture, namely the percentage of rice cultivation (Rice) in the province where the leader was born. I argue that collectivism culture is stronger in areas with a higher percentage of rice cultivation (Talhelm et al., 2014). I expect the culture to be the dominant culture in areas where rice cultivation is the prevailing agricultural activity. The findings suggest that such culture has a significantly positive impact on government green investments.

Further analysis reveals that the relationship between collectivism culture and government green investments is influenced by governors' disposition and regional characteristics. First, the positive relationship between collectivism culture and green investments is more significant when the governor is older than 57, has a higher level of education (postgraduate and above), and holds a longer term of office. Second, the positive relationship is more significant when the region has stronger collectivism culture, a higher level of marketization, and a higher degree of environmental pollution.

This research makes the following contributions. First, I examine green investments from a cultural perspective. I provide evidence that provincial governors' pro-environmental attitudes arise through a collectivist propensity and can influence green investments. Second, this study fills a gap in current research by investigating the impact of culture on green investments from a governmental perspective, thereby broadening the scope of environmental sustainability studies. Third, this study expands the possibility of rice theory application. My use of the theory to measure collectivism could provide some insight into how to broaden the scope of applying a classical theory to solve practical problems.

The rest of the paper is organised as follows. My research hypotheses are presented in Section 2, and my research design is detailed in Section 3. The results with baseline regression, endogenous analysis, robustness tests and heterogeneity issues are reported in Section 4. Finally, concluding remarks are presented in Section 5.

2 Background and hypotheses

2.1 Rice theory

Talhelm et al. (2014) determined that there are clear cultural differences between the south and north of China. [1] This is reflected in the fact that the south, where rice is grown, is more collectivist, while the north, where wheat is grown, is individualist. This led them to develop the rice theory. This theory argues that rice farming leads to collectivism culture, while wheat farming leads to an individualist culture. This is because growing rice requires intensive cooperation, while growing wheat does not. Over time, the two cultures took shape through farming activities and social interaction. Once the cultures were formed, they also had an impact on people who were not involved in agriculture. Talhelm et al. (2014) empirically demonstrate the link between rice cultivation and collectivism in China.

2.2 Collectivism culture and green investments

Collectivism culture emphasises the needs and goals of the group rather than those of the individual. One reason people are more interdependent in some societies is that group cooperation is more productive. For example, interdependence is more valuable in agricultural activities than in herding activities and over time, farmers become more inclined to collectivism than herders (Berry 1967; Nisbett et al., 2001). Some research suggests that collectivism culture can influence a person's behaviour through self-identity, which is their internal construct of the self. Thus, collectivism culture influences individuals from within, which in turn influences their green investment behaviour. Collectivism culture shapes individual values and can directly influence green investments. In addition, the conservative disposition of individuals with a collectivist tendency influences investment preferences, which in turn affects green investments.

Because culture has a significant impact on people's values, collectivism can directly influence the environmental preferences of provincial governors, which will then have an impact on green investments. According to the values-beliefs-norms theory, individuals with strong environmental values are likely to be aware of the consequences of environmental problems, adopt responsible environmental behaviour, and participate in or support environmental action (Stern et al., 1999; Stern, 2000).

The theory of planned behaviour (TPB) (Ajzen, 1991) also explains the relationship between values and behaviour. This theory suggests that individuals' beliefs and attitudes towards a particular behaviour determine their intention to engage in that behaviour. Research on the psychological determinants of pro-environmental behaviour suggests that personal values are an important factor in an individual's commitment to pro-environmental behaviour (Nordlund and Garvill, 2002). Kaplan Mintz and Kurman (2020) selected recycling from pro-environmental behaviours to examine the relationship between such behaviour and collectivism culture. The findings suggest that the collectivism culture facilitates individuals' recycling behaviour by influencing a person's belief in recycling.

