



CEO Tenure and Green Innovation: The Mediating Role of ESG

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Abstract

With growing attention to environmental sustainability and corporate social responsibility, Chinese corporations are facing increasing regulatory and market pressures to adopt practices that foster long-term competitiveness. Green innovation has become a critical strategy for sustainable growth. In addition, ESG practices have gained increasing focus as a mechanism to promote corporate sustainability and improve transparency. In this case, this study examines the effect of CEO tenure on green innovation and the mediating role of ESG. Using data from Chinese corporations between 2020 and 2024, this study finds a negative association between CEO tenure and green innovation. Furthermore, ESG is shown to mediate this relationship, indicating that CEO tenure influences green innovation both directly and indirectly. Moreover, the negative influence of CEO tenure on green innovation is stronger in manufacturing firms than in non-manufacturing firms. These findings provide implications for corporate governance and policies to foster the development of green innovation.

Keywords: CEO Tenure; ESG; Green Innovation; China; Sustainable Development.

1. Introduction

In recent years, increasing attention to environmental sustainability and long-term economic development has led to growing expectations for corporations to consider environmental and social responsibility into account. Based on this background, green innovation, which is defined as environmentally friendly and resource-efficient improvements in product design, production processes, and managerial practices, is increasingly considered as a potential method for fostering sustainable development and enhancing firms' long-term competitiveness (Qin et al., 2026). In the context of China, China has been accelerating its transformation toward green development and high-quality economic growth (Wu et al., 2024). With the introduction of "Dual Carbon" targets, environmental regulations and information disclosure requirements have been gradually strengthened (Yang et al., 2024). It indicates that firms are placing increasing emphasis on environmental and social responsibilities in their strategic decision-making. In this case, green innovation is increasingly considered as a critical method for Chinese corporations to enhance their sustainable development and long-term competitiveness.

However, compared with conventional innovation, green innovation tends to involve high initial investment, considerable uncertainty, and double-externalities (Hao et al., 2022). On the one hand, green innovation is likely to require sustained and considered initial investment, and its economic returns appear to be realized over a relatively long time horizon, with a relatively high risk of failure. On the other hand, although green innovation may generate private benefits for firms, it also tends to produce environmental improvements and social gains not fully internalized by firms. In this case, the development of green innovation is more likely to be influenced by financing constraints and short-term performance pressure, which indicates that internal governance mechanisms and top managers' strategic orientation may play a significant role in shaping firms' green innovation activities.

As the critical decision-maker in corporate strategy, the CEO's personal characteristics and behavioral preferences are considered as important internal factors influencing green innovation (Shuyi & Tham, 2025), such as the length of their tenure. Specifically, the CEO with a shorter tenure appears to face higher career uncertainty and market evaluation pressure. They may prefer to demonstrate their capabilities, build a reputation, and gain stakeholder support through innovation and sustainability strategies. In contrast, the CEO with longer tenure has already established market trust, which indicates that they may experience lower career anxiety and show less focus on long-term, high-investment green innovation activities. Therefore, CEO tenure may have an influence on green innovation.

However, strategic preferences of the CEO typically affect green innovation indirectly, through observable strategic and governance practices. Specifically, environmental, social, and governance (ESG) refers to the management practices and disclosure of information related to environmental protection, social responsibility and corporate governance, which appears to reflect sustainability strategy and the awareness of corporate responsibility (Guo et al., 2025). It seems to gradually become a critical way for firms to implement their sustainability strategies. In this case, strengthening ESG practices is likely to reduce information asymmetry and establish external trust. It may facilitate the allocation of internal resources toward long-term sustainable projects (Xinan & Hazlina, 2026), including green innovation. In addition, it is widely accepted that ESG engagement may be associated with CEO characteristics. For example, the CEO with different tenure lengths

faces different levels of career pressure and external evaluation. It appears to affect their level of ESG involvement. In this case, ESG appears to be considered as a possible mechanism through which CEO tenure affects green innovation activities.

Although CEO tenure, green innovation and ESG have attracted increasing attention, existing studies just focus on the direct relationship between CEO tenure and green innovation (Khanchel et al., 2024) and the direct association between CEO tenure and ESG (Muttakin & Khan, 2025). However, few research has revealed how CEO tenure influences green innovation through the ESG mechanism. Although previous studies have often used corporate social responsibility (CSR) indicators to measure non-financial performance of the firm, CSR typically includes a wide range of dimensions, including community responsibility and employee welfare, which appears to be not strongly related to green innovation. In this case, this study adopts ESG indicators, whose environmental dimension more directly reflects green innovation orientation of the firm. In addition, the social and governance dimensions capture strategic capability and governance quality of the management. To fill this research gap, this study uses the latest data from Chinese A-share listed companies over the period 2020 to 2024 and focuses on the following research questions: (1) How does CEO tenure affect green innovation? (2) Does CEO tenure have an influence on ESG? (3) Does ESG promote green innovation? (4) And does ESG play a mediating role in the relationship between CEO tenure and green innovation? Through a systematic empirical analysis of these issues, this study not only deepens the understanding of the relationship between top executive characteristics and green innovation but also provides valuable theoretical insights and practical implications for executive selection, ESG strategy formulation, and green innovation practices.

