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Confucian Culture and Corporate Green Innovation

Kedi Xu[1,a,*]

[1]*School of Accounting, Shanghai University of Finance and Economics, Shanghai, 200433, China*
a. kedi@stu.sufe.edu.cn
**corresponding author*

Abstract: Under the pursuit of high-quality and sustainable development, green development has become a global consensus. This study, using data from Chinese A-share listed companies from 2007 to 2021, finds that Confucian culture significantly promotes corporate green innovation. The mechanisms include reducing agency costs, enhancing social responsibility awareness, and improving environmental awareness. The effect is more pronounced in non-state-owned enterprises and those with more environmentally experienced executives. Additionally, there is a complementary relationship between environmental regulations and Confucian culture in fostering green innovation. This study provides theoretical support for leveraging traditional Chinese culture in contemporary contexts and offers insights for improving corporate green governance and policy-making.

Keywords: Confucian culture, informal institution, green innovation.

1. Introduction

As international business grows more complex and global ecological challenges intensify, focusing solely on total factor productivity no longer meets the demands for sustainable development. Promoting harmony between humans and nature has become a global consensus, and "green innovation" has emerged as a key driver. The State Council's "Implementation Plan for Further Improving the Market-Oriented Green Technology Innovation System (2023-2025)" emphasizes strengthening leadership in green technology innovation and expanding responsible entities. The 20th National Congress of the Communist Party of China also highlighted the importance of building a market-oriented green technology innovation system, underscoring the crucial role of enterprises. Thus, corporate-level green innovation is essential for sustainable socio-economic development and achieving harmony between humans and nature.

Green innovation involves innovating processes, products, or systems to reduce environmental impact [1], with dual benefits of enhancing economic efficiency and promoting environmental sustainability[2]. Beyond technological advancements, it encompasses institutional, organizational, managerial, and service innovations. The core objective of corporate green innovation is integrating environmental principles into economic activities to gain competitive advantages that yield economic, social, and ecological benefits. Existing research on drivers of corporate green innovation categorizes factors into internal, such as knowledge management[3] and executives' international experience [4], and external, including environmental regulations[5], industry competition[6], and government subsidies [7]. Regrettably, most studies focus on isolated internal or external factors, primarily from formal institutional perspectives, neglecting cultural and ethical aspects as informal institutions.

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In the context of Chinese society, culture is a profound and enduring force in social development, with Confucian culture exerting extensive influence. It shapes corporate ethos through its innovation attributes and ecological ethics, serving as a spiritual pillar in modernization[8]. Confucian culture influences corporate green management and innovation by embodying innovation qualities like "keeping pace with the times" and ecological philosophies such as "harmony between heaven and humanity." These aspects provide theoretical guidance for studying the relationship between Confucian culture and corporate green innovation. Unlike purely economically driven activities, corporate green innovation has the "externality" of ecological protection, which can conflict with economic interests. Therefore, relying solely on formal regulations is insufficient; stimulating intrinsic motivation through informal institutions like culture is essential. Hu Jun et al. [9] note that market-oriented environmental regulations are widely accepted in the West but are less effective in China's transitioning market. This suggests that in China, where market and institutional environments are still developing, long-standing informal institutions like culture have a more significant impact on corporate behavior and decisions.

Based on this, This paper uses classical interpretation, theoretical analysis, and empirical testing to explore Confucian culture's impact on corporate green innovation. The findings show that Confucian culture significantly promotes green innovation, with higher cultural influence leading to more green patents. The culture affects green innovation by reducing agency costs, enhancing social responsibility, and increasing environmental awareness. The effect is stronger in non-state-owned enterprises and in firms with more executives having environmental backgrounds. Additionally, Confucian culture and environmental regulations complement each other in promoting green innovation, with stronger regulations enhancing Confucian culture's positive effect.

The marginal contributions of this paper are: (1) It enriches the literature on corporate green innovation by examining the influence of Confucian culture as an informal institution. This study links internal and external drivers of green innovation, providing a better understanding of sustainable green innovation in enterprises. (2) It deepens the understanding of Confucian culture's economic impact, focusing on micro-level enterprises and their green innovation behaviors, which are closely related to sustainable development. By combining theoretical and empirical research paradigms, it broadens the scope of related research. (3) It offers practical significance, revealing the mechanisms through which Confucian culture promotes corporate green innovation and providing policy implications for green modernization governance. This emphasizes the importance of recognizing cultural factors in promoting high-quality green development.

