The Impact of Red Culture on Corporate Green Innovation: The Moderating Role of the Degree of Marketization and the Level of Clean Politics

Qin Zhang [1, 2], Chuan Hu [2, *]

[1] School of Business Administration, Division of Business administration, Zhongnan University of Economics and Law, Wuhan, People's Republic of China

[2] Department of Information Management, School of Management, Wuhan College, Wuhan, People's Republic of China

* Corresponding Author Email: Chuan.hu0606@outlook.com

Abstract. This study analyzed 29,630 A-share listed companies from China's Shanghai and Shenzhen stock exchanges between 2010 and 2021, using data from 20 national 5A red scenic spots. The OLS regression revealed that a strong red cultural atmosphere and a culture-cognition orientation significantly foster corporate green innovation. However, in areas with a high degree of marketization, improvements in formal systems weaken the positive impact of the red culture. Conversely, in regions with high levels of clean politics, red culture functions as an implicit contract thus enhancing the effectiveness of formal systems in promoting corporate green innovation.

Keywords: Red culture, Degree of marketization, Clean politics, Corporate green innovation, Informal institutions.

1. Introduction

The 20th National Congress of the Communist Party of China emphasized accelerating green transformation. The conference proposed the development of green, low-carbon industries and the promotion of green, low-carbon production methods. Green innovation is key to balancing economic growth and protecting the environment. China has attached great importance to the inheritance and innovation of red culture, issuing the "Opinions on Implementing the Project for the Inheritance and Development of China's Excellent Traditional Culture" (2023). This document encourages the integration of red culture into all areas of economic and social development, injecting a new cultural impetus into enterprise sustainable development. Therefore, exploring how red culture influences and promotes corporate green innovation is necessary to explore the value of red culture and the inevitable requirement to respond to national policies and promote corporate transformation and upgrading.

According to North (1990), the institutional environment is divided into formal and informal institutional environments [1]. The formal institutional environment encompasses regulations governing planning, such as laws and policies. The informal institutional environment is influenced by culture, traditions, customs, ethics, and ideology and is shaped by the evolution of social relations [2-3]. Current research focuses on how formal institutions, such as policy incentives and legal restrictions, drive corporate green innovation (Wang et al., 2019; Tang et al., 2023) [4-5]. Previous research has limited attention to the role of implicit factors, such as culture.

New institutional economics argues that informal institutions have an irreplaceable influence [6]. Abramson (2001) noted that culture is a crucial factor influencing society, politics, and the economy [7]. Coccia (2014) demonstrated that clan culture, as a crucial component of the social system, influences technological innovation [8]. Cao et al. (2024) found that regions with strong Confucian cultural influence experienced reduced corporate pollution emissions [9]. Other scholars have studied the impact of dialect culture and gambling culture on micro-enterprise decision making [10-11]. However, research on the impact of red culture on corporate governance practices is scarce.

Douglas and Wildavsky (1982) demonstrated that cultural worldviews reflect specific preferences within cultural values regarding social organizational decision-making [12]. Yang (2020) emphasized

that red culture is a core element of Chinese culture, embodying firm beliefs, tenacity, and a sense of historical responsibility [13]. Xu et al. (2020) combined advanced and imprinting theories to demonstrate that red culture creates a unique "cultural imprint" on management, influencing its thinking [14]. However, current research on the impact of red culture on corporate green innovation has not fully explored its mechanisms or the boundary conditions.

Based on the above analysis, we explore the following questions: What factors play a key role in promoting corporate green innovation through red culture? How do the degree of marketization and the degree of political integrity affect red culture's impact on corporate green innovation? Can red culture complement formal institutions to promote corporate green innovation?

This study makes several contributions. First, it analyzes the impact of red culture on corporate green innovation from the perspective of informal institutions, thereby broadening the research lens on the factors influencing corporate green innovation. Second, it focuses on the Chinese context to explore the mechanisms, boundary conditions, and heterogeneity of the relationship between red culture and corporate green innovation. By integrating red culture with formal institutions, this study provides theoretical support for the governance of corporate green innovation. Third, it advances the measurement of red culture variables and validates the reliability of the distance model in assessing their impact on corporate green innovation, offering new insights into the role of culture in shaping corporate decision making.

2. Literature Review and Research Hypotheses

2.1 Red Culture and Green Innovation

Green innovation fosters economic development by reducing resource consumption and creating value. It encompasses the green economy, technological progress and scientific advancement. While emphasizing independent innovation, it also encourages the introduction of advanced international technologies and expertise in China. The primary goal of green innovation is to improve the ecological environment and generate positive externalities for companies. At the corporate level, green innovation involves integrating cultural, technological, and human resources.

Hofstede (1980) argued that individual cultural perspectives directly influence economic activity [15]. DiMaggio (1997) emphasized that culture is a key element of the economic system, playing a decisive role in shaping social structures and institutional frameworks [16]. Thompson et al. (1990) demonstrated that the historical wisdom and experience embedded in cultural values can inspire innovative thinking in individual decision-making [17]. Ottaviano and Peri (2006) suggested that different cultural backgrounds influence employees' innovative thinking within organizations [18]. Guiso et al. (2015) further argued that a company's cultural spirit shapes individual values and behaviors [19].

Red culture, rooted in revolutionary history and heroic deeds, conveys the values of reform, struggle, and innovation. It shapes people's moral and behavioral standards and enhances their motivation for innovation. Red culture also encourages active engagement in socially responsible activities. Xu and Lan (2020) demonstrated that incentive mechanisms increase the emphasis on green innovation among "transformative" managers in state-owned enterprises [20]. Song and Yu (2018) found that managers with a green innovation consciousness develop corresponding strategies and further promote their implementation [21]. Together, these studies suggest that red culture influences corporate green innovation through various channels. Therefore, this study proposes the following hypothesis:

H1: The stronger the influence of red culture on a company, the greater its willingness to engage in green innovation.