2.3 Hypotheses

Through the above analysis, I have developed hypotheses about the relationship between collectivism culture and government green investments. I expect that governors born in provinces with stronger collectivism culture make more green investments.

3 Model setup and variable description

3.1 Benchmark regression

To verify the above hypotheses, I first construct the basic econometric model as follows.

$$lnGI_{it} = \alpha_0 + \alpha_1 Rice_{it} + \beta X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \qquad (1)$$

Where i denotes province and t denotes year. The explained variable $lnGI_{it}$ represents green investments. The explanatory variable $Rice_{it}$ measures the cultural value of rice in the governor's birthplace. X is a set of control variables including level of economic development (log), pollution emissions (log), intensity of environmental regulation (log), level of urbanisation (log), and governor characteristics (age, tenure, education). γ_i is the province fixed effect, controlling for any permanent differences between provinces, such as geographical characteristics and natural endowments. μ_t is the time fixed effect, capturing any unobserved year-specific effects, such as macroeconomic shocks, business cycles, and fiscal and monetary policies common to both planned and unplanned areas.

3.2 Selection of data and variables

This study uses panel data from 2004 to 2017 on 31 provincial-level administrative regions in China. I set the starting point for temporal observation as 2004 because there are limited sources of information on government officials prior to this. The information after this year is comprehensive and reliable. In the Chinese political system, the provincial party secretary is usually in charge of personnel affairs and the provincial governor is responsible for managing the provincial economy. As such, provincial governors play an important role in government green investments. Therefore, I have chosen data on provincial governors.

In addition, environmental and other economic indicators for each province were obtained from *China Urban Statistical Yearbook*,

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1 Distribution of rice culture in China can be seen in Figure 1 of Talhelm et al. (2014).

China Environmental Statistical Yearbook, and *China Statistical Yearbook*. Data on governors' tenure, age and other personal information were obtained from the China Leaders Database (http://people.cn), from which I gathered the CVs of 125 governors holding office from 2004 to 2017 and collected their information manually.

3.2.1 Explanatory variables

The collectivism culture is used as the explanatory variable. As culture is usually acquired during childhood, I use the prevailing culture of the governors' birthplace to capture their cultural origins. As children's minds are impressionable, such cultural imprints are easily remembered and retained (Hofstede and Hofstede, 2005). It is important to note that under China's hukou (household registration) system, a child's hukou location is registered as that of their parents. Some people may be concerned that if a child is born in City A and the parents' hukou is City B, then the child's hukou will be City B, which is different from the place of birth. This concern would be warranted if the child had been born after 1978. This is because population movements gradually became more frequent along with China's economic reform. However, the governors in the sample were all born in a time when migration was strictly limited (before 1978) (Chan and Zhang, 1999; Wu and Treiman, 2004). Therefore, misidentification of place of birth is not a main concern in this study. Following Talhelm et al. (2014), I use the level of rice cultivation in the region to measure the degree of collectivism culture in the governor's birthplace. Specifically, I construct a proxy variable ($Rice_{it}$) for collectivism culture, which is the percentage of rice cultivation in the province where the governor was born. I expect that collectivism culture is stronger in areas with a higher percentage of rice cultivation.

3.2.2 Explained variables

The green investments ($lnGI_{it}$) is used as the explained variable to reflect regional green transition. I expect that more green investments are made if degree of green transition is higher. Based on previous studies, green investments are investments into industrial pollution controls in a bid to mitigate environmental pollution (Li et al., 2020). Therefore, I use the data of 'completed investment in industrial pollution control' in provincial statistical yearbooks to measure the level of green investment in the province.

3.2.3 Control variables

Based on existing research, I selected a set of governor characteristics as control variables, including age (old), education (edu), and tenure (term). At the same time, I also take level of economic development (pgdp), pollution emission (so2), intensity of environmental regulation (sewage), and level of urbanisation (nub) of each province as control variables. In addition, year fixed effects (year) and province fixed effects (province) are controlled. The descriptive statistics of all variables used in the baseline regression are postponed to Appendix A.