2. Theoretical Analysis and Research Hypotheses

2.1. Evolutionary Background of Confucian Culture

Confucian culture, founded by Confucius during the late Spring and Autumn period and further developed by figures like Mencius and Xunzi, centers around the core values of "benevolence, righteousness, propriety, wisdom, and trustworthiness." Following the Han Dynasty's policy of "dismissing a hundred schools of thought and respecting only Confucianism," it became the state-endorsed ideology and dominant orthodoxy in feudal society. Despite periods of coexistence with Buddhism and Daoism, Confucian values regained dominance, especially after the Song Dynasty's Cheng-Zhu Neo-Confucianism integrated Buddhist and Daoist ideas. During the Ming and Qing dynasties, the imperial examination system expanded Confucianism's influence across various aspects of life, embedding it as an ethical framework and cultural gene in Chinese national identity.

Even in modern times, despite challenges from Western culture, Confucian values such as humanism, inclusiveness, and pragmatism have persisted and thrived. Since the 18th National Congress of the Communist Party of China, General Secretary Xi Jinping has emphasized the

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importance of inheriting and promoting traditional Chinese culture, advocating for its "creative transformation and innovative development" to address contemporary global challenges.

Confucian culture significantly impacts corporate behavior and decision-making. Research has shown that it enhances internal control quality, corporate investment efficiency, social responsibility disclosure, and reduces managerial self-interest and stock price crash risk. However, the literature rarely addresses Confucian culture's role in green development and innovation. This paper aims to explore Confucian culture's contemporary value, particularly in stimulating corporate green innovation and supporting high-quality green development, offering significant theoretical and practical insights.

2.2. Confucian Culture and Corporate Green Innovation

Compared to the regulatory and constraining effects of formal institutions such as policies and laws, Confucian culture, as a profoundly influential informal institution, drives corporate green innovation from within through its value systems, moral norms, and ecological ethics. Its promoting effects are mainly manifested in the following three aspects:

(1) Reducing Agency Costs

First, from the perspective of corporate governance, Confucian ethical thoughts such as "loyalty and trustworthiness" and "self-discipline" can curb managerial self-interest and alleviate agency problems, thereby promoting corporate green innovation. The dual externalities of corporate green innovation indicate that it can create positive environmental benefits for society and generate industry-level innovation effects. The latter means that the experiences and technologies gained from green innovation can become best practices within the industry, providing opportunities for other companies to learn and emulate.

However, this also implies that the entities undertaking green innovation must bear substantial costs and potential risks, which often leaves corporate managers lacking sufficient motivation for green innovation. Agency theory suggests that, without supervision and proper incentives, managers are inclined to favor investment projects that enhance short-term business performance, avoiding high-risk, long-term, low-success-rate green innovation projects that benefit long-term value enhancement[10].

Confucian culture, as a profoundly influential informal institution, embeds long-standing values of "loyalty and trustworthiness" and "self-discipline" that subtly form moral constraints on corporate members. These values function as "implicit contracts" that restrict managerial self-interest, thereby improving corporate agency efficiency [11]. For instance, Confucius stated, "Without trustworthiness, a person cannot be established" (Analects, Wei Zheng), and "A Confucian does not treasure gold and jade but values loyalty and trustworthiness" (Book of Rites, Ruxing). Mencius remarked, "Benevolence, righteousness, loyalty, and trustworthiness are the heavenly duties," and Zengzi queried, "When engaged in a person's business, have I been loyal? When interacting with friends, have I been trustworthy?" (Analects, Xue Er). The Confucian idea of "loyalty and trustworthiness" emphasizes that a gentleman should focus on loyalty and righteousness rather than short-term self-interest, encouraging managers to prioritize the overall interests of the enterprise. Furthermore, the Confucian concepts of "self-restraint" and "self-discipline" are widespread, as illustrated by sayings like "A gentleman is cautious about his conduct when alone" (Book of Rites, Doctrine of the Mean) and "I examine myself thrice daily" (Analects, Xue Er), which all reflect a strict self-discipline and self-supervision ethos.

Under the influence of Confucian values such as diligence, impartiality, self-restraint, and self-discipline, corporate managers are more likely to consider the demands of all stakeholders, adhere to professional ethics, and develop a long-term strategic vision. This not only saves supervision and

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agency costs but also increases investment in green innovation projects, enhancing the overall economic, social, and environmental performance of the enterprise.

(2) Enhancing Corporate Social Responsibility Awareness

Secondly, from the perspective of social responsibility, the Confucian concept of "righteousness over profit" helps guide companies to actively assume social responsibilities and engage in innovation and research activities with higher sustainability and social benefits, thereby promoting corporate green innovation. The Confucian view on righteousness and profit aligns closely with corporate social responsibility (CSR) theories in many respects. For example, sayings such as "A gentleman understands righteousness, a petty person understands profit" (Analects, Li Ren), "A gentleman prioritizes righteousness" (Analects, Yang Huo), and "Wealth and rank obtained unrighteously are as fleeting as floating clouds to me" (Analects, Shu Er) reflect the Confucian value of prioritizing righteousness over profit, which, from a corporate perspective, emphasizes responsibility and contribution to consumers, society, and the environment. Confucius also stated, "Wealth and honor are what people desire; if they cannot be obtained in the proper way, they should not be held. Poverty and low status are what people detest; if they cannot be avoided in the proper way, they should not be avoided" (Analects, Li Ren), highlighting the principle that "a gentleman loves wealth, but takes it properly." This underscores the integration of righteousness and profit, which aligns with the modern expectation that companies fulfill social responsibilities while balancing economic and environmental benefits[12].