2.2 Red Culture and Marketization Degree

The main approach to measuring the level of marketization in China is constructing a comprehensive indicator system. Gu (1997) applied an analytical judgment method to evaluate the

degree of marketization across labor, capital, production, prices, and other aspects, thereby assessing China's overall marketization level [22]. Jiang and Song (1995) established a set of indicators including enterprise freedom, market openness to foreign countries, market openness to domestic markets and macroeconomic regulation [23]. The data from the four indicators were synthesized and averaged to obtain the degree of marketization. Subsequent scholars have developed marketization indices based on six dimensions: government–market relations, non-state-owned economic development, product market development, factor market development, the development of market intermediary organizations, and the legal and institutional environment [24-25]. Building on the framework of Wang et al. (2019), this study employs an overall marketization index to measure regional marketization [24]. This index has become a relatively standardized tool and is widely regarded as the most authoritative measure of marketization in China [26].

Xu et al. (2021) argued that the level of marketization plays a significant role in regulating technological innovation in enterprises [27]. Shen et al. (2023) emphasized that a high degree of marketization is characterized by adherence to market principles in the economic activities of a sector, industry, or region, with reliance on market mechanisms to allocate resources, regulate supply and demand, and determine prices, thereby ensuring the free flow of factors and efficient resource utilization [28]. Lin et al. (2019) found a positive correlation between a high degree of marketization and the improvement of formal institutions [29]. Yan (2007) noted that regions with higher levels of marketization possess more robust formal institutions and demonstrate superior economic resource allocation [30]. Zhang et al. (2024) found that a sound legal system constrains market behavior, encouraging companies to allocate resources toward innovative activities, thereby improving innovation efficiency [31]. Conversely, other scholars have confirmed that an imperfect formal institutional environment increases foreign companies' operational difficulties [32-33]. Investments in technological innovation and risk aversion should be balanced using a combination of policy support and market mechanisms. These studies indicate that the more market-oriented a region is, the more effectively a sound institutional system promotes corporate green innovation.

Carpenter et al. (2004) argued that the degree of marketization is a key factor influencing managers' external environmental decisions [34]. Nadkarni and Barr (2008) suggested that corporate strategic decisions are closely linked to managers' cognition and their environmental context [35]. Li et al. (2005) emphasized that culture can shape managerial cognition, thereby alter risk appetite and ultimately influence corporate strategic decisions [36]. However, Zhang et al. (2024) found that in regions with a high degree of marketization, corporate managers' decisions are driven more by market factors, such as risk appetite and economic benefits, than by cultural factors alone [37]. Similarly, Yan et al. (2024) observed that in highly marketized regions, a well-developed formal institutional environment weakens the role of red culture in promoting green innovation in enterprises [38]. Yates and De Oliveira (2016) pointed out that the internal mechanisms through which cultural values influence decision-making remain unclear [39]. Moreover, even within the same sociocultural environment, differences in knowledge structures and resource endowments can lead to divergent decision-making results. Yu et al. (2019) found that internal control systems impose varying constraints on management across enterprises with different ownership structures, and these differences affect the effectiveness of the red culture value of "equality" in corporate governance [40]. Beyond internal governance, intense competition in external markets further constrains managerial discretion [41].

The literature indicates that in regions with a high degree of marketization, business managers tend to prioritize economic benefits and avoid risks, leading to a more efficient allocation of innovation resources and promoting green innovation. However, under such conditions, strengthening formal institutions may reduce the scope for red culture to exert influence, thereby weakening its role in fostering green innovation [42]. Based on this reasoning, we infer that increasing marketization diminishes the impact of red culture on green innovation in corporations. Accordingly, we propose the following hypothesis:

H2: The impact of red culture on corporate green innovation is weaker in regions with a high degree of marketization.

2.3 The Moderating Effect of Clean Politics

Clean politics requires integrity in political activities, opposition to corruption, and adherence to the principles of fairness, transparency, and rule of law [43]. A clean political atmosphere fosters a fair and honest social and cultural environment based on mainstream social values [44]. Zhao and Bai (2020) defined corrupt activities as businesses making payments to obtain "specific" resource allocations or paying unreasonable fees to avoid extortion and plunder [45]. Popescu and Kelley (2013) noted that bribery is a common form of corruption that hinders socioeconomic development [46]. Wu and Rui (2010) identified an inverted U-shaped relationship between corruption and economic growth: the positive effect of corruption on economic growth in eastern China, where marketization is more advanced, is weaker than in central and western China [47]. Xiang and Li (2014) argued that implementing anti-corruption measures is essential to achieving clean governance [48]. However, efforts to combat bribery face challenges due to imperfect anti-corruption and judicial systems [49].

Institutional theory posits that institutions, such as laws and culture, impose significant constraints on social behavior. Individuals' decision-making experiences are shaped by their cultural and cognitive values [50]. Social network theory suggests that individuals within the same network tend to develop consistent value and behavioral norms. The cultural "profit drive" encourages corporate management to establish norms of integrity, trustworthiness, and risk aversion in decision making [51]. Tang et al. (2024) found that a company's risk–return perception can drive management teams to adjust their strategies in response to existential threats [52]. Moreover, management teams often choose safer projects because of personal gain motives and a desire for control [53]. The high risk, long cycles, and low success rates associated with innovation can reduce corporate managers' willingness to invest in green innovation [54].