4 Results and discussion

4.1 Results of the baseline regression

To examine the relationship between collectivism culture and green transition, I construct the basic econometric model 1). Results

of the Hausman test indicate that the fixed effects model outperforms the random effects model. The results of the baseline regressions are reported in Table 1. Column 1) presents estimates of the impact of the governor's collectivism culture on green investments in the province, along with control variables. Year fixed effects are added in Column 2), province fixed effects in Column 3), and both year and province fixed effects in Column 4). All estimates consistently demonstrate that collectivism culture of the governor has a significant positive impact on green transition. Collectivism culture emphasises the needs and goals of the group, and pays more attention to social responsibility. The attitudes towards environmental issues and investment preferences of regions with higher collectivism culture are more inclined to the aspects conducive to environmental protection. Therefore, collectivism culture has a positive impact on green transition.

4.2 Endogenous analysis

The share of rice fields in an area of cultivated land is a proxy variable for whether the culture favours collectivism or individualism, but there is still the problem of endogeneity caused by reverse causation. One way to address endogeneity is to identify instrumental variables, and a place's suitability for growing rice is considered to be a good instrumental variable for the share of rice fields (Caruso et al., 2016; Yuan, 2020). Generally speaking, whether rice is grown is closely related to elements such as water, temperature, and terrain. Therefore, this study uses precipitation and temperature in the province to measure rice cultivation suitability as an instrumental variable for the share of rice fields.

The results of the first stage regression are reported in Column 1) of Table 2. The instrumental variable is significantly and positively correlated with the explanatory variable at the 1% level. The second stage estimation results reported in Column 2) of Table 2 again indicate that the governor's collectivism has a significant positive impact on green investments in the province. Furthermore, the results of the Underidentification test, weak identification test and Hansen J statistic indicate that the instrumental variables do not suffer from weak instrumental variable problems and are both correlated and exogenous.

4.3 Robustness tests

To verify the robustness of the baseline regression results, I conducted the robustness test from the perspective of the influence of migration, of nomadic regions, of Confucian culture, and of the financial crisis and green credit policies. The results confirm the main findings of the fixed effects model and indicate that the empirical results remain highly stable.

4.3.1 Provincial governors from a border region separating rice and wheat cultivation

As a result of foreign invasions and civil wars, China has witnessed several large population migrations throughout its history, mostly from the north to the south. Although most occurred around 1000 years ago during the Song dynasty, after

TABLE 1 Baseline regression.

Variables	(1)	(2)	(3)	(4)
	lnGI	lnGI	lnGI	lnGI
Rice	0.0033***	0.0030***	0.0034***	0.0030***
	(0.0010)	(0.0009)	(0.0010)	(0.0010)
lnpgdp	0.6250***	0.6210***	0.6190***	0.3290
	(0.0871)	(0.1940)	(0.0942)	(0.2760)
lnso2	0.4060***	0.4240***	0.3290***	0.3170***
	(0.0591)	(0.0658)	(0.0851)	(0.1180)
lnsewage	0.4350***	0.4290***	0.3990***	0.4030***
	(0.0599)	(0.0618)	(0.0733)	(0.0712)
lnnub	−0.2250	−0.2960	−0.2930	−0.3310
	(0.2470)	(0.2940)	(0.3410)	(0.3450)
old	−0.0081	−0.0056	−0.0090	−0.0062
	(0.0070)	(0.0068)	(0.0073)	(0.0069)
edu	0.0039	0.0186	−0.0023	0.0191
	(0.0515)	(0.0485)	(0.0552)	(0.0514)
term	−0.0534***	−0.0390**	−0.0486***	−0.0348*
	(0.0163)	(0.0173)	(0.0182)	(0.0182)
Constant	0.5870	0.6820	1.6300	4.2850*
	(0.7900)	(1.2730)	(1.2160)	(2.3210)
Provinces FE	NO	NO	YES	YES
Year FE	NO	YES	NO	YES
Observations	424	424	424	424
R-squared	0.716	0.750	0.352	0.464