This research includes five contents. The second part describes the previous literature and develops the hypothesis. The third part illustrates the research methodology. The fourth part presents the empirical results of the research. The last part concludes the entire research, gives the suggestions, propose the limitations of the study and describes the direction of the future study.

2. Literature Review and Hypothesis Development

2.1. CEO tenure and green innovation

Previous studies have shown that CEO personalities significantly affect firms' strategic decisions and innovation activities. For example, Khanchel et al. (2024) claim that CEO personalities may be considered as a critical influencing factor for fulfilling the social responsibility by using the data from U.S. firms. In addition, Liu et al. (2024) demonstrate that innovation initiatives may be affected by CEO tenure. Although this research primarily focus on the direct relationship between CEO tenure and green innovation, it has not explored the underlying mechanism. Moreover, some studies focus on the association between CEO hubris and strategic decisions (Asa & Sadler-Smith, 2020) and Park et al. (2018) suggest that CEO tenure plays a significant role in shaping CEO hubris and narcissism. These previous studies shown the possibility of the influence of CEO tenure on green innovation. It can be explained by the combination of the upper echelons theory and signaling theory.

According to the upper echelons theory, managerial characteristics, such as tenure, affect firms' strategic choices by influencing the manager's cognitive framework, value orientation, and risk preference (Hambrick & Mason, 1984). Specifically, as CEOs' tenures lengthen, they accumulate experience and power, which gradually solidifies their cognitive frameworks and decision-making patterns (Lestari & Soewarno, 2024). It indicates that the accumulated experience may shape managers' cognition, which may constrain the flexibility of CEOs and reinforce existing strategic paths over time. In this case, CEO with long tenure are more likely to maintain existing strategies and adopt conservative behaviour. It may result in reduced attention to external information and high-uncertainty activities, which may reduce their support for green innovation.

From the perspective of signaling theory, information may be conveyed through specific actions or decisions, from which external stakeholders can assess abilities and intentions (Spence, 1974). In addition, CEOs with shorter tenures often face higher performance pressure and career-related anxiety (Bendell & Huvaj, 2020), which may be considered as the reason for their need to build professional reputation and gain recognition from stakeholders. Moreover, developing green innovation aligns with the long-term development of the corporation (Qin et al., 2026), which demonstrates the strategic insight and capacity for future performance of the CEO. Hence, CEOs with shorter tenures prefer to foster the development of green innovation. In contrast, CEOs with longer tenure have already established credibility and authority. In this case, they may face less performance pressure and have weaker incentives to employ green innovation as a signal of strategic competence. Hence, they may allocate fewer resources to develop green innovation. Empirically, Khanchel et al. (2024) prove the negative association between CEO tenure and green innovation. Based on this, this study proposes hypothesis 1 as:

H₁: CEO tenure is negatively associated with green innovation.

2.2. CEO tenure and ESG

ESG is a long-term and strategic information disclosure mechanism, which provides insights into the corporate social responsibility performance and the strategic and governance capabilities of the management. Existing studies demonstrate that CEO personality traits have an influence on ESG. For example, Dabbeb et al. (2022) give empirical evidence for the relationship between CEO characteristics and ESG disclosure. In addition, some studies focus on how CEO narcissism affects the corporate social responsibility disclosure in the U.S. (Lasoued & Khanchel, 2023). In addition, differences in CEO tenure may be associated with CEO personality characteristics (Darouichi et al., 2021), potentially influencing strategic decision-making. In this case, the CEO tenure may have an influence on ESG disclosure. It can be illustrated by signaling theory.

Based on signaling theory, external stakeholders can obtain information based on the corporate disclosure (Spence, 1974). In this case, voluntary disclosure serves as an important approach for CEO to convey their competence and reputation to external stakeholders. Accordingly, stakeholders may evaluate the capacity of the CEO based on the disclosure, including the financial information and non-financial information. In this case, if the quality of disclosure is largely misaligned with the standards expected by external stakeholders, the performance and long-term value creation of the corporations may be affected adversely. This may result in a reduction in the compensation of the CEO or even increase the risk of dismissal. Moreover, the study conducted by Ali and Zhang (2015) proves that forced CEO turnover is positively associated with earnings management, which indicates that CEO in the early stages of their careers may face considerable professional uncertainty. In this case, CEO with shorter tenure are more likely to engage in voluntary disclosure, including ESG disclosure, to establish their reputation, reduce career uncertainty and gain recognition from external stakeholders.

In contrast, the long tenure of the CEO leads to the high concentration of power in a single individual, which appears to result in the issue of entrenchment (Oh et al., 2018). In this case, the entrenched CEO may have greater power and engage in prioritizing individual interests over enhancing information transparency. It indicates that they may conduct disclosure practices that inadequately address the requirements

of stakeholders. Furthermore, ESG disclosure typically requires sustained investment and produces benefits in the long term (Pan et al., 2016). Hence, CEOs with long tenure, having already established career stability and accumulated reputation, face lower motivation to engage in new ESG initiatives. Therefore, they are more likely to maintain existing disclosure rather than actively pursue additional practices. Empirically, there is evidence that there is an association between CEO tenure and corporate social and environmental disclosures (Khan et al., 2021). Based on this, this research proposes hypothesis 2 as:

H₂: CEO tenure is negatively associated with ESG.

