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Managerial Discretion and Corporate Green Innovation: An Inverted U-Shaped Relationship under Non-Uniform Density

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Abstract

As the central actors in corporate strategy formulation and resource allocation, managers exert a profound influence on a company's green development. Against the backdrop of China's policy-driven push for corporate green transformation, this study examines the impact of managerial discretion on corporate green innovation and its underlying mechanisms. Drawing on a sample of Chinese A-share listed companies from 2014 to 2023, the analysis integrates agency theory and stewardship theory, focusing on the formal authority granted to Chief Executive Officer by their boards of directors. Empirical results indicate that managerial discretion exhibits an inverted U-shaped relationship with corporate green innovation: moderate power stimulates stewardship behavior among managers, thereby promoting green innovation, whereas excessive power induces agency problems, which in turn exerts a suppressing effect. Mechanism analysis reveals that R&D investment serves as a key transmission channel and itself exhibits an inverted U-shaped relationship with green innovation. Heterogeneity analysis reveals that this effect is more pronounced in state-owned enterprises and under conditions of high environmental uncertainty. Therefore, firms should reasonably delegate authority to management and actively establish monitoring mechanisms for green R&D investment thresholds to precisely enhance green innovation capabilities.

Keywords: *Managerial Discretion; R&D Expenditures; Corporate Green Innovation*

Introduction

Against the backdrop of the global response to climate change and increasingly scarce resources, green development has become a key pathway to driving sustainable economic growth and achieving harmony between humanity and nature. In recent years, China's policy framework for corporate green development has been continuously refined, with the government successively issuing a series of targeted policy documents. The 2024 "Opinions on Accelerating the Comprehensive Green Transformation of

Economic and Social Development" explicitly states that promoting the greening and decarbonization of economic and social development is a significant hallmark of the Party's governance practices in the new era, a crucial step toward achieving high-quality development, and a fundamental strategy for addressing China's resource, environmental, and ecological challenges. These policies fully demonstrate the state's firm resolve to advance corporate green development.

As the primary actors in economic activity, enterprises are situated within this wave of policies, yet their performance in green innovation shows significant divergence. Behind this divergence, aside from external factors such as industry-specific technological barriers and the intensity of policy enforcement, the core contradiction lies in the following: when policy signals are transmitted to the internal levels of an enterprise, who determines the allocation of innovation resources? Within the corporate decision-making system, managers, as the central actors in strategy formulation and resource allocation, exert a decisive influence on the direction of innovation through the boundaries and manner of exercising their authority. Managerial discretion—the autonomy granted by the board of directors to make independent decisions—directly impacts the quality of green innovation strategy implementation. Existing research has largely focused on the influence of managers' informal power. Therefore, examining the impact of managerial discretion on corporate green innovation from the perspective of the CEO（Chief Executive Officer)'s formal power holds significant practical significance.

The drivers of green innovation have long been a focal point in academia. Existing research is primarily divided into three categories [1][2]. At the policy level, these include government subsidies, environmental inspections, and emission reduction plans [3][4][5]; at the market level, they encompass carbon emissions trading markets [6] and environmental rights trading markets [7]; simultaneously, corporate factors, such as corporate governance models [8] and the sophistication of environmental management systems [9], have also been shown to exert a profound influence on green innovation activities. Existing research examines, at the macro level, how relevant policies unlock institutional dividends to drive corporate green development and stimulate green innovation; at the micro level, it focuses on firm-level variables to explore the mechanisms through which they influence green innovation. However, whether it is the conversion of policy dividends or the activation of internal structures, both ultimately depend on managers' strategic judgment and decision-making execution. Existing research has paid insufficient attention to the proactive role of managers—the core decision-makers within firms—in green innovation.