By fostering an intrinsic motivation, Confucian culture strengthens companies' willingness to assume social responsibilities, thus mitigating conflicts of interest between the company and stakeholders such as the government, shareholders, and consumers. It also encourages companies to engage in green research and development activities that benefit long-term high-quality social development. Existing research indicates that companies with high levels of social responsibility tend to establish a positive corporate image[13], which in turn facilitates green innovation through expanded financing channels and favorable policy conditions[14].

(3) Improving Corporate Environmental Cognition

Lastly, from the dimension of corporate cognition, the ecological philosophy of Confucianism can shape the green development values of corporate managers, effectively enhancing their environmental awareness and prompting them to engage in more efficient and green production practices to protect the ecological environment. The Confucian concept of "harmony between man and nature" elucidates the relationship between humans and nature, aligning with the contemporary idea of "harmonious coexistence between humans and nature" under the green development paradigm. Confucius stated, "The gentleman has three fears: fear of the mandate of Heaven, fear of great men, and fear of the words of the sages" (Analects, Ji Shi), advising people to revere nature. Building on this, Xunzi proposed "the cooperation between Heaven and man," suggesting that people can "organize the seasons, regulate all things, and benefit the world" (Xunzi, Wang Zhi), leveraging subjective initiative to achieve harmonious development. Therefore, this notion of "unity" is both a normative value pursuit and a practical endeavor.

Moreover, Confucianism, centered on the core ethic of "Ren" (benevolence), emphasizes "benevolence towards people and love for all creatures." Mencius's statement, "Being affectionate to one's kin leads to benevolence towards people, and benevolence towards people leads to love for all creatures" (Mencius, Jin Xin I), extends the object of "Ren" to include all natural things, embodying a compassionate and protective ecological philosophy.

From the perspective of resource utilization, Confucian ecological views advocate for sustainable practices such as "taking in due time and using with restraint." Confucius's saying, "Be economical in expenditures and love people; employ the people at the proper times," and Mencius's saying, "Axes and hatchets should enter the mountains only at the proper times," both emphasize exploring and

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adhering to natural laws to achieve environmentally friendly sustainable development. For enterprises, green innovation is the path to efficiently utilizing natural resources and enhancing environmental benefits. Under the broad influence of Confucian ecological thought, corporate managers are likely to abandon anthropocentric views and instead, guided by ecological wisdom that combines "regulation and protection," a cosmic concern for the coexistence and mutual prosperity of all things, and a sustainable development mindset, engage in green innovation activities. This internal force of Confucian culture is key to stimulating corporate environmental awareness and green innovation motivation.

Drawing from the theoretical analysis above, the moral values and ecological ethics inherent in the Confucian value system positively influence the willingness and level of corporate green innovation. Thus, this paper puts forward the following hypothesis:

Hypothesis: Confucian culture promotes corporate green innovation.

3. Research Design

3.1. Data Source and Sample Selection

This study uses data from Chinese A-share listed companies from 2007 to 2021. The data underwent the following filtering processes:

(1) Excluding ST and *ST companies.

(2) Excluding financial companies.

(3) Removing samples with missing values for key variables.

After these filters, the final sample consists of 23,261 observations. The data sources for this study are as follows: the core variable "Confucian Culture" was manually compiled, green patent data was collected and organized from the China National Intellectual Property Administration (CNIPA) patent database, and corporate financial and governance data primarily came from the CSMAR and Wind databases. To mitigate the influence of outliers, all continuous variables were winsorized at the 1% level.

3.2. Variable Definition and Measurement

3.2.1. Explanatory Variable: Confucian Culture

The explanatory variable in this study is Confucian Culture. Measuring it accurately is debated in academia. Some studies use surveys[15], but they face challenges in capturing its essence and large-scale data collection. Others use Hofstede's framework[16], focusing on collectivism/individualism and power distance, but this doesn't fully cover Confucian Culture's unique ecological and innovation aspects.