2.3. ESG and green innovation

Under the background of sustainable development, ESG is widely regarded as an important signal reflecting the sustainable development of the corporation. Existing research generally suggests that ESG promotes corporate green innovation through two primary approaches. On the one hand, ESG conveys positive signals to stakeholders, which may facilitate access to external support (Wu et al., 2025). On the other hand, ESG strengthens internal governance, which may foster the development of green innovation (Xu et al., 2021).

Based on signaling theory, investors may evaluate the corporation based on the information disclosed by the corporation (Spence, 1974). In this case, enhancing ESG performance may increase transparency and conveys the sustainability orientation of the corporation. When a firm provides comprehensive ESG disclosure, the information asymmetry may be mitigated and recognition and support from external stakeholders may be reinforced. This support, in turn, appears to provide a favorable environment for accessing policy incentives and financial resources, which suggests that financing constraints may be alleviated. Moreover, there is evidence shown that green innovation involves high investment, long development cycles, and considerable uncertainty (Fülöp & Cifuentes-Faura, 2025). It shows that its development may be highly dependent on the external financing and supportive policies. Hence, ESG performance may promote green innovation by enhancing corporate reputation and its ability to secure financial and policy support.

Furthermore, ESG involve environmental, social and governance contents of the corporation (Lian et al., 2023). In this case, the implementation of ESG practices is likely to contribute to the improvement of internal governance structures and the optimization of resource allocation for green innovation. Specifically, proactive ESG practices seem to facilitate the integration of ESG considerations into corporate strategies, which encourages corporations to prioritize the development of green innovation. As a result, corporate resource allocation may become increasingly oriented toward supporting green innovation. Empirically, Wu et al. (2025) give evidence for the positive association between ESG and green innovation. Based on this, the study proposes hypothesis 3 as:

H₃: ESG is positively associated with green innovation.

2.4. The mediating role of ESG

Previous studies focus on exploring the mediating role of ESG in the association between external influencing factors of green innovation and green innovation. For example, Duan and Rahbarimanesh (2024) examines environmental tax affects green innovation through ESG. Similarly, Ali et al. (2022) focus on the mediating role of ESG in the relationship between environmental management and sustainable practices. Furthermore, the mediating role of ESG in the relationship between corporate governance and financial performance is regarded as another focus in the existing research. For example, Ouni et al. (2020) explore how board characteristics have an influence on financial performance through ESG practices by using the data from Canada. Based on these studies, ESG is considered a critical mediating mechanism that associates corporate strategies, governance practices and managerial decisions with firm performance. In this case, ESG may provide a pathway through which managerial characteristics, such as CEO tenure, influence green innovation. Although few studies explore the mediating role of ESG in the relationship between CEO characteristics and green innovation, this relationship may be observed. It can be illustrated by signaling theory.

Specifically, signaling theory suggests that CEO may communicate their governance quality and strategic orientation to external stakeholders through corporate disclosures (Spence, 1974). In addition, CEO in the early stage of their tenure typically face heightened career uncertainty and greater external evaluation pressure because their personal reputation and career stability have not yet been fully established (Bendell & Huvaj, 2020). In this case, they are more motivated to convey their managerial capacity and strategic orientation through observable strategic practices. Furthermore, ESG engagement is considered as a positive signal for external stakeholders (Lian et al., 2023), indicating that the firm prioritizes sustainable development and effective governance. In this case, the CEO enhances the reputation of the corporation, thereby strengthening stakeholder confidence in the long-term development capabilities of the firm by actively implementing ESG practices. Hence, it is likely to facilitate access to external resources for the development of green innovation.

As CEO tenure extends, their organizational position and accumulated reputation appear to be established, which may reduce the pressure to convey a positive signal to external stakeholders. It may lead to a decline in involvement in ESG practices. In this case, environmental and social matters may be less emphasized by the CEO when establishing the corporate strategy. Based on this, the ability of the firm to obtain external financial and policy support of sustainable development may be decreased. Hence, the internal and external effects jointly influence the attention and engagement of green innovation practices. Consequently, differences in CEO tenure indirectly shape green innovation through ESG practices. Therefore, based on signaling theory, corporations may convey their long-term strategic commitment and governance capabilities to external stakeholders through ESG performance, thereby capturing resources and support for green innovation. This mechanism explains the possible pathways through which CEO tenure has an indirect impact on green innovation. Based on this, the study proposes hypothesis 4 as:

H₄: ESG plays a mediating role in the association between CEO tenure and green innovation.

In summary, the conceptual framework is established in Figure 1. It proposes the hypothesis 1 is that CEO tenure is negatively associated with green innovation. Hypothesis 2 is that CEO tenure is negatively related to ESG. Furthermore, hypothesis 3 is that ESG is positively associated with green innovation. Hypothesis 4 is that ESG plays a mediating role in the relationship between CEO tenure and green innovation.