In fact, there has long been a divergence in the academic community regarding the impact of leaders on organizational outcomes. Demographic ecology and new institutional theory argue that, due to external forces and norms, leaders have very little influence on organizational outcomes. In contrast, top-level theory emphasizes that the experience, values, and personality of leadership influence organizational activities through strategic choices [10]. To reconcile this contradiction, the top-down theory introduces the concept of managerial discretion—that is, the influence of leaders on organizational outcomes depends on the extent of their managerial discretion. Managerial discretion reflects the CEO's control over the entire enterprise and exerts a significant influence on corporate strategic choices and operational decisions; its magnitude directly impacts the efficiency of corporate investment [11]. As the formulators, participants, and implementers of corporate investment decisions, corporate management plays a crucial role in corporate green innovation. Drawing on sociological theories of power classification, existing literature divides a CEO's power into formal and informal categories. Formal power consists of statutory authority conferred by position; it is coercive and normative, relying on organizational hierarchy and institutional safeguards. Informal power is influenced by personal traits, professional competence, reputation, or interpersonal relationships and represents the CEO's personal, implicit power.

In recent years, most scholars have focused on the perspective of informal power, examining the impact of CEO gender, age, overseas experience, educational background, and professional experience

[12][13][14] on corporate value. However, there remains a significant gap in research regarding the statutory power granted to CEOs by the board of directors, and even fewer scholars have investigated the impact of formal power on green innovation. Some scholars, drawing on agency theory, argue that CEOs may act to pursue personal gain, thereby creating agency problems that hinder the promotion of corporate green innovation [15]. However, according to stewardship theory, the discretionary power held by CEOs allows them to leverage their informational advantages and enhance decision-making autonomy, thereby improving corporate investment efficiency. Does the relationship between managerial discretion and corporate green innovation, then, amount to a simple linear relationship?

In summary, this paper adopts a perspective centered on the formal power granted to CEOs by the board of directors, integrating insights from agency theory and stewardship theory. Using a sample of Chinese A-share listed companies from 2014 to 2023, it analyzes the impact and mechanisms of managerial discretion on corporate green innovation and explores the heterogeneous effects of managerial discretion on green innovation under different scenarios.

The main contributions of this paper are as follows: Starting from the position-based power of the CEO, it enriches and expands the existing research on corporate green innovation. It challenges the assumption of a linear relationship and reveals an inverted "U"-shaped relationship between managerial discretion and corporate green innovation. At the same time, it provides insights for companies seeking to enhance green innovation by granting reasonable authority to management. Regarding the inverted "U"-shaped relationship between R&D investment and green innovation, it warns companies of the need to establish a threshold monitoring mechanism for green R&D investment.

Theoretical Analysis and Research Hypotheses

Managerial discretion refers to the scope of authority granted by the board of directors that allows managers to independently allocate corporate resources and select decision-making options when formulating corporate strategic decisions. Corporate green innovation differs from traditional technological innovation in many respects; it is characterized by high investment, long cycles, and strong externalities, requiring long-term resource support from the enterprise. The relationship between the two can be analyzed based on agency theory and stewardship theory.

When managerial discretion is at a low level, managers face greater constraints and limitations when making decisions [16]. The CEO's stewardship behavior is restricted, and multiple constraints make it difficult for them to autonomously adjust resource allocation plans. Insufficient resource allocation capabilities prevent them from consistently supporting the R&D of green innovation, which is characterized by long cycles and slow returns. In particular, if green innovation activities do not generate new net returns, management typically underinvests [17]. At the same time, the CEO's strategic proposals must undergo multi-level approvals, making it easy to miss the window of opportunity for green technology iteration and policy dividends. Green innovation also faces technological and market uncertainties. Since companies are profit-driven and CEOs are accountable for short-term performance, green innovation may trap enterprises in a dilemma of "high investment, slow returns, and strained cash flow." In such situations, managers tend to avoid these high-risk decisions, thereby stifling green innovation. Therefore, companies should appropriately increase the CEO's authority to activate and empower their stewardship spirit.

As managerial discretion increases, the authority granted by the board provides the CEO with the space to "exercise their full potential" and satisfy their stewardship needs, while remaining subject to oversight and constraints, effectively mitigating agency problems. In this scenario, the CEO's scope for autonomous decision-making expands; they possess the authority to mobilize the company's unutilized surplus resources and have the capacity to provide a solid R&D foundation for green innovation. This, in

turn, enhances long-term value, such as improving the company's ESG ratings. Furthermore, from a behavioral perspective grounded in organizational theory, corporate CEOs are not always self-serving agents. Driven by their own sense of dignity, beliefs, and need for self-fulfillment, they work diligently to align their personal goals with the company's long-term interests, effectively serving as "stewards" [18]. Executive equity incentives help them overcome risk-averse tendencies and promote corporate risk-taking [19]. Board-delegated authority boosts their confidence and similarly enhances their capacity for risk-taking. In such cases, they will assess the risks and returns of green innovation more rationally. Moderate discretionary authority will also grant the CEO cross-departmental coordination capabilities, enabling the promotion of collaborative participation in green innovation across departments such as production, R&D, and supply chain.

