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The Impact of Environmental Regulations on Enterprises' Green Innovation: The Mediating Effect of Managers' Environmental Awareness

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Abstract: It is of great significance to clarify the impact and mechanism of environmental regulations on enterprises' green innovation. This paper empirically studies the impact of command-and-control environmental regulation (CCER) and market-incentive-based environmental regulation (MBER) on enterprises' green innovation and tests the mediating effect of managers' environmental awareness by using the data of Chinese A-share companies listed in the Shanghai and Shenzhen stock exchange from 2011 to 2020. The results show the following: 1. the CCER has a significant promoting effect on both the quantity and quality of green innovation, but the impact of the MBER is significantly negative; 2. managers' environmental awareness has a mediating effect on the impact of the CCER, but there is no such mediating effect on the impact of the MBER; 3. The CCER has a strong promoting effect on the quantity and quality of the green innovation of heavily polluting state-owned enterprises with a high innovation capacity in central cities, while the MBER has a significant negative impact on the green innovation capacity of heavily polluting non-state-owned enterprises but can significantly promote the quantity and quality of enterprises' green innovation with a high innovation capacity located in central cities. Finally, this paper gives some suggestions to promote the green innovation capacity of enterprises by optimizing the design of environmental regulation tools, improving managers' environmental awareness and enhancing the degree of marketization.

Keywords: environmental regulation; enterprises' green innovation; mediating effect; heterogeneity; managers' environmental awareness

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1. Introduction

China's rapid economic development is characterized by high energy consumption and high emissions, with the resulting problems of resource scarcity and environmental pollution becoming increasingly severe. This type of development is not conducive to achieving the goals of sustainable economic growth and green development. The 2022 Global Environmental Performance Index, published jointly by Yale University and Columbia University, assigns China a score of 28.4 points, ranking it 160th among all countries or regions [1]. The growing problem of environmental pollution and the resultant economic and social problems have been addressed through policy measures in China; environmental protection was made a basic state policy in 1983. The Fifth Plenary Session of the 18th Party Central Committee put forward the development concept of "innovation, coordination, green, openness and sharing" and placed innovation at the top of the five development concepts [2]. In 2020, China made the strategic decision to achieve a "double carbon" target based on the inherent requirement of sustainable development; this demonstrates China's political determination to follow a green and low-carbon development path and promote the sustainable improvement of the natural environment through high-quality development [3]. Green technology innovation is a powerful means to achieve the coordinated development of environmental protection and economic growth. Meanwhile, in order to effectively address the negative externalities and market failures caused by environmental pollution, government departments also compel, regulate and guide the green innovation behaviors of enterprises through various environmental regulatory instruments. According to Li and Ramanathan [4] and Zhang et al. [5], environmental regulation is divided into the following two different types: command-and-control environmental regulation (CCER) and market-incentive-based environmental regulation (MBER). Therefore, it is of great theoretical and practical significance to empirically analyze the impact of environmental regulations on enterprises' green innovation capability. Although this issue has been studied in some depth in the literature, there is a lack of consensus on the subject, with the following two distinctive views emerging: the "facilitation theory" and the "inhibition theory". The former is studied by Porter [6], and the latter is studied by Peng Jiachao and Xiao Jianzhong [7]. The new institutionalism theory believes that firms' behaviors converge when they face the same environment, and uses the concept "isomorphism" to analyze the homogeneity process of firms [8]. Di Maggio and Powell further classify isomorphism into the following three categories: coercive isomorphism, normative isomorphism and mimetic isomorphism [9]. As one of the tools of coercive isomorphism, command–control and market-incentive environmental regulations motivate enterprises to engage in R&D activities and energy conservation, thereby gaining competitive differentiation, corporate reputation and legitimacy through green innovation. Heterogeneity in the impact of environmental regulations on enterprises' green innovation has been found by researchers, but the literature has few investigations regarding the reasons for the heterogeneity of enterprises' green innovation when faced with the same regulatory pressures (i.e., the pathways and mechanisms by which environmental regulations affect enterprises' green innovation). Therefore, it is particularly important to clarify the mechanisms of influence and inhibition of environmental regulations on enterprises' green innovation capability so as to enrich and complement the existing relevant studies. This paper distinguishes the green innovation capability of enterprises into the two dimensions of green innovation, which are quantity and quality, and takes the A-share listed companies in China from 2011 to 2020 as a sample to empirically analyze the impact of the two different environmental regulation tools, command-and-control-based and market-incentive-based. By analyzing Chinese enterprises and their heterogeneity, we aim to determine whether there is a mediating effect of managers' environmental awareness (MEA) in order to further clarify the influence mechanism of environmental regulation on the green innovation capability of enterprises.