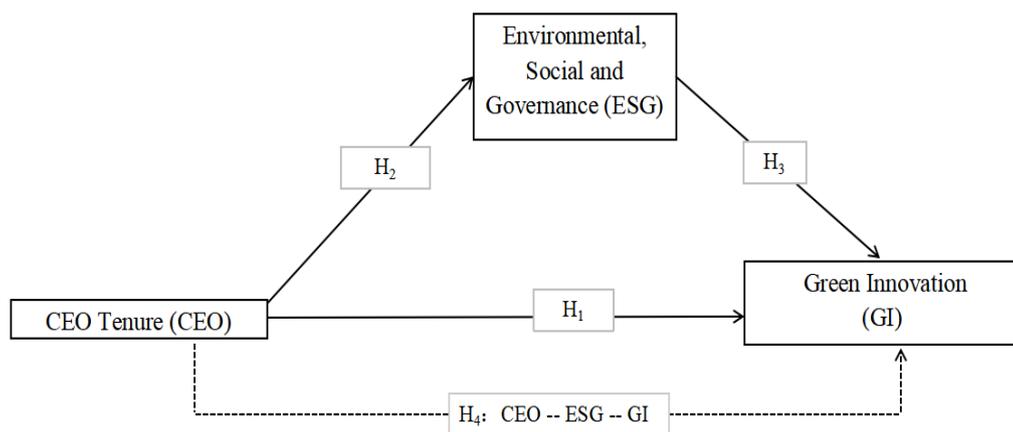


Fig. 1: Conceptual Framework.

3. Research Methodology

3.1. Source of data

This study uses data from 2020 to 2024 and covers the most recent five-year period. In order to maintain the robustness the results, ST and ST* firms are excluded because they have abnormal financial performance and extremely high operational risks. Similarly, financial firms are also excluded due to their different financial structures. After the process, the final sample consists of 16,210 observations. The study includes four types of variables, including the dependent variable, the independent variable, the mediating variable, and the control variables. The dependent variable is green innovation and its data are obtained from the Chinese Research Data Service (CNRDS) database. The independent variable is CEO tenure and the data are collected from the China Stock Market and Accounting Research (CSMAR) database. The mediating variable is ESG and its data are sourced from the Wind database. Data on control variables, including firm size, profitability, solvency, and growth potential, are also collected from CSMAR.

3.2. Selection of variables

3.2.1. Dependent variable

The dependent variable is green innovation. It is regarded as the combination of green and innovation. Following the research conducted by Liu et al. (2024) and Xue et al. (2022), green innovation can be measured by both the number of green patent applications and the number of green patents granted. However, the number of green patents granted may be influenced by factors beyond the control of the firm, such as examination procedures and approval lags, it may not fully capture the actual level of green innovation. In this case, this research uses the number of green patent applications as the proxy for green innovation.

3.2.2. Independent variable

The independent variable is CEO tenure. It may be regarded as a kind of CEO characteristic, which appears to affect the strategic orientation and managerial behaviour. Following by the research conducted by Lestari and Soewarno (2024), it can be measured by the total number of months an executive has served as CEO.

3.2.3. Mediating variable

The mediating variable is ESG. It reflects the performance of the corporation in environmental protection, social responsibility and governance practices, which may have an influence on green innovation. Since ESG involves various dimensions of non-financial information, reliable and quantifiable data are required to be employed. In this case, following the research conducted by Zhou et al. (2022), this study uses the ESG rating scores in the Wind database. The score combines the environmental, social and governance dimensions. In addition, it is calculated by weighting information from corporate disclosures, third-party assessments and market performance. Hence, the ESG score from the Wind database appears to reflect the comprehensive and objective evaluation of the ESG performance of the corporation.

3.2.4. Control variables

There are four control variables, including firm size, profitability, solvency and growth potential. Although the four factors are not the main explanatory variables, they may also affect green innovation. Specifically, firms of different sizes differ in financial and resources, which may affect the development of green innovation (Lestari & Soewarno, 2024). Furthermore, profitability shows the operating condition of the corporation and may affect its ability to invest in green innovation (Li et al., 2017). In addition, solvency indicates that the financial pressure and funding situation of the corporation (Isran et al., 2021), which may also have an influence on how resources are arranged for green innovation. Moreover, growth potential shows the development stage and future expectations of the corporation. In addition, firms at different growth stages may adopt different innovation strategies (Hao et al., 2022). Therefore, these variables are included as control variables to reduce the influence of other firm characteristics and to better examine the relationship between CEO tenure and green innovation. In summary, the measurement of variables is summarized in Table 1.