When managers possess excessive discretionary authority, their decisions may no longer be subject to effective oversight. An increased power gap between the CEO and other executives strengthens the CEO's sense of control over the company, leading to overconfidence in their own abilities and decisions, and thereby placing them in an irrational "steward" state. Due to the cognitive bias of overconfidence, managers are highly prone to underestimating investment risks and overestimating investment returns [20]. A CEO with greater power tends to adopt a more optimistic outlook on risk, diminishing concerns about negative outcomes of R&D decisions while increasing focus on potential returns, ultimately leading the CEO to allocate more resources to R&D [21]. When discretionary power becomes sufficient to bypass oversight, the agent-principal nature of managers is unleashed. Their core objective in exercising power shifts from maximizing corporate value to maximizing personal interests, diverting funds originally intended for green R&D into low-risk, short-term, non-green areas. At this point, the CEO may still view himself as a "steward," but the entity he serves has already been transformed from the corporate entity into a personal empire. Managers also tend to adopt aggressive strategies, pouring substantial resources into vanity projects designed to bolster their personal reputations, which leads to resource waste and hinders corporate green innovation.

Based on this, this paper proposes the following hypothesis:

H1: As managerial discretion increases, corporate green innovation first rises and then declines, exhibiting an inverted "U"-shaped relationship.

H2: Managerial discretion exerts a nonlinear influence on corporate green innovation—first promoting and then inhibiting it—by stimulating R&D investment; that is, R&D investment serves as a mediating mechanism.

Research Design

Data Notes

This study uses Chinese A-share listed companies from 2014 to 2023 as the research sample and processes the data as follows: 1. Companies classified as ST or ST* during the sample period were excluded. 2. Companies in the financial and real estate sectors were excluded. 3. Samples with abnormal or missing data were excluded. 4. For continuous variables, the data were trimmed at the 1st and 99th percentiles to eliminate the influence of outliers. This resulted in a final sample of 29,747 valid observations. All data used in this study were sourced from the Guotai-An database and the CNRDS database.

Model Building

To examine the impact of managerial discretion on corporate green innovation, we construct Model (1):

$$lngreen_{i,t} = \beta_0 + \beta_1 CEO_{DC_{i,t}} + \beta_2 CEO_{2_{i,t}} + \beta_3 Cs + \sum YearDum + \sum IndustryDum + \varepsilon_{i,t}$$

Variable Description

Corporate Green Innovation (*lngreen*). Following the approach of Li Wenjing and Zheng Manni [22], this paper defines the measurement of green innovation as follows: First, the number of green invention patent applications and the number of green utility model patent applications are aggregated to obtain the total volume of green innovation, denoted as green. To address the right-skewed distribution of green patent application data, green is incremented by 1, and the natural logarithm of the result is taken to obtain *lngreen*.

Managerial Discretion (*CEO_DC*). Drawing on the approach of Chen Zhibin and Wang Guanzhen [23], and based on higher-order theory, we select four aspects—the largest shareholder's equity stake, the combination of executive and supervisory roles, the CEO's equity stake, and the CEO's compensation—to comprehensively measure this metric. ①The higher the largest shareholder's equity ratio, the greater the concentration of equity, and the smaller the managerial discretion. Therefore, a reverse indicator is used: if the largest shareholder's equity ratio exceeds the industry average, the value is set to 0; otherwise, it is set to 1. ②The dual role of CEO and chairman implies that the CEO's authority within the management team increases, as does their discretionary power. If the CEO serves as chairman, the value is 1; otherwise, it is 0. ③CEO shareholding means that, as a shareholder, the CEO has greater influence on the board and, consequently, greater discretionary power. If the CEO holds company shares, the value is 1; otherwise, it is 0. ④Research indicates that the higher a manager's compensation, the stronger their control over the firm. Therefore, when the CEO's compensation exceeds the industry average, the value is set to 1; otherwise, it is set to 0. Following Ke Dongchang et al. [21], principal component analysis is applied to the above four dummy variables to comprehensively measure managerial discretion, yielding *CEO_DC*, whose squared term is *CEO_2*.