Notes: ***, **, and * represent significant at 1, 5, and 10% significance level, respectively; standard errors are provided in parentheses.

which descendants of these northern migrants became adapted to the local rice culture; these migrations still mixed-up rice, wheat, and other cultures and may have weakened the influence of regional cultures (Fan et al., 2022). To address this issue, I followed Jiang et al. (2019) and excluded provinces along the Qinling-Huaihe border (Sichuan, Chongqing, Hubei, Anhui, Guizhou, and Jiangsu) and conducted the robustness test. The results are shown in Column 1) of Table 3, where the signs of the *Rice* estimated coefficients are consistent with the assumptions made in the baseline regression and are significant at the 1% level.

4.3.2 Impact of nomadic regions

Although China has always been regarded as a country of crop cultivation, herding is still the main agricultural activity in Tibet, Xinjiang, and Inner Mongolia. Therefore, I re-ran the test after excluding governors from these pastoralist regions. The results are reported in Column 2) of Table 3, where the culture of collectivism among governors still has a significant positive impact on green investments in the province.

4.3.3 Influence of the Confucian values system

The Confucian values system has had a profound influence in China, which may also have led governors to make more green investments. If areas with more rice cultivation (i.e. areas with stronger collectivism culture) also have stronger Confucian values, the previous conclusion may also be due to such values rather than collectivism culture itself.

The system originated in Confucius' homeland of Shandong province, a wheat-producing region in northern China, and then gradually spread to the south as Han Chinese migrated from the north to the south. Since the Han dynasty (202 BC to 220 AD), dynastic rulers have used Confucian values to govern the country and its people, with this system becoming ever more entrenched during the Ming (1368–1644) and Qing (1644–1912) dynasties. The capital cities of the Han dynasty were Chang'an and Luoyang, and during the Ming and Qing dynasties, the capital was Beijing. These capital cities were located in wheat-producing areas. The Confucian values system was the most dominant in power centres and radiated to remote areas. Therefore, to assess and control for

TABLE 2 Endogenous analysis.

Variables	(1)	(2)
	First	Second
	Rice_culture	lnGI
humidity	3.2093***	
	(0.1795)	
temperature	1.0065***	
	(0.3051)	
Rice		0.0030*
		(0.0016)
lnpgdp	6.1771**	0.5612***
	(2.5301)	(0.1122)
lnso2	1.3699	0.3650***
	(1.4660)	(0.0848)
lnsewage	−2.2872	0.4602***
	(1.5252)	(0.0860)
lnnub	−3.8059	−0.1215
	(5.4378)	(0.3034)
old	0.2465	−0.0033
	(0.2168)	(0.0100)
edu	1.5985	0.1057
	(1.5717)	(0.0799)
term	2.1211***	−0.0436
	(0.5601)	(0.0374)
Constant	−265.6863***	0.3736
	(23.7875)	(1.2949)
Provinces FE	YES	YES
Year FE	YES	YES
Observations	427	424
R-squared	0.8318	0.7667

Notes: ***, **, and * represent significant at 1, 5, and 10% significance level, respectively; standard errors are provided in parentheses.

the potential impact of the Confucian values system, I measured the regional system using *CC*, a dummy variable equal to 1 if the founder was born in Shandong, Henan, Jiangsu, Shaanxi, or Zhejiang, and 0 otherwise. Shandong province is the hometown of Confucius and the birthplace of the Confucian culture. The latter four regions were home to ancient cities of the Han dynasty (202 BC to 220 AD), the Tang Dynasty (618–907) and the Song and Ming Dynasties (960–1911), respectively. The Confucian values system in these regions was significantly stronger than in other parts of China.