To address these limitations, this study follows methods used in existing research[17][18] by using historical information and a distance model. We use the number of Confucian academies within 100, 200, and 300 kilometers of a company's registered location as proxies for Confucian Culture. First, we manually compile the addresses and names of Confucian academies from sources like the "Chinese Academy Dictionary." Next, we obtain the latitude and longitude coordinates of these academies and listed companies using tools like Baidu Maps. Finally, we calculate the spatial distance between the academies and the companies' registered locations and count the number of academies within 100 (*Confu_100*), 200 (*Confu_200*), and 300 kilometers (*Confu_300*) radii. A higher *Confu* value indicates a greater influence of Confucian Culture. To ensure the observability of the coefficients, we standardized these indicators by adding 1 and taking the natural logarithm.

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3.2.2. Dependent Variable: Corporate Green Innovation

The dependent variable in this study is corporate green innovation, measured primarily by green technological innovation. Following the methodology of scholars like Kong Dongmin et al. [19], we use the number of annual green patent applications filed by companies as a proxy. First, we retrieve patent application data from China's State Intellectual Property Office. Then, we match this data with the International Green Patent Inventory (IPC classification) to identify the number of green patent applications filed by each company annually. This count is then transformed by adding 1 and taking the natural logarithm (*GreenPatent*). A higher number of green patent applications indicates more significant achievements in green technological innovation and a stronger capacity for green innovation.

3.2.3. Control Variables

Based on prior studies, this research incorporates several control variables: company size (*Size*, natural logarithm of total assets plus 1), financial leverage (*Lev*, total liabilities/total assets), company growth (*Growth*, revenue growth rate), return on assets (*Roa*, net profit/total assets), operating cash flow (*Cash*, net cash flow from operating activities/total assets), company age (*Age*, number of years since establishment), ownership concentration (*Top1*, shareholding ratio of the largest shareholder), board size (*Board*, natural logarithm of the number of directors plus 1), proportion of independent directors (Indratio, number of independent directors/total number of directors), CEO duality (*Dual*, 1 if the CEO also serves as the board chair; otherwise 0), and ownership nature (*Soe*, 0 for state-owned enterprises; otherwise 1). Additionally, the analysis also accounts for fixed effects related to industry (*Industry*) and year (*Year*).

3.3. Model Specification

To investigate the impact of Confucian culture on corporate green innovation, this study constructs the following econometric model:

$$Greeninno_{i,t} = \alpha_0 + \alpha_1 Confucian_{i,t} + Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (1)$$

Where *i* represents individual firms and *t* represents the year; *Greeninno* is the dependent variable indicating the level of green innovation for firm *i* in year *t*, measured by the natural logarithm of one plus the number of green patent applications for that year (*GreenPatent*). *Confucian* is the independent variable representing the intensity of Confucian cultural influence on firm *i* in year *t*, measured using *Confu_100*, *Confu_200*, and *Confu_300* as indicators. *Controls* refers to the set of control variables selected for this study; *Year* and *Industry* denote year fixed effects and industry fixed effects, respectively; and ε is the random disturbance term.

4. Empirical Results Analysis

4.1. Analysis of Baseline Regression Results

Table 1 reports the main regression results examining the impact of Confucian culture on corporate green innovation. Columns (1) to (3) present the results with only the core explanatory variables *Confu_100*, *Confu_200*, and *Confu_300*, respectively. Columns (4) to (6) include the control variables, while columns (7) to (9) further incorporate year and industry fixed effects.

After sequentially adding the control variables and the year and industry fixed effects, the regression coefficients for *Confu_100*, *Confu_200*, and *Confu_300* with *GreenPatent* are 0.066, 0.056, and 0.052, respectively, all of which are positively significant at the 1% level. These results indicate

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that the greater the influence of Confucian culture on a firm, the higher its green patent output, thus reflecting stronger green innovation capability.

As hypothesized, Confucian culture significantly promotes corporate green innovation by mitigating agency problems, guiding firms to undertake social responsibilities, and enhancing corporate environmental awareness. This supports the proposed research hypothesis.

Table 1: Baseline Regression Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	GreenPatent			*GreenPatent*			*GreenPatent*		
Confu_100	**0.055*** **			**0.066*** **			**0.066*** **		
	(11.519)			**(14.679)**			**(14.972)**		
Confu_200		**0.045*** **			**0.054*** **			**0.056*** **	
		(10.184)			**(13.202)**			**(13.730)**	
Confu_300			**0.042*** **			**0.049*** **			**0.052*** **
			(9.315)			**(12.020)**			**(12.731)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	No	No	No	Yes	Yes	Yes
Year	No	No	No	No	No	No	Yes	Yes	Yes
N	23,240	23,240	23,240	23,240	23,240	23,240	23,240	23,240	23,240
R2	0.0040	0.0030	0.0020	0.1680	0.1660	0.1650	0.3080	0.3060	0.3060

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The same notation applies to all subsequent tables.