Control variables (*Cs*). To control for other economic indicators that may influence a firm's green innovation, following the approach in existing literature, this study selects the following control variables: firm growth (*growth*), debt-to-asset ratio (*lev*), whether the firm is loss-making (*loss*), profitability (*roa*), firm size (*ln_size*), firm value (*TbQA*), and years since listing (*age*). This study also controls for year-specific and industry-specific fixed effects. The specific measurement methods for the control variables are shown in Table 1 [24][7].

Table 1: Definitions of Control Variables

Variable symbol	Measurement methods
growth	Company Revenue Growth Rate
lev	Total Liabilities / Total Assets
loss	Dummy variable: 1 if the company reported a loss in the current year, 0 otherwise
roa	Net Profit / Total Assets
ln_size	Logarithm of Total Assets
TbQA	Company Tobin's Q Ratio
age	Number of years since the company's initial public offering

Empirical Findings and Analysis

Descriptive Statistical Analysis

Table 2 shows that the mean value of corporate green innovation is 0.876, with a standard deviation of 1.147. The median is 0.000. Similar to the findings of Wang Xin et al. [24], more than half of the enterprises had a total of zero green innovation applications, indicating that Chinese enterprises generally lack green innovation capabilities. The median value for managerial discretion is 0.409, and the mean is 0.400; the difference between the two is negligible, indicating a relatively uniform distribution. Overall, managerial discretion is at a moderate level. According to Table 3, the variance inflation factors (VIFs) for all variables are well below 10, with a mean VIF of 1.54, suggesting weak correlations among the variables.

Table 2: Descriptive Statistics

Variable	Sample Size	Mean	Standard Deviation	Median	Minimum	Maximum
lngreen	29747	0.876	1.147	0.000	0.000	4.554
CEO_DC	29747	0.400	0.295	0.409	0.000	1.000
growth	29747	0.288	0.714	0.115	-0.724	4.610
lev	29747	0.398	0.203	0.383	0.054	0.933
loss	29747	0.867	0.339	1.000	0.000	1.000
ln_size	29747	22.104	1.249	21.932	16.412	28.341
roa	29747	0.035	0.071	0.039	-0.319	0.199
TbQA	29747	2.098	1.364	1.661	0.846	8.898
age	29747	9.446	8.044	7.000	0.000	33.000

Table 3: Multicollinearity Test

Variable	VIF value	Tolerance（1/VIF）
CEO_DC	1.06	0.941
growth	1.01	0.989
lev	1.56	0.639
loss	2.02	0.495
ln_size	1.76	0.568
roa	2.33	0.429
TbQA	1.24	0.808
age	1.36	0.732
VIF Mean	1.54	----

Results of the Regression Analysis

Table 4 presents the regression results regarding the relationship between managerial discretion and corporate green innovation. Column (1) shows a positive linear relationship between managerial discretion and corporate green innovation, indicating that CEOs of listed companies in China tend to assume the role of a “steward,” aligning their personal interests with the long-term interests of the firm. Based on descriptive analysis, managerial discretion in Chinese listed companies is evenly distributed and at a moderate level; therefore, the positive relationship between the two exists in most firms. Column (2) examines the relationship under nonlinear conditions: the coefficient of the quadratic term *CEO_2* is negative at −0.1769, while the coefficient of the linear term *CEO_DC* is positive at 0.2025, and both are significant at the 1% level. This indicates that the relationship between managerial discretion and corporate green innovation follows an inverted “U” shape rather than a simple linear relationship, confirming Hypothesis 1. Further analysis reveals that when managerial discretion is less than 0.5724, it has a positive effect on corporate green innovation; when managerial discretion exceeds 0.5724, it has a negative effect on corporate green innovation.