The regression results for Confucian culture are presented in Column 3) of Table 3. The measure of Confucian culture is not statistically significant, while the coefficient of the proportion of rice field area is statistically significant. Therefore, I could not find any evidence that the relationship between rice cultivation and green investments is driven by Confucianism.

4.3.4 The financial crisis and the impact of green credit policies

I have considered the impact of the 2008 financial crisis and the green credit policy enacted in 2012. The financial crisis had a huge impact on the Chinese economy (Li et al., 2012) and also brought about greater pressure and changes in the appraisal of government officials. In addition, the green credit policy enacted in 2012 also

TABLE 3 Robustness tests.

Variables	(1)	(2)	(3)	(4)	(5)
	lnGI	lnGI	lnGI	lnGI	lnGI
Rice	0.0028***	0.0026***	0.0029***	0.0027***	0.0027***
	(0.0010)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
CC			−0.0298		
			(0.0696)		
GC				0.1080	
				(0.1600)	
FC					0.3700**
					(0.1550)
lnpgdp	0.7710***	0.2550	0.5610***	0.6650***	0.6650***
	(0.1090)	(0.2780)	(0.0963)	(0.0891)	(0.0891)
lnso2	0.4330***	0.1390	0.3650***	0.3990***	0.39900***
	(0.0590)	(0.1250)	(0.0573)	(0.0529)	(0.0529)
lnsewage	0.4090***	0.3510***	0.4590***	0.4630***	0.4630***
	(0.0646)	(0.0715)	(0.0584)	(0.0539)	(0.0539)
lnnub	−0.4000*	0.0627	−0.1190	−0.3510*	−0.3510*
	(0.2280)	(0.3490)	(0.2110)	(0.1930)	(0.1930)
old	0.0030	−0.0085	−0.0035	0.0004	0.0004
	(0.0086)	(0.0071)	(0.0083)	(0.0076)	(0.0076)
edu	0.0006	0.0141	0.1060*	0.0172	0.0172
	(0.0556)	(0.0501)	(0.0605)	(0.0497)	(0.0497)
term	−0.0741***	0.0384**	0.0428**	0.0535***	0.0535***
	(0.0191)	(0.0181)	(0.0218)	(0.0158)	(0.0158)
Constant	−0.7790	4.9060**	0.3420	−0.3310	−0.3310
	(0.8310)	(2.3700)	(0.8090)	(0.7470)	(0.7470)
Provinces FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	341	392	424	424	424
R-squared	0.750	0.426	0.682	0.737	0.737

Notes: ***, **, and * represent significant at 1, 5, and 10% significance level, respectively; standard errors are provided in parentheses.

affected government green investments (Zhang et al., 2021). Therefore, I use two dummy variables, *GC* and *FC*, to assess and control for the potential impact of the financial crisis and the green credit policy. *GC* measures the green credit policy, which I set at 1 for 2012 after the policy was announced and 0 for the years prior to 2012. *FC* measures the financial crisis, which is 1 for the year of 2008 and 0 for other years. The results are reported in Columns 4) and 5) of Table 3, where it can be seen that there is a significant positive effect of collectivism culture on green investments in the province, even after controlling for the financial crisis and green credit policy.

4.4 Heterogeneity issues

4.4.1 Heterogeneity analysis of governors' characteristics

Each governor has their own characteristics. Even with the same cultural background, governors with different personalities may have significantly different attitudes and practices when confronted with environmental issues (Yu et al., 2019). Local cadres are diverse, and their behaviour may differ significantly (Pizer and Yates, 2015). It is therefore important to explore the influence of the personal characteristics of governors.