Table 1: Operational Variables

Type of Variables	Name	Code of Variables	Definition	Literature Foundations
Dependent	Green Innovation	GI	Ln (1+green patents applications)	Tang et al., 2023
Independent	CEO Tenure	CEO	the total number of months an executive has served as CEO	Lestari & Soewarno, 2024
Mediating	ESG	ESG	ESG rating from Wind database	
Control	Firm Size	SIZE	Ln (Total Assets)	Liu et al., 2024
	Profitability	PRO	Net Profits / Total Assets	Sasongko & Rachma, 2021
	Solvency	LEV	Total Liabilities / Total Assets	Ibendahl, 2016
	Growth Potential	GROWTH	(Current Period Revenue - Previous Period Revenue) / Previous Period Revenue	Danbolt et al., 2011

3.3. Model specification

In this research, three models are established to test the hypotheses as follows. Model 1 is used to examine the relationship between CEO tenure and green innovation (H₁). Model 2 assesses the influence of CEO tenure on ESG performance (H₂). Model 3 tests the association between ESG and green innovation (H₃). In addition, by combining model 1, model 2 and model 3, the mediating role of ESG in the association between CEO tenure and green innovation is tested (H₄).

$$GI_{i,t} = \alpha_0 + \beta_0 CEO_{i,t} + Controls_{i,t} + \eta_i + \eta_t + \epsilon_{i,t} \tag{1}$$

$$ESG_{i,t} = \alpha_0 + \beta_0 CEO_{i,t} + Controls_{i,t} + \eta_i + \eta_t + \epsilon_{i,t} \tag{2}$$

$$GI_{i,t} = \alpha_0 + \beta_0 ESG_{i,t} + Controls_{i,t} + \eta_i + \eta_t + \epsilon_{i,t} \tag{3}$$

Where GI represents the dependent variable, which is green innovation. CEO refers to the independent variable, which is CEO tenure. ESG represents a mediating variable, which is ESG. Controls refer to control variables. η_i and η_t represent industry-fixed effect and time-fixed effect, respectively. ϵ represents the error vector.

4. Empirical Results and Discussion

4.1. Descriptive statics and correlation coefficient

Table 2 shows the descriptive results, which show the distribution of the data. There are 16210 observations in the sample. Regarding the dependent variable (GI), the average value and standard deviation value of green innovation are 1.191 and 1.323, respectively. It shows that there are large differences in green innovation performance in the sample. Regarding the independent variable (CEO), the minimum CEO tenure is 0 and the maximum CEO tenure is 270 months. It indicates that the sample includes both newly appointed CEO and those with tenures as long as more than 22 years, which may highlight significant variation and maintain the representativeness of the sample. Moreover, regarding the mediating variable (ESG), its value has a similar distribution, which ranges from 3.13 to 9.62. It indicates that the ESG rating exhibits considerable variation. Regarding control variables, the average value and standard deviation of firm size (SIZE) are 22.43 and 1.299, respectively. It means that considerable variation in firm size among the sample firms. The similar distribution is also represents in the value of profitability (PRO), solvency(LEV) and growth potential (GROWTH). Especially, the value of growth potential, its value ranges from -2.394 to 1145.108. It shows that some firms demonstrate extremely high revenue growth, but others experience a decline, suggesting that the sample includes a wide range of operating conditions.

Table 2: Descriptive Statics

Variable	Obs	Mean	Std.	Min	Max
GI	16210	1.191	1.323	0	7.366
CEO	16210	63.303	45.854	0	270
ESG	16210	6.099	0.899	3.13	9.62
SIZE	16210	22.43	1.299	18.334	28.644
PRO	16210	0.029	0.084	-1.748	1.408
LEV	16210	0.418	0.199	0.014	2.471
GROWTH	16210	0.354	9.145	-2.394	1145.108

4.2. Correlation analysis

Correlation analysis includes the analysis of the correlation coefficient and the test of multicollinearity. Specifically, the results of the correlation coefficient represent the coefficient among the variables shown in Table 3. Based on this table, CEO tenure (CEO) has a negative influence on green innovation (GI) ($\beta = -0.049$, $p < 0.01$). In contrast, firm size (SIZE), profitability (PRO) and solvency (LEV) are positively associated with green innovation. Furthermore, CEO tenure shows a negative and significant association with ESG ($\beta = -0.053$, $p < 0.01$). It indicates that the ESG performance tends to decline as CEO tenure increases. Similarly, firm size, solvency and growth potential are also negatively related to CEO tenure. By contrast, profitability is positively associated with CEO tenure. With respect to ESG, firm size and profitability are positively associated with ESG performance, but solvency shows a negative relationship.

Table 3: Correlation Coefficient among Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) GI	1.000						
(2) CEO	-0.049***	1.000					
(3) ESG	0.201***	-0.053***	1.000				
(4) SIZE	0.541***	-0.040***	0.215***	1.000			
(5) PRO	0.033***	0.051***	0.166***	0.109***	1.000		
(6) LEV	0.281***	-0.086***	-0.106***	0.406***	-0.339***	1.000	
(7)GROWTH	-0.003	-0.015*	-0.010	0.006	0.000	0.014*	1.000

t statistics in parentheses; *p < 0.1, ** p < 0.05, *** p < 0.01.

The issue of multicollinearity is tested by using the variance inflation factor (VIF). Based on Table 4, its values range from 1.001 to 1.508, which is lower than 10. In this case, there may be no multicollinearity issue in the data.