Table 4: Managerial Discretion and Corporate Green Innovation

Variable	(1)	(2)
	lngreen	*lngreen*
CEO_DC	0.0405**	0.2025***
	(2.13)	(3.39)
CEO_2		-0.1769***
		(-2.86)
growth	0.0775***	0.0775***
	(9.67)	(9.68)
lev	0.2348***	0.2343***
	(7.18)	(7.17)
loss	0.0506**	0.0510**
	(2.25)	(2.27)
ln_size	0.4569***	0.4571***
	(69.76)	(69.81)
roa	-0.0737	-0.0746
	(-0.67)	(-0.68)
TbQA	0.0358***	0.0359***
	(8.02)	(8.06)
age	-0.0019**	-0.0018**
	(-2.31)	(-2.22)
_cons	-9.4536***	-9.4807***
	(-66.97)	(-67.00)
YearDum	Yes	Yes
IndustryDum	Yes	Yes
Adjusted R^2	0.3660	0.3648
N	29747	29747

Note: The t-values in parentheses are robust standard errors; the same applies below. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

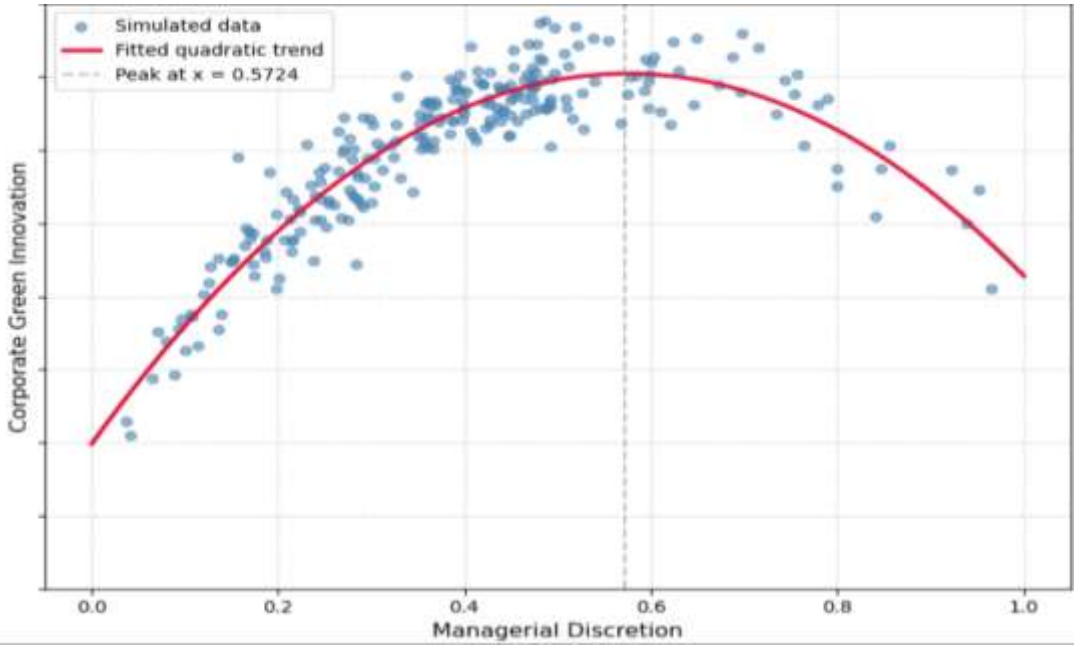

Figure 1 Managerial Discretion and Corporate Green Innovation

Stability testing

Replace the dependent variable. Following the approach of Wang Junqiu et al. [25], we replace the existing dependent variable with the natural logarithm of the total number of green patent grants plus one (*lngreen2*). The regression results are shown in Table 5, column (1). The coefficient of the quadratic term *CEO_2* for managerial discretion is negative at -0.1595, while the coefficient of the linear term *CEO_DC* is positive at 0.1766; both are significant at the 1% level.