TABLE 4 Heterogeneity analysis of governors' characteristics.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	lnGI	lnGI	lnGI	lnGI	lnGI	lnGI
Rice	−0.0004	0.0042***	−0.0007	0.0033***	0.0034	0.0037***
	(0.0036)	(0.0012)	(0.0020)	(0.0011)	(0.0033)	(0.0011)
lnpgdp	−0.0705	1.0000**	0.6920**	0.5680***	0.5280	0.5720***
	(0.7340)	(0.3860)	(0.2640)	(0.1230)	(0.3890)	(0.1050)
lnso2	0.8010**	0.3140**	0.3550**	0.1650**	0.7270***	0.3840***
	(0.3650)	(0.1480)	(0.1670)	(0.0700)	(0.2070)	(0.0669)
lnsewage	0.5720***	0.3010***	0.5510***	0.4760***	0.3810***	0.4440***
	(0.1610)	(0.0907)	(0.1520)	(0.0680)	(0.1280)	(0.0761)
lnnub	0.4480	−0.8430*	−0.3800	−0.4070	0.3360	0.0580
	(0.8350)	(0.4470)	(0.4230)	(0.2880)	(0.8220)	(0.2280)
old	−0.0195	−0.0235	−0.0297	−0.0080	−0.0200	0.0044
	(0.0200)	(0.0166)	(0.0223)	(0.0095)	(0.0182)	(0.0096)
edu	0.0793	0.0563	0.231	−0.0025	0.1160	0.0991
	(0.1100)	(0.0682)	(0.664)	(0.1100)	(0.1410)	(0.0788)
term	−0.0069	−0.0663**	0.0317	−0.0381	−0.2140	−0.0109
	(0.0465)	(0.0259)	(0.0703)	(0.0244)	(0.2940)	(0.0315)
Constant	−7.3950	1.1050	0.4480	2.4590**	0.0034	0.0037***
	(4.9530)	(4.7490)	(2.1550)	(1.1020)	(2.1680)	(0.9370)
Provinces FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	127	297	121	303	70	354
R-squared	0.612	0.435	0.793	0.560	0.892	0.698

Notes: ***, **, and * represent significant at 1, 5, and 10% significance level, respectively; standard errors are provided in parentheses.

First, I separate the sample at age 57 to get younger group and older group. As presented in Column 2) of Table 4, the results for older governors (year>57) are significantly positive at the 1% level, while they are not significant among younger governors (year≤57) shown in Column 1) of Table 4. These results show that the positive effect of collectivism culture on green investment is more pronounced when governors are older than 57 years. The behavior of politicians often reflects their goals and aspirations to maximize personal utility, consolidate power, or achieve political promotion rather than social welfare (Lindbeck, 1976; Olson, 1993; Shleifer and Vishny, 1994; La Porta et al., 2002; Rajan and Zingales, 2003; Piotroski and Zhang, 2014). In China, governors have primary responsibility for the economic development and environmental governance. In an implicit rule, when local cadres are replaced, they are able to serve one term at the age of 57, but have to retire at the age of 58 (Zhang, 2011; Iversen and Palmer-Jones, 2015). Therefore, the political aspiration of local cadres declines sharply over age 57, and they shift their focus from environment governance to economic development. Moreover, Yu et al. (2019) present that there is a

positive linear relationship between governors' age and environmental efficiency. Because older governors may have more experience in pollution control, which favors environmental efficiency.

Second, I divided governors into those with a higher level of education (postgraduate and above) and those with a lower level of education (undergraduate and below). As presented in Column 4) of Table 4, the results for better educated governors are significantly positive at the 1% level, while they are not significant among governors that are not as well educated shown in Column 3) of Table 4. The results indicate that the higher the education level of the governor, the more significant the positive impact of collectivism culture on green investments. The education level of an official is closely related to their governing characteristics. In general, the higher the level of education, the greater the likelihood of an official being promoted. As a result, officials are likely to improve public satisfaction by enhancing environmental governance (Chen et al., 2017). Highly educated mayors are more confident to undertake environmental governance actions and are likely to use efficient