Table 4: Variance Inflation Factor

	VIF	1/VIF
CEO	1.013	0.987
ESG	1.109	0.902
SIZE	1.397	0.716
PRO	1.237	0.808
LEV	1.508	0.663
GROWTH	1.001	0.999
Mean VIF	1.211	

4.3. Baseline regression

Table 5 shows the results of baseline regression, columns (1) to (3) in Table 5 summarize the estimated impact of CEO tenure on green innovation in models that exclude control variables. These models employ random effects (column 1), time fixed effects (column 2), and both industry and time fixed effects (column 3). In addition, column (4) presents the results after including control variables, providing a more complete assessment of the relationship between CEO tenure and green innovation. Based on Table 5, columns (1) to (4) present similar coefficients and significant levels. Specifically, the coefficients are all negative and the significance levels are all lower than 0.05. In this case, CEO tenure has a negative influence on green innovation. This provides support for hypothesis 1.

Table 5: Baseline Regression

Variable	(1) GI	(2) GI	(3) GI	(4) GI Model (1)
CEO	-0.001*** (-6.24)	-0.001*** (-5.62)	-0.000** (-2.05)	-0.001*** (-3.43)
SIZE				0.596*** (80.67)
PRO				-0.205** (-2.01)
LEV				0.216*** (4.43)
GROWTH				-0.001 (-1.22)
CONS	1.281*** (72.38)	1.277*** (48.55)	0.320 (1.60)	-13.077*** (-58.08)
Year FE		YES	YES	YES
Industry FE		YES	YES	YES
N	16210	16210	16210	16210
R ²	0.002	0.014	0.205	0.475

t statistics in parentheses; ** p < 0.05, *** p < 0.01.

4.4. Robustness tests

4.4.1. Replacing the measurement of CEO tenure

Following the research conducted by Brochet et al. (2021), since the distribution of CEO tenure is right-skewed and includes the value of 0, the natural logarithm of one plus CEO tenure is used as an alternative measure of CEO tenure. Column (1) of Table 6 shows the results after replacing the measurement of CEO tenure. Based on the result, CEO_new remains the negative and significant association with green innovation ($\beta = -0.041$, $p < 0.01$), which consists with the previous results. In this case, after replacing the measurement of the independent variable, the relationship between CEO tenure and green innovation remains robust.

4.4.2. Replacing the measurement of green innovation

Based on the study conducted by Liu et al. (2024), green innovation includes invention patents, utility model patents and design patents. Considering that using the number of patent applications alone may not fully capture the actual level of green innovation, the robustness test focuses on invention patents, which have higher technological content and better reflect the actual situation of green innovation compared with utility model and design patents. In this case, the measurement of green innovation can be replaced by the natural logarithm of one added to the number of green innovation patent applications. The result is shown in column (2) of Table 6. According to the results, CEO tenure is also negatively associated with green innovation ($\beta = -0.001$, $p < 0.01$). It is consistent with the previous results. In this case, after replacing the measurement of the dependent variable, the relationship between CEO tenure and green innovation remains effective, indicating the robustness of the original findings.

Table 6: Robustness Tests

Variable	(1) GI_new	(2) GI_new
CEO_new	-0.041*** (-4.38)	
CEO		-0.001*** (-4.30)
SIZE	0.595***	0.502***

	(80.60)	(75.98)
PRO	-0.196*	-0.136
	(-1.92)	(-1.49)
LEV	0.213***	0.062
	(4.38)	(1.45)
GROWTH	-0.001	-0.001
	(-1.26)	(-0.64)
CONS	-12.939***	-10.995***
	(-56.88)	(-54.67)
Year FE	YES	YES
Industry FE	YES	YES
N	16210	16210
R ²	0.475	0.422

t statistics in parentheses; ** p < 0.05, *** p < 0.01.

4.5. Endogeneity tests

Endogeneity testing examines whether the independent variables in a regression model are correlated with the error term, potentially leading to biased or directional estimations of coefficients and affecting causal inference. Following the methodology of Li et al. (2021), to mitigate the problem of reverse causality, this study lagged the CEO tenure by one period before conducting regression analysis. The testing method involved substituting the lagged variable into the regression model and comparing the sign and significance of its coefficients with the baseline regression results. The results are shown in Table 7. The coefficients of the lagged variable regression is consistent with the baseline results in both sign and significance ($\beta = -0.001$, $p < 0.01$), indicating that the endogeneity problem is not significant and the research conclusions are robust.