Eliminating the interference of relevant policies. Following the approach of Hu Jie et al. [26], and considering that the statistical standards for patent applications changed in 2017, we excluded the 2017 green innovation data and reran the regression. To avoid the impact of the implementation of the "Opinions on Fully, Accurately, and Comprehensively Implementing the New Development Philosophy and Effectively Carrying Out Work on Carbon Peaking and Carbon Neutrality" issued in March 2021, we narrowed the study sample period and re-tested the model using data from before 2021. The regression results are shown in Table 5, columns (2) and (3). The coefficients of the quadratic term *CEO_2* are −0.1780 and −0.1726, respectively, while the coefficients of the linear terms are 0.1873 and 0.2618, respectively. Both regressions are significant at the 1% and 5% levels, proving that Hypothesis 1 remains valid after excluding the interference of relevant policies.

Changing the regression method. Since the corporate green innovation variable exhibits left-censoring at zero, this study further employs the Tobit regression method to conduct robustness tests. The results are shown in Table 5, columns (4): the coefficient of the quadratic term *CEO_2* is −0.2818, and the coefficient of the linear term is 0.2898, both significant at the 5% level, further validating the robustness of the main regression conclusions.

Table 5: Robustness Test I

Variable	(1)	(2)	(3)	(4)
	lngreen2	*lngreen*	*lngreen*	*lngreen*
CEO_DC	0.1766***	0.1873***	0.2618***	0.2898***
	(3.32)	(3.00)	(3.36)	(2.58)
CEO_2	-0.1595***	-0.1780***	-0.1726**	-0.2818**
	(-2.92)	(-2.76)	(-2.10)	(-2.42)
IndustryDum	Yes	Yes	Yes	Yes
YearDum	Yes	Yes	Yes	Yes
Adjusted R^2	0.3561	0.3660	0.3597	-
N	29747	27202	17482	29747

Note: The control variables here are identical to those in the main regression; they have been omitted for brevity, and the same applies below.

Further controlling for the effects of the CEO and other characteristics. Consistent with existing research, factors such as the gender, age, and academic background of executives [12] [13][14] not only influence a firm's green innovation but may also lead to omitted variable bias in the regression model by affecting the actual exercise of CEO discretion. Therefore, building upon the control variables already included in Model (1), we further control for CEO age (*Age*), CEO gender (*Gender*), CEO educational attainment (*Degree*), and board size (*Boardsize*). As shown in Table 6, after controlling for variables related to the CEO's personal characteristics, the coefficient of the quadratic term *CEO_2* is negative at −0.1512, while the coefficient of the linear term *CEO_DC* is positive at 0.1696; both are significant at the 5% level, further validating the inverted "U"-shaped relationship between managerial discretion and corporate green innovation.

Table 6: Robustness Tests II

Variable	*lngreen*
CEO_DC	0.1696**
	(2.36)
CEO_2	-0.1512**
	(-2.08)
Age	0.0003
	(0.37)
Degree	0.0248***
	(5.05)
Gender	0.0563**
	(2.50)
Boardsize	0.0149***
	(3.35)
IndustryDum	Yes
YearDum	Yes
Adjusted R^2	0.3546
N	21733

Further Analysis

Mechanism Analysis

Based on the theoretical derivations presented above, this study posits that R&D investment serves as a mechanism through which managerial discretion influences corporate green innovation. Drawing on the approach of scholars such as Wen Zhonglin and others, and incorporating the model (1) presented above, we construct the following regression model (2) and (3):

$$RD_{i,t} = \alpha_0 + \alpha_1 CEO\_DC_{i,t} + \alpha_2 CEO\_2_{i,t} + \alpha_3 Cs + \sum YearDum + \sum IndustryDum + \varepsilon 2_{i,t}$$

$$lngreen_{i,t} = \gamma_0 + \gamma_1 CEO\_DC_{i,t} + \gamma_2 CEO\_2_{i,t} + \gamma_3 RD_{i,t} + \gamma_4 RD\_2_{i,t} + \gamma_5 Cs + \sum IndustryDum + \varepsilon 2_{i,t}$$

Here, $RD_{i,t}$ represents firm i's R&D expenditure in year t, measured as R&D expenditure divided by operating revenue, and $RD\_2_{i,t}$ represents the squared term of R&D expenditure. The remaining variables are the same as in Model (1). Additionally, to ensure the robustness of the results, the test results were subjected to 1,000 Bootstrap resampling tests.