TABLE 5 Heterogeneity analysis of regional characteristics.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	lnGI	lnGI	lnGI	lnGI	lnGI	lnGI
Rice	0.0017	0.0035**	0.0019	0.0040**	0.0017	0.0058***
	(0.0013)	(0.0014)	(0.0011)	(0.0016)	(0.0012)	(0.0015)
lnpgdp	0.4620***	0.8240***	0.3480***	0.8460***	0.5980***	0.6350***
	(0.1170)	(0.1410)	(0.4230)	(0.1790)	(0.1300)	(0.1530)
lnso2	0.3070***	0.5440***	0.3440***	0.4410***	0.3400***	0.3840***
	(0.0721)	(0.0844)	(0.0883)	(0.0925)	(0.0854)	(0.0848)
lnsewage	0.6340***	0.2510***	0.4680***	0.3640***	0.4350***	0.4160***
	(0.0717)	(0.0876)	(0.0753)	(0.1080)	(0.0863)	(0.0881)
lnnub	−0.0175	−0.5420*	−0.0226	−0.1990	−0.5000	−0.0667
	(0.2810)	(0.2880)	(0.2680)	(0.3690)	(0.3070)	(0.3160)
old	−0.0015	−0.0020	−0.0155*	0.0228	−0.0207*	0.0219
	(0.0089)	(0.0144)	(0.00926)	(0.0170)	(0.0105)	(0.0137)
edu	0.0223	0.0244	0.0388	0.2510*	0.1480*	0.1140
	(0.0654)	(0.0827)	(0.0665)	(0.1320)	(0.0764)	(0.1020)
term	0.0601***	−0.0411	0.0817***	−0.0153	−0.0134	−0.0782**
	(0.0201)	(0.0258)	(0.0268)	(0.0453)	(0.0351)	(0.0323)
Constant	−0.8660	0.4640	3.0140***	−3.4190**	2.7510**	−1.7190
	(0.9690)	(1.3180)	(0.9870)	(1.5020)	(1.1020)	(1.3210)
Provinces FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	206	215	250	174	225	199
R-squared	0.788	0.723	0.638	0.763	0.676	0.725

Notes: ***, **, and * represent significant at 1, 5, and 10% significance level, respectively; standard errors are provided in parentheses.

environmental governance techniques to improve environmental efficiency. In addition, highly educated officials are concerned about the negative impact of extensive economic growth on environmental pollution, and they put more emphasis on sustainable economic development (Yu et al., 2019).

Studies in South Africa and Latin America have confirmed the above results. For example, Besley et al. (2012) found that highly educated leaders in South Africa were able to allocate regional resources and reduce local carbon emissions by developing rigorous and effective environmental policies. Gibson and Lehoucq (2003) determined that Guatemalan mayors with advanced degrees performed well in environmental governance, for example by employing more technical staff to manage forest security.

Finally, I analysed the effect of heterogeneity in governors' tenure. As shown in Column 6) of Table 4, the results are significantly positive at the 1% level when governors' tenure is longer and are not significant when the tenure is shorter presented in Column 5) of Table 4. This indicates that the longer a governor's term of office, the more significant the positive impact

of collectivism culture on green investments. Officials with shorter terms of office tend to try and increase economic growth at the expense of the environment during their tenure to gain a competitive advantage in seizing promotion opportunities. If the tenure of officials is too long, they are less likely to be promoted, which means that their enthusiasm for economic development will diminish and their attention to the environment will increase (Yu et al., 2019).

4.4.2 Analysis of the heterogeneity of regional characteristics

In the long run, environmental regulation and economic development are consistent (Niu et al., 2022). I first examined the effect of provincial characteristics. In Columns 1) and 2) of Table 5, I measure the environmental status of each province in terms of its average PM2.5 concentration. The coefficient of collectivism is significant at the 5% level when the province has a poor environment. The results indicate that the more polluted the province, the more significant the positive impact of collectivism culture on green investments. Environmental degradation hinders

further economic development, and the government recognises the need to change the traditional approach of driving economic growth at the expense of the environment (Zhang, 2007). In provinces with high levels of environmental pollution, governors are more willing to make green investments to improve the environment.