Table 7: Endogeneity Tests

Variable	(1) GI
CEO	-0.001***
	(-3.73)
SIZE	0.520***
	(67.90)
PRO	0.037
	(0.32)
LEV	0.483***
	(9.15)
GROWTH	-0.001
	(-1.08)
CONS	-10.634***
	(-65.52)
Year FE	YES
Industry FE	YES
N	16210
R ²	0.297

t statistics in parentheses; ** p < 0.05, *** p < 0.01

4.6. Mechanism analysis

In order to analyze the mediating role of ESG in the association between CEO tenure and green innovation, two mediating analysis methods are employed, including the three-step mediation analysis and the Sobel test. Table 5 and Table 8 present the results of the three-step mediation analysis. Model 1 in column (4) of Table 5 confirms the negative relationship between CEO tenure and green innovation. Model 2 in column (1) of Table 8 shows that CEO tenure (CEO) is negatively and significantly associated with ESG ($\beta = -0.001$, $p < 0.01$), consistent with hypothesis 2. Furthermore, the model 3 in column (2) of Table 8 examines the effect of CEO tenure on green innovation after including ESG as an independent variable. The result indicates ESG is positively and significantly related to green innovation ($\beta = 0.079$, $p < 0.01$), supporting hypothesis 3. In addition, after adding ESG as an independent variable, CEO tenure remains negatively and significantly associated with green innovation ($\beta = -0.001$, $p < 0.05$). Hence, based on the results of the three-step mediation analysis, ESG mediates the relationship between CEO tenure and green innovation, which verifies hypothesis 4.

Table 8: Three-Step Mediation Analysis

Variable	(1)	(2)
	ESG Model (2)	GI Model (3)
CEO	-0.001***	-0.001**
	(-9.18)	(-2.81)
ESG		0.079***
		(8.45)
SIZE	0.257***	0.576***
	(41.34)	(74.26)
PRO	0.488***	-0.244**
	(5.70)	(-2.39)
LEV	-0.796***	0.279***
	(-19.44)	(5.67)
GROWTH	-0.001	-0.001
	(-1.40)	(-1.13)
CONS	0.148	-13.088***
	(0.78)	(-58.26)

Year FE	YES	YES
Industry FE	YES	YES
N	16210	16210
R ²	0.198	0.478

t statistics in parentheses; *p < 0.1, ** p < 0.05, *** p < 0.01.

The Sobel test is conducted to further examine the mediating effect of ESG on the relationship between CEO tenure and green innovation. Specifically, the Sobel test estimates the effect of the independent variable on the mediator and the effect of the mediator on the dependent variable. In addition, it calculates the standard error of the indirect effect and conducts a significance test to determine whether a mediating effect exists. This method has been widely applied in management and accounting research. It can effectively complement regression analysis results and validate the mediating role of ESG in the relationship between CEO tenure and green innovation. As shown in Table 9, the direct effect of CEO tenure on green innovation is negative and significant ($\beta = -0.001$, $p < 0.05$). The indirect effect through ESG is -0.000 ($p < 0.01$). The total effect amounts to -0.001 ($p < 0.01$), with the indirect effect accounting for about 30.162% of the total effect. These findings indicate that ESG serves as an important pathway through which CEO tenure affects green innovation. The Sobel test confirms that ESG plays a mediating role in the association between CEO tenure and green innovation, which is consistent with the results of the three-step mediation analysis. In summary, based on the three-step mediation analysis and the Sobel test, hypothesis 4 has been proved.

Table 9: Sobel Test Mediation Analysis

Projects	Regression Results
Direct effect	-0.001** (-2.38)
Indirect effect	-0.000*** (-7.37)
Total effect	-0.001*** (-3.39)
Indirect effect to total effect ratio	30.162%

t statistics in parentheses; *p < 0.1, ** p < 0.05, *** p < 0.01.

4.7. Heterogeneity analysis

The heterogeneity analysis is examined by dividing the sample into manufacturing and non-manufacturing corporations. The results shown in Table 10 indicate that CEO tenure has a stronger negative impact on green innovation in manufacturing firms compared with non-manufacturing firms. Specifically, the regression coefficient of CEO tenure is -0.005 in the manufacturing sample, but it is -0.001 in the non-manufacturing sample. Furthermore, the results of the Chow test show that the differences are significant. In this case, the negative effect of CEO tenure is more significant in manufacturing firms. The difference appears to explain the characteristics of the Chinese manufacturing industry.

Compared with non-manufacturing firms, manufacturing firms usually need to upgrade existing equipment and improve production processes in the process of promoting green innovation (Yang & Zhu, 2022). These activities are with significant investment and long implementation periods (Xu et al., 2021), which indicates that it is unlikely to generate immediate financial returns. In this case, green innovation in manufacturing firms depends heavily on managerial decisions. Furthermore, the CEO, as the main manager, plays a significant role in strategic decision-making (Park et al., 2018). Hence, the risk preferences and tenure of the CEO may play an important role. As CEO tenure increases, the CEO may prefer to maintain current strategies and place greater emphasis on stable performance and personal reputation. Therefore, in manufacturing firms, where green innovation requires large investment and long implementation cycles, this tendency may further strengthen the cautious attitude of the CEO toward green innovation.

In contrast, non-manufacturing corporations may have low energy consumption and pollution levels. Their development of green innovation is more likely to focus on process optimization and improvements in digital employment (Lee, 2024). These practices typically require lower capital investment, which indicates that they may be less dependent on the personal strategic decisions of the CEO. Hence, changes in CEO tenure appear to have a modest effect on green innovation in non-manufacturing firms, which is consistent with the smaller estimated regression coefficients in column (2) of Table 10. In this case, CEO tenure has a stronger influence on green innovation in manufacturing corporations.