2. Review of the Literature

2.1. The Impact of Environmental Regulation on Enterprises' Green Innovation

As environmental protection and sustainable development have received increasing attention, the negative externalities and market failures caused by environmental pollution have attracted widespread attention; environmental regulation has become one of the options for government authorities to address this issue. However, effective solutions to the problem of environmental pollution ultimately depend on the green technological innovation and progress of enterprises. As a result, the impact of environmental regulation on the capability of enterprises to seek green innovation has become a hot topic in academic circles, and the influencing mechanism, prerequisite and approach of different types of environmental regulations have different incentive effects on green innovation [10]. Two opposite conclusions have been drawn regarding the "compliance cost" effect and the "innovation compensation" effect.

The "compliance cost" effect suggests that when faced with MBER, such as emission charges, versus CCER, such as an emission standard, the costs of pollution control will lead to increased operating costs for companies, which will be detrimental to their ability to produce and innovate in an ecologically responsible fashion. For example, Karen Palmer et al. [11] argued that environmental regulations significantly increase the enterprises' costs and thus inhibit their ability to ensure green innovation. Jiang Fuxin et al. [12] found that when environmental regulation is weak, it has a significant inhibiting effect on the enterprises' technological innovation. Wang Zhenyu et al. [13] found that environmental regulations are not conducive to the enhancement of green technological innovation when environmental regulations are weak.

The "innovation compensation effect" or "Porter's hypothesis" [6] argues that although environmental regulation increases the cost of pollution control, it can also be used to improve production processes and product quality through technological innovation. The "innovation compensating effect" is a key factor in the success of environmental regulation, as verified and supported by the literature. For example, Jia Jun and Zhang Wei [14] found that environmental regulation has a significant role in the promotion of green technology innovation. Li Weihong and Bai Yang [15] found that the intensity of environmental regulation significantly contributes to the R&D investment intensity and innovation performance of enterprises. Wang Mingyue et al. [16] found that environmental regulation has a significant positive effect on managers' commitment to green technology innovation.

2.2. Heterogeneity of the Impact of Different Environmental Regulation Instruments

In recent years, an increasing number of scholars have focused on the heterogeneity of the effects of different environmental regulatory instruments on enterprises' green innovation capabilities; however, no consistent conclusions were reached. Wang Juanru and Zhang Yu [17] analyzed the effects of different types of environmental regulations on the enterprises' green technology innovation behaviors and found that both command-and-control and market-incentive environmental regulations have positive effects on enterprise green technology innovation behaviors, with the latter having a stronger effect. Fan Dan and Sun Xiaoting [18] found significant differences in the effects of environmental regulation types on green innovation capacity, with MBER having significant inhibitory and facilitative effects on green innovation capacity when at lower and higher regulation intensity, respectively, while command environmental regulations did not have a significant facilitative effect. Han Nan and Huang Yaping [19] found that both command-and-control environmental regulation and market-incentive environmental regulation significantly promoted the green development of heavy pollution enterprises, but the effect of voluntary environmental regulations (VER) was not significant. Zhou Pengfei and Shen Yang [20] found that both market-incentive and voluntary environmental regulations significantly promote green technology innovation, while command-and-control environmental regulations have a significant inhibitory effect. Tan Jin and Xu Guangwei [21] found that both command-and-control and market-incentive regulations significantly promote the level of green innovation, with the former having a greater and more significant promotion effect.

2.3. The Mediating Effects of MEA

Individuals' perceptions are influenced by external environmental pressures to adjust their decision making and behavior. Gadenne et al. [22] found that when executives are aware of the higher rewards associated with environmental practices, companies will engage in more green innovation activities and thus improve their green development. Zhang et al. [23] found that environmental stakeholders' demands influence executives' perceptions of environmental stress, which, in turn, promotes green innovation practices. Xu Jianzhong et al. [24] found a full mediating effect of executives' general environmental awareness on the normative pressure to promote enterprises' green innovation strategies. Bian Mingying et al. [25] found a partial mediating effect of executives' environmental awareness on the impact of environmental regulation on the green innovation of transportation enterprises.