Culture profoundly influences personal norms and values during childhood (Triandis, 2001). However, a person is not only influenced by the culture of their hometown, but also adapts to the culture in which they live and work. As reported in Column 4) of Table 5, a leader who serves in a province with a strong collectivism culture prefers to make more green investments. Because they are further supported by their environment. Thus, it has a positive impact on green investments. While a leader who serves in a province with a strong individualist culture is inhibited by it, which is shown in Column 3) of Table 5.

Finally, provinces with above-average marketability indices are defined as developed market regions and those with below-average levels as less developed market regions, according to the *China Provincial Marketability Index Report*. The results in Columns 5) and 6) of Table 5 reveal that the influence of collectivism culture on green investment is more pronounced in developed market areas. Such areas have higher economic and living standards than less developed market areas, and governors are more willing to respond to the call for green development when there is less economic pressure. In addition, higher living standards make the public more concerned about environmental issues, and governors are willing to respond to the public's appeal. In contrast, the economic conditions in less developed market areas are worse in comparison, and in some areas, there is even a shortage of food. Allocating resources to improving the environment in these areas will inevitably affect economic development and thus the governor's green investments are limited.

5 Conclusion

With growing concerns worldwide on global warming, emissions reduction has become a major challenge for many countries. Countries are focusing on creating efficient energy systems to move towards a low-carbon economy. In this context, the role of investment in promoting and controlling carbon emissions is particularly important. Using panel data from 2004–2017 on 31 Chinese provinces, this study examines the relationship between the collectivism culture and green transition. The results indicate that 1) places with a stronger collectivism culture tend to make more green investments, 2) the results remain valid after a battery of robustness tests, 3) the positive effects of collectivism culture on green investments are more pronounced if the province governor is advanced in age, well educated, and holds a long tenure, and 4) such effects are more conspicuous in those provinces with more serious pollution, greater levels of collectivism, and more developed markets.

This study is relevant both theoretically and pragmatically. First, it promotes the government's implementation of green economic development. Driving green and low-carbon socioeconomic development is a key link to achieving high-quality growth. The government's supportive policies regarding the environment and resources are oriented towards the green transformation of social development as a whole. Therefore, studying governors' collectivism culture for the purpose of promoting environmental sustainability

through green investments could help the government better play its role and could therefore be useful in China's green, environmentally friendly, and sustainable development. Second, the government's development of green and low-carbon industries and the high-quality development of a green economy cannot be achieved without theoretical support. In this sense, this study fills a theoretical gap in the field of research on green investments from a cultural perspective. Therefore, this study has important implications for promoting green development and achieve carbon peaking and neutrality. Third, this study expands the possibility of rice theory application. My use of the theory to measure collectivism could provide some insight into how to broaden the scope of applying a classical theory to solve practical problems.

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

DQ: conceptualization, methodology, data curation, formal analysis, software, writing-original draft, writing-review and editing. I have read and agreed to the published version of the manuscript.

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Conflict of interest

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

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Appendix A: Descriptive statistics

Variables	Obs	Mean	SD	Min	Median	Max
lnGI	429	11.667	1.217	4.859	11.830	14.164
Rice	434	36.285	33.430	0.209	22.252	89.684
lnpgdp	434	10.289	0.678	8.370	10.389	11.768
lnso2	434	3.757	1.300	−2.303	4.041	5.300
lnsewage	427	10.519	1.083	6.564	10.634	12.568
lnnub	434	3.903	0.301	2.294	3.912	4.557
old	434	58.094	4.242	36.000	59.000	65.000
edu	434	1.850	0.692	0.000	2.000	3.000
term	434	4.429	1.962	1.000	4.000	9.000

Considering that several of the variables are too large in magnitude, the variables (GI, pgdp, so2, sewage, and nub) are taken in logarithms.