4.2. Confucian Culture and Corporate Green Innovation: Examination of Channel Effects

Previous empirical findings suggest Confucian culture promotes corporate green innovation. This study explores its mechanisms through three channels:

(1) Ethical Thoughts: Confucian values like "loyalty" and "self-discipline" reduce management's self-serving behaviors, lowering agency costs and promoting green innovation.

(2) Social Responsibility: Confucian emphasis on righteousness encourages firms to take on social responsibilities, fostering sustainable research and development activities.

(3) Ecological Philosophy: Confucian ecological philosophy can raise managers' environmental awareness, prompting them to engage in more efficient green production through green innovation.

Using a mediation model, this paper tests these three possible channels.

First, examine the influence of Confucian Culture on corporate agency costs. Drawing from the studies by Ang et al.[20] and Dai Yiyi et al.[21], this paper uses the operating expense ratio (*Agc*) as an indicator to measure the agency costs of corporate managers. The operating expense ratio, calculated as the sum of administrative and selling expenses divided by operating income, can partially reflect the overconsumption behaviors of management. A higher operating expense ratio indicates higher agency costs between shareholders and management. Additionally, in Chinese enterprises with more concentrated ownership, another agency issue arises between the major and minor shareholders[22], where major shareholders might expropriate minority shareholders' interests. Following the measurement methods of Jiang Guohua and Yue Heng[23], this study employs the ratio of other receivables to total assets (*Tunnel*) as an indicator of this type of agency problem.

From the regression results in Table 2, it is evident that the regression coefficients of *Confu_100*, *Confu_200*, and *Confu_300* with *Agc* and *Tunnel* are all significantly negative at the 1% level. This indicates that Confucian ethical thoughts such as "loyalty and trust" and "self-discipline" indeed help to suppress the self-serving behaviors of executives and major shareholders, alleviate corporate

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agency problems, and improve agency efficiency, thereby promoting corporate green innovation. Thus, it can be concluded that the influence of Confucian culture on corporate green innovation is partially realized through the alleviation of agency problems.

Table 2: Confucian Culture and Corporate Agency Costs

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Agc			*Tunnel*		
Confu_100	**-0.008*** **			**-0.000** **		
	(-11.186)			**(-2.408)**		
Confu_200		**-0.009*** **			**-0.000*** **	
		(-12.715)			**(-3.284)**	
Confu_300			**-0.008*** **			**-0.001*** **
			(-12.060)			**(-3.551)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	23,068	23,068	23,068	23,068	23,068	23,068
R2	0.2630	0.2650	0.2640	0.1390	0.1400	0.1400

Secondly, examine the impact of Confucian culture on Corporate Social Responsibility (CSR). In line with stakeholder theory, actively engaging in social responsibility helps companies to build strong relationships with major stakeholders, thereby reducing their relationship maintenance costs. Consequently, measuring the extent to which companies meet the needs of multiple stakeholders has become the mainstream method in CSR quantitative research[24]. Following the approach of existing studies[25], this paper uses the Hexun Social Responsibility Score to measure the CSR performance of companies. This indicator evaluates listed companies' annual social responsibility and financial reports across five dimensions: shareholder responsibility, employee responsibility, suppliers, customer rights, environmental stewardship, and broader social obligations. These scores are then adjusted based on industry-specific weightings to obtain an accurate score, with higher total scores indicating better CSR performance.

As shown in Table 3, the regression coefficients for *Confu_100*, *Confu_200*, and *Confu_300* with *CSR* performance are all significantly positive at the 1% level. This indicates that Confucian culture indeed positively promotes companies' undertaking of social responsibilities, encouraging them to engage in more socially and ecologically beneficial innovative research and development, thereby enhancing their green innovation levels. Thus, it can be inferred that CSR performance plays an important mediating role in the impact of Confucian culture on corporate green innovation.

Table 3: Confucian Culture and Corporate Social Responsibility

Variable	(1)	(2)	(3)
		CSR	
Confu_100	**0.380*** **		
	(4.350)		
Confu_200		**0.334*** **	
		(3.996)	
Confu_300			**0.323*** **
			(3.839)
Controls	Yes	Yes	Yes

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Table 3: (continued).

Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	20,489	20,489	20,489
R2	0.3500	0.3500	0.3500

Lastly, we examine the impact of Confucian culture on corporate environmental awareness. According to upper echelons theory, corporate environmental awareness, particularly that of top executives, reflects their experiences, attitudes, and values[26], and can influence corporate willingness and actions towards green innovation. Companies with strong environmental awareness are more sensitive to potential market opportunities[27], pay more attention to stakeholder recognition and regulatory legitimacy requirements[28], and tend to proactively engage in green innovation to fulfill their resource and capability commitments. Referring to Duriau et al.'s[29] method of measuring executive cognition, we use the frequency of green-related terms (*Gn*) as an indicator of corporate environmental awareness. Specifically, we conduct a textual analysis of annual reports of listed companies, selecting relevant keywords such as "low-carbon environmental protection," "environmental protection department," "environmental governance," and "energy conservation and emission reduction" for word frequency statistics to measure the environmental awareness and green focus of management decisions in listed companies.