However, the red culture's emphasis on selfless dedication and integrity aligns closely with the requirements for clean governance [55]. Yu et al. (2020) noted that the values of fairness and justice embedded in red culture can guide management in making strategy-oriented decisions [56]. Within the framework of clean governance, red culture encourages corporate executives to assume social responsibility and implement green innovation strategies [57]. Empirical evidence also shows that companies in regions prioritizing clean governance increase their green investments and innovation due to policy support and fiscal subsidies [58]. Together, these studies underscore the significant influence of red culture on corporate governance. Based on the above literature, we propose the following hypothesis:

H3: Red culture has a stronger impact on corporate green innovation in regions with higher levels of clean governance.

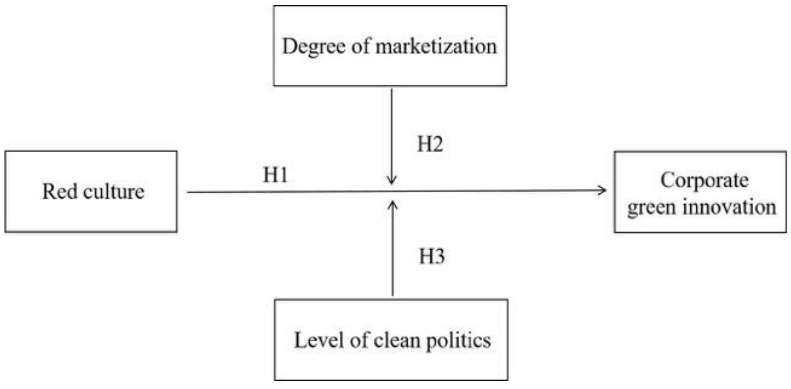

Figure 1. Logic diagram of research hypothesis

Source: Author (s) work.

To examine the relationship between red culture, marketization, clean governance, and corporate green innovation, we developed a theoretical model (Figure 1) based on upper echelons theory and institutional theory [59]. Upper echelons theory suggests that culture shapes executives' values and beliefs, thereby influencing organizational goals and strategic decisions [60]. Institutional theory posits that institutions, such as laws, customs, and culture, exert constraining influences on social behavior. Consequently, corporate decision-making is shaped by cultural-cognitive value elements and belief systems embedded in the environment in which firms operate [61].

3. Research Methodology

3.1 Sample Selection

We selected data on A-share listed companies from China's Shanghai and Shenzhen stock exchanges covering the period 2010–2021 for empirical analysis and applied the following screening criteria. First, we excluded ST and *ST companies because these firms are subject to strict regulatory oversight and exhibit significant performance fluctuations. Second, we removed companies with substantial missing data on the main research variables to ensure data integrity, as well as firms that had been listed for less than one year to guarantee a sufficiently long observation period. Third, we excluded firms in the financial industry because of their unique business models and regulatory environments. After applying these criteria, the final sample comprised 4,273 companies with 29,630 valid firm-year observations.

3.2 Data Source

Data on the number of green patent applications were obtained from the China Research Data Service (CNRDS) database. Enterprise characteristics and financial data were collected from the Guotai'an database (CSMAR), and corporate annual report data were obtained from CNINFO. To mitigate the influence of extreme values, all continuous variables were winsorized at the 1% level in all models. Data matching across datasets, variable construction, and empirical analyses were conducted using Stata 15.

3.3 Variable Measurement

3.3.1 Explanatory Variable: Green Innovation (lnpat)

We followed the processing method of Andreoni and Chang (2019) and used the number of green patent applications to measure a company's green innovation level [62]. First, green technologies were identified using the "International Patent Classification Green List" (IPC) issued by the World Intellectual Property Organization (WIPO) in 2010, which was formulated according to the technical standards of the United Nations Framework Convention on Climate Change (UNFCCC). The number of green patent applications was then transformed by taking the natural logarithm of one plus the application count. The larger the value of lnpat, the higher is the level of green innovation in the enterprise. Second, data on green patent applications for China's A-share listed companies were obtained from the China Research Data Service (CNRDS) and cross-validated with the China National Intellectual Property Administration (CNIPA) database to construct the green patent dataset. Using patent data not only directly reflects a company's green technology innovation output but also ensures data availability and accuracy.

3.3.2 Explanatory Variable: Red Culture (red)

Building on the work of Yu et al. (2020), we used data on China's national 5A red scenic spots as the key indicator for measuring the influence of red culture and employed the distance model to evaluate its impact on corporate green innovation [56]. Red scenic spots symbolize revolutionary heritage and typically include sites such as monuments, memorials, and historical buildings. Since the China National Tourism Administration introduced the Classification and Assessment of Quality

Levels of Tourist Attractions standard in 2004, 5A-level red scenic spots have become an important benchmark for assessing the cultural significance and characteristics of these sites.

First, based on the National Red Tourism Classic Scenic Spots List issued by the National Development and Reform Commission of China in 2016, together with relevant policy documents from 2016 to the present, and considering the feasibility of obtaining data on red scenic spots, we identified 20 representative red scenic spots as the objects of study. Next, we used Baidu Maps to manually collect the latitude and longitude coordinates of the listed companies in China's Shanghai and Shenzhen stock markets, as well as those of the 5A-level red scenic spots. We then calculated the average distance from the offices of the listed companies to the 20 red spots. After data processing, we obtained a final sample of 4,273 listed companies over 11 years, yielding 29,630 firm-year observations.