Table 10: Heterogeneity Analysis

Variables	(1) Manufacturing corporations GI	(2) Non-manufacturing corporations GI
CEO	-0.005** (-2.70)	-0.001** (-1.96)
SIZE	0.607*** (70.24)	0.574*** (40.30)
PRO	-0.420*** (-3.55)	0.494** (2.45)
LEV	0.336*** (5.94)	-0.191** (-1.97)
GROWTH	0.019** (3.38)	-0.001 (-1.47)
CONS	-13.163*** (-67.18)	-12.417*** (-35.56)
Year FE	YES	YES
Industry FE	YES	YES
N	11880	4330
R ²	0.468	0.488
Chow test	25.530***	

t statistics in parentheses; *p < 0.1, ** p < 0.05, *** p < 0.01.

5. Discussion and Conclusions

The characteristics of the CEO may have an influence on the strategic decisions of the corporation. In addition, CEO tenure can be regarded as the critical factor to shape the risk preference and strategic orientation of the CEO. In this case, the research explores whether the development of green innovation can be affected by CEO tenure and how CEO tenure has an influence on green innovation. Based on the data of listed Chinese companies from 2020 to 2024, this research gives the empirical evidence for the negative association between CEO tenure and green innovation, the negative association between CEO tenure and ESG and the positive relationship between ESG and green innovation. In addition, the mediating role of ESG in the association between CEO tenure and green innovation is also proven. Furthermore, this research also conducted robustness analysis and heterogeneity analysis to extend the results of this study. Although this research employs the data of China, the research results can be extended to other countries which have similar institutional frameworks, market environments, and corporate governance systems.

5.1. Theoretically implication

There are three kinds of implications theoretically. Specifically, this research introduces CEO tenure as an important characteristic of management into the study of green innovation. It enriches the understanding of managerial characteristics in affecting the development of green innovation. Based on the results of the study, CEO tenure has a negative and significant impact on green innovation. By integrating upper echelons theory with signaling theory to explain this relationship, the study extends the theoretical application of managerial characteristics in the field of green innovation. Furthermore, this study considers the life-cycle effect of CEO tenure. The results show that CEOs in the early stages of their tenure are more motivated to promote green innovation due to higher professional pressure and external evaluation needs, but CEOs with longer tenures, having already established power and reputation, show reduced active engagement in green innovation. This finding provides new theoretical insights into the dynamic impact of CEO tenure. Moreover, this research introduces ESG as a mediating variable in examining the relationship between CEO tenure and green innovation. In addition, the results of the research show that CEO tenure not only has a direct impact on green innovation but also indirectly influences it through ESG performance. In this case, by combining CEO tenure, ESG and green innovation, it fills the gap in previous research regarding the mediating role of ESG in the relationship between managerial characteristics and corporate sustainable innovation. In addition, by conducting heterogeneity analysis between manufacturing and non-manufacturing firms, the research finds that the impact of CEO tenure on green innovation varies across industries. Specifically, compared with non-manufacturing corporations, the negative effect of CEO tenure on green innovation is more pronounced in manufacturing firms. In this case, industry characteristics appear to affect the influence of managerial characteristics on green innovation. It provides a new theoretical perspective for examining similar relationships in different contexts.

5.2. Practically implication

Firstly, regulators and policymakers should pay attention to managerial characteristics when promoting corporate green innovation, such as CEO tenure. Based on the results of the research, the CEO with a long tenure may reduce the incentives of the corporation to pursue green innovation. In this case, policies need to encourage firms to establish robust governance mechanisms, conduct regular reviews of managerial strategies and use board evaluation systems to provide incentives for long-tenured CEOs, thereby guiding them to maintain a sustained focus on green innovation and sustainable development objectives. Secondly, due to the mediating role of ESG in the relationship between CEO tenure and green innovation, policymakers appear to strengthen ESG disclosure requirements, which may indirectly encourage managers to pursue green innovation. Thirdly, according to the results of heterogeneity analysis, policies should be designed based on the specific characteristics of the industry. For example, since manufacturing corporations require considerable investment and long implementation periods in the development of green innovation, targeted support, such as financial subsidies, tax incentives and technical assistance, can be issued to reduce the cost and risk of green innovation in manufacturing corporations.

5.3. Limitations and future research suggestions

There are several limitations in this research. Firstly, the analysis is based on Chinese listed companies from 2020 to 2024. Although the findings provide insights into the role of CEO tenure and ESG in promoting green innovation, they may not be fully generalizable to firms in other countries. In this case, future research can extend the analysis to other countries. Secondly, this study focuses on CEO tenure as the managerial characteristic. However, other characteristics of the management have not been included in this research. In this case, future studies appear to take other managerial characteristics into account. Thirdly, this study conducts an exploration of industry heterogeneity but other potentially important dimensions of heterogeneity remain unaddressed. In this case, future research can take other detailed heterogeneity analyses into account.

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