As shown in Table 4, the regression coefficients of *Confu_100*, *Confu_200*, and *Confu_300* with *Gn* are all significantly positive at the 1% level. This indicates that Confucian culture can indeed effectively enhance corporate environmental awareness by shaping the green development values of corporate executives, thereby promoting higher levels of green innovation and more efficient green economic activities. Thus, enhancing corporate environmental awareness is an important channel through which Confucian culture promotes corporate green innovation.

Table 4: Confucian Culture and Corporate Environmental Awareness

Variable	(1)	(2)	(3)
		Gn	
Confu_100	**0.110*** **		
	(31.124)		
Confu_200		**0.127*** **	
		(33.585)	
Confu_300			**0.119*** **
			(31.278)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	20,163	20,163	20,163
R2	0.4510	0.4630	0.4570

4.3. Endogeneity Test

This study may have potential endogeneity issues. To mitigate potential endogeneity issues arising from omitted variables and bidirectional causality, and to further enhance the reliability of the empirical results, this research uses the Propensity Score Matching (PSM) method and the Instrumental Variable (IV) approach for endogeneity tests.

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4.3.1. PSM Sample Test

This study utilizes the Propensity Score Matching (PSM) method to control for sample selection bias. Specifically, company size, financial leverage, company growth, return on assets, operating cash flow, company age, ownership balance, board size, proportion of independent directors, CEO duality, and ownership nature are used as characteristic variables for nearest neighbor matching. The regression results after matching are shown in Table 5. It can be observed that the regression coefficients of *Confu_100*, *Confu_200*, and *Confu_300* with *GreenPatent* remain positively significant at the 1% level, indicating that the previous conclusions still hold after controlling for omitted variable issues.

Table 5: PSM Test Results

Variable	(1)	(2)	(3)
	GreenPatent		
Confu_100	**0.071*** **		
	(12.163)		
Confu_200		**0.059*** **	
		(11.142)	
Confu_300			**0.054*** **
			(10.216)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	12,702	12,702	12,702
R2	0.3010	0.2990	0.2980

4.3.2. Instrumental Variable Test

During feudal times under the imperial examination system, mastery of Confucian classics was crucial for success. According to the "History of Chinese Printing," government-operated printing bureaus undertook most of the book printing and publishing during the Ming and Qing dynasties. This setup varied regionally, impacting scholar access and exam success. Scholars, carriers of Confucianism, reflect its influence through jinshi (successful candidates in the highest imperial examinations) density. Thus, the distance of a listed company's location from the Ming and Qing dynasty printing bureaus would strongly correlate with the concentration of jinshi and the intensity of Confucian cultural influence. While these bureaus are defunct, their historical proximity to firms doesn't relate to modern green innovation efforts.

Building on the preceding analysis, this study calculates the distance (log-transformed after adding 1) from each listed company's registration location to the ancient printing bureaus, as an instrumental variable (*Press*) for the intensity of Confucian cultural influence at the company's registration location. Table 6 reports the results of the instrumental variable regression using the two-stage least squares method. Columns (1) to (3) show the first-stage regression results. It can be observed that the regression coefficients of *Press* with *Confu_100*, *Confu_200*, and *Confu_300* are significantly positive at the 1% level, indicating a significant positive correlation between the distance to Ming and Qing printing bureaus and Confucian cultural influence. The F-statistics for the weak instrument test are 2364.62, 2704.71, and 2696.27, respectively, far exceeding the critical value, indicating no weak instrument problem and validating the effectiveness of the chosen instrument. Columns (4) to (6) show the second-stage regression results, revealing that the regression coefficients of *Confu_100*, *Confu_200*, and *Confu_300* remain significantly positive at the 1% level. Therefore, after controlling

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for potential endogeneity issues, Confucian culture still significantly promotes corporate green innovation, supporting the previous conclusions.