The specific calculation steps are as follows: the longitude and latitude of listed companies are marked as μ_F and ω_F. The longitude and latitude of the red scenic spot are marked as μ_R and ω_R. We calculated the central angle using the following formula (β):

$$\cos\beta = \sin\omega_F \times \sin\omega_R + \cos\omega_F \times \cos\omega_R \times \cos(\mu_F - \mu_R)$$

We then calculated the geographical distance from each listed company's office to the 20 red scenic spots. Here, ARCrepresents the arc length on the Earth's surface, with the Earth's radius approximated to be 6,370 km.

$$\mathrm{DIS} = \mathrm{ARC} \times \left[\frac{\pi}{2} - \arctan\left(\frac{\cos\beta}{\sqrt{1-\cos^{2}\beta}}\right)\right]$$

Finally, the average distance between each listed company's office and the 20 red scenic spots was computed using the following formula:

$$\mathrm{DIS_A} = \frac{\mathrm{DIS_1} + \mathrm{DIS_2} + \mathrm{DIS_3} + \ldots + \mathrm{DIS_{19}} + \mathrm{DIS_{20}}}{20}$$

To reduce the differences in numerical magnitude among the variables, we applied a logarithmic transformation to the geographical distance between the listed companies and red scenic spots. A smaller geographical distance indicates a stronger cultural influence of red culture on the company's behavior. To ensure that larger values represented a stronger cultural influence, we took the negative of the logarithmic values and defined this as the core explanatory variable, lndist. Thus, the larger the lndist value, the closer the company is to the red scenic spots, and the greater the influence of red culture.

3.3.3 Adjusting Variables

Degree of marketization (market)

We adopted the "China Marketization Index" constructed by Wang et al. (2019) to measure the degree of marketization [24]. This index provides a comparative assessment of marketization across China's provincial administrative regions, considering factors such as government–market relations, the development of the non-state-owned economy, product market development, factor market development, the degree of financial marketization, the role of market intermediary organizations, and the legal environment of the market. To minimize the impact of differences in numerical ranges, we normalized the index by dividing the total score by 100 and rescaling it from zero to ten. Given the varying levels of marketization across regions, to ensure data accuracy, we randomly sampled 1,000 listed companies from our database and compared their marketization-related indicators with the operating data disclosed in their annual reports. Through this validation process, we identified 713 indicators with a high accuracy. A higher index value indicates a higher degree of marketization.

Level of clean politics (lngov)

We followed Wu and Rui (2010) and used the degree of anti-corruption as a measure [47]. In their study, anti-corruption was defined as the promotion of marketization and economic growth through institutionalized measures aimed at reducing corrupt practices. Anti-corruption cases primarily include criminal cases of corruption and bribery, criminal cases of dereliction of duty, and criminal

cases of infringement of citizens' personal and democratic rights. The number of malfeasance, corruption, and bribery cases directly reflects corruption frequency. A higher number of such cases indicates more frequent corruption and lower political integrity in the region. Given that anti-corruption efforts generally reflect trends in clean governance, we measured clean governance (lngov) using the logarithm of the annual number of derelictions of duty, embezzlement, and bribery cases filed by the procuratorates across Chinese regions [63]. The "number of cases filed for dereliction of duty, embezzlement, and bribery," as reported in the China Procuratorial Yearbook, refers to corruption cases investigated and prosecuted nationwide. We manually collected and compiled 6,449 records of such cases from 558 Annual Work Reports of the People's Procuratorates covering 31 provinces, as documented in the China Procuratorial Yearbook (2010–2021).

3.3.4 Control Variables

Following the measurement method of Yu et al. (2019) [40], we included the following control variables in Table 1: board independence (dld), dual positions (dual), board size (bd), ownership concentration (top1), firm growth (gro), financial leverage (lev), profitability (roa), firm size (size), cash flow (cf), regional economic development (lngdp), an industry dummy variable (Indus), and a year dummy variable (year).

Table 1. Variable definition

Variable type	Variable name	Variable symbol	Variable definition and measurement
Explained variable	Green innovation	*lnpat*	The natural logarithm of the number of green patent applications plus one.
Explanatory variables	Red culture	*red*	Red culture intensity based on distance measurements between red scenic spots and listed company offices.
Moderator	Degree of clean politics	*lngov*	Logarithm of the annual number of malfeasance, corruption and bribery cases filed for investigation by local procuratorates.
Control variables	Marketization degree	*market*	Total score of marketization index of China Identity Marketization Index (2018) compiled by Wang et al. (2019) [24] /100.
	Board independence	*dld*	Number of independent directors / total number of board members.
	Two jobs in one	*dual*	Whether the chairman serves as general manager or CEO, it takes 1, otherwise it takes 0.
	Board size	*bd*	The natural logarithm of the total number of directors plus one.
	Ownership concentration	*top1*	Number of shares held by largest shareholder/total number of shares in company.
	Company growth	*gro*	The difference between the company's operating income in period t and period t-1 is used as the ratio of the operating income in period t-1.
	Financial leverage	*lev*	Total liabilities at the end of the period/total assets at the end of the period.
	Company profitability	*roa*	Net profit/ (average of total assets at the beginning and total assets at the end of the period).
	Enterprise size	*size*	Year-end logarithm of assets.
	Cashflow	*cf*	Cashflow from operating activities/assets.
	Regional economic development	*lngdp*	Logarithm of GDP per capita in the province in which the company is located.
	Industry dummy variable	*Indus*	Industry type, represented by a dummy variable.
	Year dummy variable	*Year*	Year of observation, represented by a dummy variable.

Source: Author (s) work.

3.4 Model Settings

To test the research hypotheses, we constructed the following three models.