As shown in Table 7, the coefficient of *CEO_DC* in Column (2) is positive at 1.5071 and is significant at the 1% level, indicating that as managerial discretion increases, corporate R&D investment also increases. This suggests that CEOs have greater control over resources, thereby supporting the long-term development of corporate green innovation. Furthermore, when examining whether there is an inverted U-shaped relationship between R&D investment and corporate green innovation, the coefficient of the quadratic term *RD_2* is not significant. Therefore, R&D investment and corporate green innovation exhibit a positive linear relationship. As shown in Column (3), after incorporating R&D investment as a mediating mechanism, the coefficient of the quadratic term of managerial discretion (*CEO_2*) is negative 0.1491 and is significant at the 5% level. Its absolute value is smaller than that of the *CEO_2* coefficient in the main effects column (1), indicating that R&D investment plays a partial mediating role. In Column (3), the coefficient of the quadratic term *RD_2* for R&D investment is -0.0022, while the coefficient of the linear term RD is 0.0857. This confirms an inverted U-shaped relationship between R&D investment and corporate green innovation: within a certain range, R&D investment is positively correlated with green innovation; however, beyond this range, managers' overconfidence and risk-ignoring investments may inhibit green innovation. This validates Hypothesis 2: managerial discretion achieves an inverted U-shaped relationship with corporate green innovation by promoting R&D investment.

In 1,000 Bootstrap sample tests, as shown in Table 8, the 95% confidence interval for the indirect effect does not cross zero, and the P-value is significant. This further confirms the significance of the indirect effect: "managerial discretion → R&D investment → corporate green innovation."

Table 7: Mechanism Verification

Variable	(1)	(2)	(3)
	lngreen	*RD*	*lngreen*
CEO_DC	0.1063***	1.5071***	0.1349**
	(2.97)	(15.49)	(2.16)
CEO_2	-0.1671***		-0.1491**
	(-2.58)		(-2.34)
RD			0.0857***
			(26.27)
RD_2			-0.0022***
			(-22.04)
IndustryDum	Yes	Yes	Yes
YearDum	Yes	Yes	Yes
Adjusted R^2	0.3817	0.4228	0.3978
N	26954	26954	26954

Table 8: Bootstrap Sampling Test

	coefficient	coefficient	Z	P	95% confidence interval	
Indirect effects	-0.0868	0.0162	-5.36	0.000	-0.1186	-0.0550
Direct effect	-0.1317	0.0666	-1.98	0.048	-0.2623	-0.0010

Heterogeneity Analysis

The findings of the baseline regression analysis demonstrate an inverted U-shaped relationship between managerial discretion and corporate green innovation. We will now further examine under what circumstances this relationship is more pronounced.

Firms with different ownership structures may play distinct roles in high-quality development and green innovation [27]. Compared with private enterprises, state-owned enterprises exhibit a stronger willingness to innovate in green technologies, greater depth and breadth of innovation, and a longer cumulative history of engagement in green technology innovation [28]. Therefore, this study argues that firm characteristics should be incorporated into the analysis to further examine the impact of managerial discretion on corporate green innovation. Using state ownership as the classification criterion, the full sample was divided into two groups for separate regression tests, with the results presented in Table 9. In Column (1) (the state-owned enterprise group), the coefficient of the quadratic term of managerial discretion is negative at 0.8341 and is significant at the 1% level, whereas in Column (2) (the non-state-owned enterprise group), it is not significant.

A possible reason is that state-owned enterprises, by virtue of their special status, have an advantage in resource acquisition. As market competition intensifies, state-owned enterprises have received higher levels of subsidy support, whether viewed from an industry or regional perspective [29]. When managerial discretion increases moderately, these resources can be better allocated to green innovation. In contrast, non-state-owned enterprises face relative difficulties in accessing resources; from a long-term and dynamic perspective, they are more likely to be over-leveraged [30]. Even if their CEOs possess a certain degree of discretion, they may be unable to fully allocate resources to green innovation activities due to funding shortages and insufficient policy support. State-controlled listed companies tend to reduce corporate risk-taking to a greater extent [31]. Even when managers of non-state-owned enterprises have a

high degree of discretionary power, they are reluctant to invest excessive resources in green innovation and tend to avoid risks. Therefore, the negative effects of excessively high discretionary power are not pronounced, and the inverted U-shaped relationship is difficult to observe.