Table 6: Instrumental Variable Regression Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Confu_100	*Confu_200*	*Confu_300*	*GreenPatent*		
Press	**-0.138*** **	**-0.152*** **	**-0.150*** **			
	(-48.627)	**(-52.007)**	**(-51.926)**			
Confu_100				**0.172*** **		
				(10.009)		
Confu_200					**0.155*** **	
					(10.007)	
Confu_300						**0.158*** **
						(9.995)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	22,747	22,747	22,747	22,747	22,747	22,747
R2	0.1530	0.1560	0.1480	0.2950	0.2950	0.2930

5. Extension Study: Heterogeneity Test

5.1. Nature of Enterprise Ownership

During China's "emerging and transitioning" period, its unique property rights system leads to distinct management characteristics in state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). SOEs often experience monopolistic conditions and non-market-oriented executive promotions, resulting in severe owner absenteeism and principal-agent issues[30], affecting management quality and innovation efficiency. Green innovation, with its significant externalities, high risk, and long investment cycles, may be less prioritized in SOEs due to their political functions, reducing investments in uncertain green projects[31]. Thus, the influence of Confucian culture on green innovation in SOEs may be weakened by political functions and agency costs, while non-SOEs have greater incentives to achieve differentiated value and competitiveness through green innovation. To explore this, the paper introduces an interaction term between Confucian culture and ownership nature in the model. Regression results in Table 7 show that the interaction terms *Soe×Confu_100*, *Soe×Confu_200*, and *Soe×Confu_300* are significantly positively correlated with GreenPatent at the 1% level or higher. These findings, consistent with Liu Shiyuan et al.[32], indicate that Confucian culture's promotion of green innovation is more evident in non-SOEs and relatively limited in SOEs.

Table 7: Analysis Based on Ownership Nature

Variable	(1)	(2)	(3)
	GreenPatent		
Confu_100	0.067***		
	(13.668)		
Soe×Confu_100	**0.023*** **		
	(6.461)		
Confu_200		0.056***	

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Table 7: (continued).

		(12.418)	
Soe×Confu_200		**0.017*** **	
		(5.833)	
Confu_300			0.054***
			(11.643)
Soe×Confu_300			**0.014*** **
			(5.393)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	20,163	20,163	20,163
R2	0.3080	0.3070	0.3070

5.2. Executives' Environmental Background

In line with upper echelons theory, an executive's long-term experience in a particular field leads to selective perception, influencing decision-making based on cognitive preferences. Executives with backgrounds in environmental fields tend to prioritize environmental issues, seize green development opportunities, and assume corporate environmental responsibilities, integrating these into strategic decisions and promoting green innovation. Thus, it can be predicted that the positive influence of Confucian culture on corporate green innovation might be enhanced by executives' environmental backgrounds.

To measure executives' environmental backgrounds, this study uses the methodology of previous research[33], manually collecting resumes of executives from listed companies (2000-2022) and using text analysis to identify environmental keywords. If a resume contains terms like "environment," "environmental protection," "clean energy," "ecology," "low carbon," "sustainability," "energy saving," or "green," the executive is considered to have an environmental background. The study counts the number of such executives in each company, resulting in two indicators: whether the company employs executives with an environmental background (*EP*) and the proportion of such executives (*EPratio*).

The study introduces interaction terms between Confucian culture and executives' environmental backgrounds into the baseline model. Regression results, shown in Table 8, indicate that the interaction terms *EP×Confu_100*, *EP×Confu_200*, *EP×Confu_300*, and *EPratio×Confu_100*, *EPratio×Confu_200*, *EPratio×Confu_300* are significantly positively correlated with *GreenPatent* at the 1% level. This demonstrates that employing executives with an environmental background enhances the positive effect of Confucian culture on corporate green innovation, with a higher proportion of such executives further amplifying this effect. The results suggest that executives with an environmental background integrate their expertise into corporate decisions, focusing on sustainability and promoting green innovation.

Table 8: Analysis Based on Executives' Environmental Background

Variable	*Regression of EP Indicator*			*Regression of EPratio Indicator*		
	(1)	(2)	(3)	(4)	(5)	(6)
	GreenPatent			*GreenPatent*		
Confu_100	0.070***					
	(14.143)					

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Table 8: (continued).

EP×Confu_100	**0.098*** (16.450)**					
EPratio×Confu_100				**0.219*** (21.020)**		
Confu_200		0.059*** (12.899)				
EP×Confu_200		**0.079*** (16.331)**				
EPratio×Confu_200					**0.177*** (20.992)**	
Confu_300			0.056*** (12.038)			
EP×Confu_300			**0.071*** (16.289)**			
EPratio×Confu_300						**0.160*** (20.962)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	20,163	20,163	20,163	20,161	20,161	20,161
R2	0.3190	0.3190	0.3190	0.3280	0.3280	0.3280

5.3. Intensity of Environmental Regulation

Environmental regulation refers to government policies or measures aimed at environmental protection. The Porter Hypothesis suggests that well-crafted and strictly enforced environmental regulations tend to incentivize corporate innovation[34]. As a formal institution, environmental regulation significantly influences corporate behavior and decision-making, encouraging green research and innovation to meet regulatory requirements and enhance competitiveness. Confucian culture, an informal institution, may interact with environmental regulations, forming either a competitive substitution or a mutually complementary relationship.