Model (1):

$$\mathrm{lnpat}_{i,t} = \alpha_0 + \alpha_1 \mathrm{indist} + \alpha_2 X_{i,t} + \sum \mathrm{year} + \sum \mathrm{Industry} + \varepsilon_{1i,t} \quad (1)$$

Model (2):

$$\mathrm{lnpat}_{it} = \beta_0 + \beta_1 \mathrm{lndist} + \beta_2 \mathrm{market}_{i,t} + \beta_3 \mathrm{indist} \times \mathrm{market}_{i,t} + \beta_i X_{i,t} + \sum \mathrm{year} + \sum \mathrm{Industry} + \varepsilon_{2i,t} \quad (2)$$

Model (3):

$$\mathrm{lnpat}_{i,t} = \gamma_0 + \gamma_1 \mathrm{indist} + \gamma_2 \mathrm{lngov}_{i,t} + \gamma_3 \mathrm{indist} \times \mathrm{lngov}_{i,t} + \gamma_i X_{i,t} + \sum \mathrm{year} + \sum \mathrm{Industry} + \varepsilon_{3i,t} \quad (3)$$

Model (1) tested the main effect, and Model (2) and Model (3) tested the moderating effect. Among them, i represented enterprise and and t represented year; lnpat represented enterprise green innovation; indist represented the intensity of the influence of red culture on enterprise i in year t; α_0 was the intercept term; $X_{i,t}$ represented the control variable; year was the control variable; industry was the industry dummy variable; and ε was the random error term.

In Model (1), when $\alpha_1 < 0$, the smaller the geographical distance between the listed company's office and the red scenic spot, the greater was the company's impact on the intensity of red culture.

In Model (2), $\mathrm{indist} \times \mathrm{market}_{i,t}$ meant the cross-product term between red culture and the degree of clean politics. When $\beta_2 > 0$, it indicated that the degree of marketization can weaken the impact of red culture on corporate green innovation.

In Model (3), $\mathrm{indist} \times \mathrm{lngov}_{i,t}$ meant the cross-term of red culture and the level of clean politics. When $\gamma_2 > 0$, It indicated that clean politics could enhance the impact of red culture on corporate green innovation.

We used the State software to conduct ordinary least squares (OLS) regression analysis on models (1), (2), and (3). To ensure accurate results, we preprocessed 29,630 valid observation data points to reduce the interference of outliers. (1) All continuous variables were winsorized by 1% above and below. (2) When verifying the interaction, all interaction term indicators were processed centrally to avoid the collinearity of the interaction term affecting the results.

4. Empirical Results

4.1 Descriptive Statistics

Table 2. Descriptive statistics of variables

VarName	Obs	Mean	SD	Min	Median	Max
lnpat	29630	0.845	1.181	0	0	7.364
indist	29630	6.860	0.231	6.455	6.839	8.189
market	29630	9.637	1.668	-0.161	9.860	12.390
lngov	29630	7.042	0.795	3.526	7.271	8.085
size	29630	22.064	1.314	15.577	21.871	28.636
lev	29630	0.408	0.208	0.048	0.395	0.916
gro	29630	0.188	0.394	-0.540	0.125	2.451
roa	29630	0.0402	0.065	-0.283	0.041	0.206
cf	29630	0.0462	0.069	-0.166	0.046	0.242
bd	29630	8.480	1.674	3.000	9.000	18.000
dld	29630	0.376	0.056	0.143	0.364	0.800
dual	29630	0.313	0.464	0.000	0.000	1.000
Top1	29630	0.342	0.149	0.024	0.320	0.900
lngdp	29630	11.161	0.478	9.464	11.182	12.123
dual	29630	0.313	0.464	0.000	0.000	1.000
Top1	29630	0.342	0.149	0.024	0.320	0.900
lngdp	29630	11.161	0.478	9.464	11.182	12.123

Source: Author (s) work.

Table 2 presents the descriptive statistics of the main variables. The mean value of lnpat was 0.845, with a standard deviation of 1.181 and a maximum of 7.36. The standard deviation was significantly greater than the mean, indicating a substantial variation in the number of green patent applications among the listed companies. The mean value of indist was 6.860, with a standard deviation of 0.231, suggesting that this variable was relatively concentrated with little dispersion. The mean, standard deviation, maximum, and minimum values of the remaining variables were within reasonable ranges.

4.2 Correlation Analysis

To mitigate potential multicollinearity problems arising from correlations between variables, we conducted correlation tests on core variables. The results indicate that the correlation coefficient between corporate green innovation (lnpat) and red culture (lndist) was –0.011, as shown in Table 3. This suggests that there is no linear correlation between red culture and corporate green innovation. Accordingly, in the subsequent regression analyses, these two variables can be included in the model simultaneously without introducing estimation bias from multicollinearity.

Table 3. Correlation test

	lnpat	lndist	market	lngov	SIZE	LEV	GRO	ROA	CF	BD	DLD	DUAL	TOP1	lngdp
lnpat	1													
lndist	-0.011**	1												
market	0.067***	-0.359***	1											
lngov	-0.00600	-0.238***	0.127***	1										
SIZE	0.424***	0.075***	-0.00500	-0.057***	1									
LEV	0.183***	0.051***	-0.090***	0.013**	0.490***	1								
GRO	0.014**	-0.00500	0.00200	-0.00800	0.032***	0.028***	1							
ROA	-0.00300	-0.053***	0.046***	0.00800	-0.036***	-0.374***	0.235***	1						
CF	0.010*	-0.036***	0.051***	0.018***	0.063***	-0.167***	0.019***	0.381***	1					
BD	0.104***	0.031***	-0.132***	-0.013**	0.277***	0.150***	-0.013**	0.00600	0.037***	1				
DLD	0.019***	0.00300	0.040***	-0.023***	-0.00100	-0.011*	-0.00200	-0.019***	-0.011*	-0.511***	1			
DUAL	-0.037***	-0.046***	0.134***	-0.00600	-0.179***	-0.143***	0.023***	0.049***	-0.00800	-0.177***	0.109***	1		
TOP1	0.024***	0.022***	-0.039***	-0.042***	0.177***	0.033***	0.00600	0.138***	0.096***	0.027***	0.036***	-0.036***	1	
lngdp	0.117***	-0.100***	0.732***	-0.381***	0.091***	-0.081***	-0.00700	0.020***	0.052***	-0.124***	0.058***	0.121***	-0.034***	1

Source: Author (s) work.