Table 9: Regression by Enterprise Type

Variable	(1) State-owned enterprise	(2) non-state-owned enterprise
	lngreen	*lngreen*
CEO_DC	0.7487***	0.0611
	(5.86)	(0.86)
CEO_2	-0.8341***	0.0123
	(-5.01)	(0.17)
YearDum	Yes	Yes
IndustryDum	Yes	Yes
Adjusted R^2	0.4567	0.3111
N	8701	20403

The persistent rise in environmental uncertainty undermines firms' motivation to engage in green innovation by eroding management confidence and increasing financing constraints, thereby significantly reducing their capacity for green innovation [32]. Therefore, this study argues that environmental uncertainty should be incorporated into the analysis to further examine the impact of managerial discretion on firms' green innovation. Regression analyses were conducted by grouping the sample into categories based on low and high levels of environmental uncertainty. Following the approach of Shen Huihui [33], we utilize data on sales revenue (*Sale*) from the past five years. Using ordinary least squares (OLS), we run Model (4) to estimate the abnormal sales revenue over the past five years and calculate its standard deviation. We then divide this by the mean sales revenue for the same period to obtain the industry-unadjusted environmental uncertainty. To measure environmental uncertainty in this context, we divide the industry-unadjusted environmental uncertainty by the median of the industry-unadjusted environmental uncertainty across all companies in the same industry for the same year.

$$Sale = \varphi_0 + \varphi_1 Year + \varepsilon$$

As shown by the regression coefficients for managerial discretion in columns (1) and (2) of Table 10, the inverted U-shaped relationship between managerial discretion and corporate green innovation is significant regardless of whether environmental uncertainty is high or low; however, this inverted U-shaped relationship is more pronounced when external environmental uncertainty is high. A possible explanation is that high levels of environmental uncertainty amplify the "double-edged sword" nature of managerial discretion. When power is exercised appropriately, it enhances the value of a CEO's decisions in complex situations, thereby reinforcing the positive effects. When power is excessive, it lays bare the risks and agency problems associated with CEO authority, thereby reinforcing the negative effects.

Table 10: Regression by Environmental Uncertainty Group

Variable	(1) Low environmental uncertainty	(2) High environmental uncertainty
	lngreen	*lngreen*
CEO_DC	0.1640*	0.2897***
	(1.90)	(3.33)
CEO_2	-0.1562*	-0.2448***
	(-1.75)	(-2.72)
YearDum	Yes	Yes
IndustryDum	Yes	Yes
Adjusted R^2	0.3927	0.3423
N	14354	14138

Recommendations

Based on the above findings, this paper offers the following recommendations: First, enterprises should appropriately delegate authority to managers according to their own scale, ownership structure, and industry characteristics. State-owned enterprises can avoid excessive concentration of power by improving the supervisory functions of their boards of directors. Non-state-owned enterprises can moderately expand the scope of delegated authority and alleviate managers' short-term performance pressures through equity incentives and long-term performance evaluations, thereby stimulating their initiative to promote green innovation. Second, the government can support enterprises in leveraging their resource advantages to conduct green technology R&D by establishing special subsidy funds for green innovation and streamlining project approval processes. Policies such as preferential green credit terms and facilitation of green bond issuance should be introduced for non-state-owned enterprises, with a focus on alleviating their financing constraints and enhancing their motivation to use managerial discretion to drive green innovation. Third, enterprises need to establish a dynamic monitoring system for R&D investment. By combining industry averages, their own green innovation goals, and resource carrying capacity, they can calculate the optimal proportion of R&D investment. On the one hand, they should set an upper limit warning threshold for R&D investment; when the proportion of R&D investment relative to operating revenue exceeds this threshold, a resource efficiency assessment should be initiated to avoid blind investment. On the other hand, they should establish a mechanism for linked analysis between R&D investment and green innovation, regularly tracking the efficiency of R&D funds in the green technology development process to ensure that resources are precisely channeled toward green innovation.

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