Drawing on existing research[35], this study uses the proportion of environment-related word frequencies in municipal government work reports (*Gnlaw*) as a proxy for the intensity of environmental governance by municipal governments. Text analysis counts the occurrences of terms like "environmental protection," "emission reduction," "green," "ecology," "low carbon," "energy consumption," and "PM2.5" in these reports, calculating their proportion relative to the total word count. A higher proportion indicates stronger local environmental regulation.

Regression results in Table 9 show that the interaction terms *Gnlaw×Confu_100*, *Gnlaw×Confu_200*, and *Gnlaw×Confu_300* with *GreenPatent* are significantly positive at the 1% level. This indicates that as environmental regulation intensity increases, the positive effect of Confucian culture on corporate green innovation is enhanced, suggesting that environmental regulation strengthens the innovation compensation effect of Confucian culture. This conclusion provides empirical evidence for the complementary and synergistic relationship between informal and formal institutions.

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Table 9: Analysis Based on Intensity of Environmental Regulation

Variable	(1)	(2)	(3)
	GreenPatent		
Confu_100	0.070***		
	(14.143)		
Gnlaw×Confu_100	**8.855*** **		
	(9.425)		
Confu_200		0.059***	
		(12.899)	
Gnlaw×Confu_200		**6.379*** **	
		(8.017)	
Confu_300			0.056***
			(12.038)
Gnlaw×Confu_300			**5.295*** **
			(7.130)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	19,119	19,119	19,119
R2	0.3150	0.3140	0.3130

6. Research Conclusions and Implications

6.1. Research Conclusions

In China's shift toward high-quality development, green innovation is key to building an environmentally friendly economy. This paper examines the impact of Confucian culture on corporate green innovation using data from China's A-share listed companies (2007-2021). Empirical results show that Confucian culture significantly promotes green innovation, with stronger cultural influence correlating with higher green patent output. This finding is robust across various tests. Confucian culture influences green innovation through three main mechanisms: reducing agency costs, enhancing corporate social responsibility, and increasing environmental awareness.

Heterogeneity tests reveal that this effect is more pronounced in non-state-owned enterprises. Companies with executives who have environmental background also tend to drive green innovation, with a greater proportion of such executives amplifying the effect. Additionally, the study finds that Confucian culture and environmental regulation complement each other in promoting green innovation. As environmental regulation intensity increases, the positive influence of Confucian culture on green innovation is strengthened, highlighting the role of regulation in enhancing the cultural impact.

6.2. Implications and Recommendations

The conclusions of this research have important implications.

On the theoretical level, this study examines the drivers of corporate green innovation through the lens of informal institutions, a perspective relatively neglected in existing research. It investigates the impact of Confucian culture on the economic behavior of enterprises, the microeconomic agents, and through mechanism analysis, links external cultural factors to internal factors such as corporate governance, corporate social responsibility, and corporate ethos. Through empirical testing, it robustly explains the motivation for green innovation under dual externalities. Furthermore, this study

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expands the understanding of the economic implications of Confucian culture by examining the positive impact and underlying mechanisms of Confucian culture's basic connotations, management concepts, and ecological philosophy on environmental economics. It corrects the negative cognitive bias held by some scholars towards Confucian culture, providing theoretical support for further promoting Chinese traditional culture and enhancing cultural confidence. In the context of modern transformation guided by new development concepts and aimed at high-quality development, this study further demonstrates the enduring value and vigorous vitality of Confucian culture.

On the practical level, the conclusions provide empirical evidence supporting Confucian culture's positive promotion of corporate green innovation, thereby enlightening corporate managers to integrate Confucian cultural wisdom and economic ethics into modern corporate governance practices. On the basis of deeply learning, exploring, and transmitting the core of Confucian culture, enterprises can consciously form a scientific governance system, a high degree of social responsibility, and deep environmental awareness. They should also actively comply with environmental regulations, focus on cultivating managers' environmental concepts, continuously enhance green innovation capabilities, and gradually establish a long-term governance mechanism of "managing enterprises with Confucianism."

In terms of policy recommendations, based on the complementary and synergistic effects of informal and formal institutions, the conclusions of this study provide insights for relevant government departments on how to effectively guide enterprises to focus on environmental governance and accelerate green transformation. While further improving environmental regulations and policies, attention should also be paid to leveraging the intrinsic educational role of informal institutions such as Confucian culture. Continuous promotion and popularization of Confucian culture and green development concepts should be pursued, along with targeted assistance to help enterprises overcome technological or resource bottlenecks in green innovation, making green innovation a voluntary and conscious pursuit for more enterprises.

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