4.3 Regression Analysis

We used unbalanced short panel data with a short time dimension (T is short) and many individuals (N is large) and performed regression analysis using the least squares method (OLS). We then combined the research methods of Zhu et al. (2025) and clustered robust standard errors to address the heteroskedasticity problem [64].

In Table 4, column (1), we present the independent variable, red culture (indist). The R-squared value was 0.131, and the F value was 184.1, indicating that the model was overall significant. In columns (2) and (3), we gradually add the control variables. Compared with column (1), the R-squared value increased from 0.331 to 0.334, the F value increased from 260.4 to 232.6, and the overall model remained significant. The regression analysis results show that the new control variables significantly impact lnpat. These results show that the influence of red culture on the office location of listed companies significantly increases their willingness to engage in green innovation. In other words, the stronger the influence of red culture on an office location, the greater the company's willingness to engage in green innovation. H1 is true.

Column (1) of Table 5 reveals that the coefficient of indist_market is 0.0512, indicating that the interaction between the degree of marketization (market) and the average distance from a listed company's office to the nearest red scenic spot (indist) has a significant positive effect on corporate green innovation (lnpat). This suggests that the degree of marketization influences corporate green innovation through variations in the average distance to red scenic locations: the greater the distance, the greater the promotion of corporate green innovation.

Table 4. Stepwise regression analy

Variable	(1)	(2)	(3)
	m1	m2	m3
	lnpat	lnpat	lnpat
indist	-0.0474*	-0.1807***	-0.1548***
	(-1.79)	(-7.66)	(-6.49)
SIZE		0.4431***	0.4403***
		(65.72)	(63.40)
LEV		0.0108	0.0390
		(0.31)	(1.12)
GRO		-0.0111	-0.0130
		(-0.73)	(-0.85)
ROA		0.3166***	0.3450***
		(3.21)	(3.49)
CF		-0.2964***	-0.2782***
		(-3.36)	(-3.16)
BD			0.0142***
			(2.94)
DLD			0.3459***
			(2.68)
DUAL			0.0392***
			(3.13)
TOP1			-0.1931***
			(-4.72)
lngdp			0.1218***
			(7.92)
Constant	-0.0770	-8.5168***	-10.1531***
	(-0.40)	(-37.32)	(-32.79)
Observations	29,630	29,630	29,630
R-squared	0.131	0.331	0.334
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
F	184.1	260.4	232.6

Note: () is the t value calculated based on robust standard errors. ***p<0.01, **p<0.05, *p<0

Table 5. Test of moderating effect

VARIABLES	(1)	(2)
	Marketization degree	Level of clean politics
	lnpat	lnpat
indist_market	0.0512***	
	(4.82)	
market	-0.3321***	
	(-4.43)	
red_lngov		-0.0984***
		(-3.36)
lngov		0.7236***
		(3.55)
lndist	-0.5147***	0.5635***
	(-5.95)	(2.79)
Constant	-7.1948***	-15.8614***
	(-11.49)	(-10.71)
Observations	29,630	29,630
R-squared	0.335	0.334
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
F	223.8	222.5

Note: () is the t value calculated based on robust standard errors. ***p<0.01, **p<0.05, *p<0.1

In column (2), the coefficient of indist_lngov is –0.0984, indicating that the interaction between the average distance from a listed company's office to the nearest red scenic spot (indist) and the level of political integrity (lngov) has a significant negative effect on corporate green innovation (lnpat). This suggests that political integrity influences corporate green innovation through variations in the average distance to red scenic spots: the greater the distance, the weaker the promotion of corporate green innovation.

4.4 Robustness Test and Endogeneity Treatment

4.4.1 Replace Different Variables for Further Testing

Given that omitted variables may cause endogeneity issues and weaken the robustness of the benchmark regression results, we conducted further tests by substituting alternative variables to address this concern. First, we replaced the explanatory variable with the average distance between the company's registered location and the nearest red scenic spot (lndist1). Because the office location of many companies does not coincide with their place of registration, the choice of registration is often associated with firms' goals of obtaining policy preferences and tax exemptions. For instance, a company may register in an economically underdeveloped area to benefit from local preferential policies while locating its office in a more developed region to access superior resources. Second, we replaced the dependent variable with the logarithm of the number of authorized green patent applications plus one (lnpat1). Finally, we modified the regression model. As some companies reported zero green patent applications, we adopted a Tobit model to account for the characteristics of the data, using 29,630 valid observations from 4,273 companies. The results of these robustness tests, presented in Table 6, are consistent across all three models, confirming the reliability of the previous findings.

Table 6. Test results of replacing variables

VARIABLES	(1)	(2)	(3)
	Average distance from company registration place	Number of patents granted	TOBIT
	lnpat	lnpat1	lnpat
lndist1	-0.1190***		
	(-5.02)		
lndist		-0.1086***	-0.4787***
		(-5.16)	(-9.30)
Constant	-9.5455***	-8.9472***	-16.8538***
	(-24.67)	(-31.92)	(-29.04)
Observations	29,592	29,630	29,630
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes

Note: () is the t value calculated based on robust standard errors. ***p<0.01, **p<0.05, *p<0.1

4.4.2 Change the Measurement Method of Red Culture

In Table 7, we followed the measurement approaches of Chen et al. (2013) and Xu and Li (2019) to further validate the reliability of the distance-based model used to measure red culture [65-66]. The procedure was as follows. First, we used the logarithm of the number of national 5A red scenic spots within 200 km and 300 km of a listed company's office (BConf_200, BConf_300) as proxy variables for red culture. Second, drawing on information from 227 national-level martyrs' memorials in China, we calculated the logarithm of the number of such memorials within 200 km and 300 km of the company's office (BJNred_200, BJNred_300) as alternative proxies for red culture [42]. Specifically, we estimated four models using the following proxy variables: the number of scenic spots within 200 km (Model 1), the number of scenic spots within 300 km (Model 2), the number of martyrs'

memorials within 200 km (Model 3), and the number of martyrs' memorials within 300 km (Model 4).

Table 7. Test results of replacing the proxy variable of red culture

VARIABLES	(1)	(2)	(3)	(4)
	Number of attractions within 200 km	Number of attractions within 300 km	Number of martyrs memorial halls within 200 km	Number of martyrs memorial halls within 300 km
	lnpat	lnpat	lnpat	lnpat
BConf_200	0.0101			
	(0.82)			
BConf_300		0.0299**		
		(2.43)		
BJNred_200			0.0833***	
			(6.95)	
BJNred_300				0.0273**
				(2.54)
Constant	-11.1977***	-11.1176***	-11.0481***	-11.2645***
	(-43.44)	(-44.05)	(-44.90)	(-45.92)
Observations	29,630	29,630	29,630	29,630
R-squared	0.333	0.333	0.334	0.333
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
F	233.1	232.5	233.1	232.2

Note: () is the t value calculated based on robust standard errors.; ***p<0.01, **p<0.05, *p<0.1

The choice of 200-300 km as the distance threshold was based on its rationality and feasibility. From the perspective of rationality, the "cultural-cognitive" values of red culture are essentially reflected in people's behavioral responses to their cultural cognition. Red scenic spots are important material manifestations of red culture. The closer a listed company's office is to such a site, the stronger is the surrounding red cultural atmosphere. From the perspective of feasibility, data on red culture were collected manually from official sources and are, therefore, highly reliable.

We also selected the Revolutionary Martyrs Memorial Hall as a separate measure for the study. Although memorial halls are formally included in the category of red scenic spots, they differ significantly in terms of definition, function, and content. Red scenic spots combine natural and historical resources, reflecting the broader role of red tourism in promoting local economic development. In contrast, the Revolutionary Martyrs Memorial Hall is dedicated specifically to commemorating and displaying the deeds and contributions of revolutionary martyrs. Such halls typically contain detailed information, including martyrs' life stories, combat experiences, and reasons for sacrifice, thereby highlighting the influence of the martyr spirit on corporate values and culture.

5. Group Inspection

In recent years, the Chinese government has emphasized green finance and credit policies to promote industrial restructuring and green innovation through financial means. Green credit policies restrict high-pollution, high-energy-consuming industries and encourage financing green industries to achieve sustainable economic development. We divided the sample into restricted (1,305 samples) and non-restricted groups (28,325 samples) based on whether the companies' industries were subject to green credit restrictions. There are 16 green credit-restricted industries, covering heavily polluting subsectors such as metallurgy, pharmaceuticals, leather, chemicals, fermentation, building materials, cement, thermal power, coal, electrolytic aluminum, petrochemicals, textiles, papermaking, brewing, mining, and steel. The sample was divided into pilot zones (553 samples) and non-pilot zones (29,077

samples) based on the location of the companies in green finance pilot zones. The first batch of pilot zones included Huzhou and Quzhou in Zhejiang Province, Ganjiang New Area in Jiangxi Province, Guangzhou in Guangdong Province, Gui'an New Area in Guizhou Province, and Karamay and Hami in Xinjiang Uyghur Autonomous Region.

We grouped the sample according to whether the industry was subject to green credit restrictions and whether the enterprise was in a green finance pilot zone. Table 8 shows that in the restricted group (column 1), the regression coefficient for lndist was 0.4936, but the t-value was only 1.56, failing to reach statistical significance (typically requiring a t-value greater than 1.96, corresponding to $p < 0.05$). This indicates that the relationship between lndist and lnpat is not significant in the restricted group, indicating that the impact of red culture on corporate green innovation is not significant in a green credit restriction environment. This may indicate that the restrictive effect of green credit policies within the restricted group weakens the potential impact of red culture on corporate green innovation.

Table 8. Group inspection

VARIABLES	Green credit		Green finance	
	Restricted group	Unrestricted group	Non-experimental group	Experimental group
	(1)	(2)	(3)	(4)
	lnpat	lnpat	lnpat	lnpat
lndist	0.4936	-0.1966***	-0.1598***	-0.7288
	(1.56)	(-7.96)	(-6.67)	(-1.50)
Constant	-22.7466***	-9.5660***	-9.2737***	11.9964
	(-19.89)	(-31.64)	(-25.14)	(1.16)
Observations	1,305	28,325	29,077	553
R-squared	0.586	0.322	0.334	0.431
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
F	47.54	156.34	227.6	18.92

Note: () is the t value calculated based on robust standard errors; ***p<0.01, **p<0.05, *p<0.1

In the unrestricted group (column 2), the regression coefficient for lndist is －0.1966, with a t-value of －7.96 and a significance level of $p < 0.01$. This indicates a significant negative correlation between red culture and corporate green innovation in the unrestricted group. Specifically, the negative coefficient for lndist indicates that the farther away from the red cultural area (i.e., the weaker the influence of red culture), the higher the level of green innovation. This result may reflect that in the unrestricted group, companies supported by green credit can allocate resources more flexibly, thereby promoting green innovation and are less likely to be constrained by red culture.

In the non-experimental area (column 3), the regression coefficient for lndist is －0.1598, indicating that red culture significantly negatively impacts corporate green innovation. This may be due to relatively weak policy support, which makes the role of red culture more significant. In contrast, in the experimental area (column 4), the regression coefficient for lndist is －0.7288, but its impact is insignificant. This may indicate that enterprises in the experimental area receive stronger policy support and possess stronger endogenous innovation motivation, thereby weakening the impact of the red culture on corporate green innovation. This suggests that the relationship between red culture and green innovation varies across policy environments. As an informal institution, red culture can complement formal institutions in specific contexts, compensating for the shortcomings of policy tools such as green finance and thereby promoting green innovation activities within enterprises.

6. Discussion

6.1 Research Findings

This study's finding that red culture has a significant positive effect on promoting green innovation in enterprises further supports DiMaggio and Powell's (1983) [50] view that culture shapes individuals' cognitive patterns, which in turn reinforce cultural characteristics. This result support H1. Previous studies have provided additional support for this mechanism (Shen & Zhou (2018); Wang et al., 2024; Yan et al., 2024). This study further clarifies the path model through which the culture-cognition mechanism influences corporate governance practices: red culture provides enterprises with expectations and norms of social behavior through its ideas, spiritual values, and ethical pursuits, thereby motivating firms to fulfill their social responsibilities and promote green innovation.

The results confirm H2, indicating that the degree of marketization moderates the relationship between red culture and green corporate innovation. In regions with a high degree of marketization, companies tend to invest more resources to fulfill their environmental responsibilities in response to the oversight and constraints of formal environmental regulations. This, to some extent, weakens the influence of informal red culture on the green innovation. This finding supports Li and Xu's (2020) argument that as formal institutions improve, corporate culture becomes more oriented toward economic interests, while the role of red culture diminishes [69]. Moreover, stronger competition among firms in highly marketized regions implies more robust governance structures [70]. In this context, environmental regulations constrain corporate environmental investment by raising pollution emission costs (Leiter et al., 2011; Bian et al., 2022) [71-72]. This study demonstrates that in regions with a high degree of marketization, a conflict emerges between the value orientation of red culture and the pursuit of economic profits. While red culture emphasizes non-economic goals, such as social responsibility and dedication, firms must allocate more resources to short-term economic objectives and comply with formal institutional regulations. Consequently, in driving green innovation, the influence of red culture is weaker than the coercive force of formal institutions.

The results support H3, which posits that red culture has a more significant impact on corporate green innovation in regions with higher levels of clean government participation. This finding is consistent with the conclusions of Twum et al. (2024) [73]. The values of fairness, justice, and integrity promoted by red culture can shape societal values, strengthen awareness of the rule of law, and contribute to social stability. This study further confirms the positive role of clean political values embodied in red culture in both internal and external corporate governance. In regions with high political integrity, stories of red cultural deeds and exemplary figures are preserved and disseminated as tools for anti-corruption education. By reinforcing clean political values, red culture can encourage firms to make green innovation decisions openly and fairly, thereby reducing the likelihood of corruption.

Furthermore, red culture and formal institutions exert a complementary effect, jointly promoting corporate green innovation. This result supports the view of Deng and Wang (2023) that informal and formal institutions reinforce each other [74]. Informal institutions, through social norms and cultural traditions, can enhance the implementation of formal institutions and improve social governance effectiveness. Prior studies have also shown that culture plays a complementary role in institutional development and is critical for legitimacy recognition in the process of endogenous institutional selection [75-76]. While formal institutions regulate corporate behavior to a certain extent, the theory of incomplete contracts suggests that culture, as an informal institution, can compensate for the deficiencies of formal regulation [77]. We argue that the implicit values of red culture complement the inherent limitations of these formal institutions. Functioning as an "implicit contract," red culture not only restrains managerial opportunism but also shapes managers' cognitive patterns and value orientations, thereby positively influencing their green innovation decision making.

6.2 Research Contribution

Previous research has largely focused on evaluating the effectiveness of formal institutions (external policies) and has primarily focused on internal pay disparities and corporate philanthropy. This study breaks away from the traditional framework that emphasizes only formal institutions by organically integrating macro-regional culture into corporate decision making. Specifically, we analyze its mechanisms of action, boundary conditions, and heterogeneous impacts on corporate green innovation, thereby filling a research gap in integrating culture and management practices.

This study enhances the reliability of using distance variables to measure the red culture. Few studies have examined the influence of red culture on the geographical location of firms. Accordingly, we measured red culture by calculating the geographic distance between a firm's office location and the nearest national 5A red scenic site, and employed a distance model to quantitatively assess red culture, thereby strengthening the reliability and robustness of our empirical analysis.

7. Conclusion

This study provides empirical evidence that in institutional environments where formal rules are insufficient, red culture functions as a value-shaping mechanism that guides firms from shared social norms toward innovation-oriented cognitive values. However, as formal institutions strengthen, the marginal effect of red culture declines. In highly marketized regions, firms should primarily align themselves with formal regulatory frameworks. In regions with stronger political integrity, integrating fairness and justice inherent in red culture into internal governance can reduce corruption and reinforce firms' intrinsic motivation for green innovation.

However, red culture is an evolving, multifaceted construct, and our measures may not fully capture its richness. Future research could explore additional ideological and historical dimensions, such as Marxist principles, socialism with Chinese characteristics, and the legacy of revolutionary heroes, to deepen our understanding of the cultural influence on innovation. Moreover, the distance-based measure adopted here rests on specific assumptions; alternative approaches, including survey data on managers' exposure to red cultural practices or sites, may yield more direct assessments of the cultural effects. Finally, this study focuses on marketization and political integrity as boundary conditions, leaving room for examining other contextual moderators, such as regional cultural diversity, industry characteristics, and institutional complexity. Future investigations into these factors will help clarify the broader applicability and mechanisms of the influence of red culture on corporate green innovation.

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