The impact of environmental regulation on the enterprises' green innovation capability has been extensively studied in the literature, and some consensus has been reached. However, there are several shortcomings in the existing research. 1. The number of green patent applications as an evaluation indicator to measure the green innovation capability of enterprises is not fully scientific or representative. In reality, in order to meet the environmental regulation requirements of the government, enterprises often tend to approach green utility patent innovation with less investment and faster results. However, there are significant differences in the degree of innovation between green utility model patents and green invention patents, and the failure to distinguish between the two categories may lead to inaccurate results. 2. Few studies have empirically examined the mediating effect of managers' environmental awareness on the impact of environmental regulation on the enterprises' green innovation capabilities. Although Bian Mingying et al. [25] conducted a study in this area, the study was limited to transportation enterprises, and the sample data were obtained from a questionnaire survey rather than objective data. 3. Little empirical analysis has been conducted on the time lag and dynamics of the impact of environmental regulations on the green innovation capability of enterprises. Given the shortcomings of the existing studies, this paper complements and innovates in the following ways: 1. Considering the difference in the degree of innovation between green utility patents and green invention patents, the green innovation capability of enterprises is evaluated in two dimensions, i.e., the quantity of green innovation and the quality of green innovation. 2. We objectively measure managers' environmental awareness through a textual analysis and empirically investigate its mediating effect and heterogeneity in terms of the impact of different types of environmental regulations on the quantity and quality of the enterprises' green innovation. 3. We introduce lags between different types of environmental regulations and managers' environmental awareness in the empirical model to reflect the time lag and dynamic characteristics of their impact on the quantity and quality of the enterprises' green innovation.

3. Theoretical Analysis and Research Hypotheses

3.1. Impact of Different Environmental Regulations on Enterprises' Green Innovation

In order to effectively address the environmental pollution problems caused by the production process of enterprises and to achieve the goal of environmental protection and sustainable economic development, government departments adopt various measures and instruments, including environmental regulations, to restrict and guide the production and business decisions of enterprises. Shen Chen et al. [26] and Bo Wenguang et al. [27] classify environmental regulations into CCER and MBER regulations according to their nature. Most of the existing literature measures the green innovation capability of enterprises using the number of green patent applications. However, since green invention patents and green utility model patents differ in terms of originality, they need to be treated differently. Tan Jin and Xu Guangwei [21] measured the enterprises' green innovation behaviors using both quantitative and structural dimensions and determined the enterprises' green innovation according to the number of green invention patent applications.

3.1.1. CCER and Enterprises' Green Innovation

As a means of addressing the negative externalities and market failures caused by corporate pollution, CCER relies mainly on legal and administrative means, using emission standards, technical regulations and non-tradable emission permits to force enterprises to regulate their emissions and environmental behavior. Because of the mandatory requirement to meet emission standards and the penalties for non-compliance, companies have no choice but to passively accept and implement regulations and policies. Although it is less efficient than MBER, in a less market-based environment, CCER can be used as a coercive tool to encourage enterprises to make quick decisions, increase investment in innovation resources to promote green innovation and achieve the goal of energy savings and emission reduction. A sound and efficient monitoring mechanism can also help achieve the above functions of CCER. Han Nan and Huang Yaping [19] found that CCER plays an important role in promoting the green development of heavily polluting enterprises. Therefore, this paper proposes the following hypotheses:

H1: *CCER has increased the quantity of enterprises' green innovation.*

H2: *CCER has improved the quality of enterprises' green innovation.*

3.1.2. MBER and Enterprises' Green Innovation

In contrast to CCER, which is highly coercive, MBER is designed according to the "polluter pays" principle and includes various instruments, such as emission charges, environmental taxes, emission reduction subsidies and tradable emission permits. It uses economic instruments to affect the production and operating costs of companies, thereby inducing them to save energy, reduce emissions and innovate in a green way [28]. For example, if enterprises face negative incentives in the form of emission charges, they will have a stronger desire to invest in the elements and resources leading to green technology innovation, thereby achieving the goal of energy saving and emission reduction. However, as a policy tool based on market regulation mechanisms, the function of MBER must be guaranteed by a sound market mechanism and a strong regulatory environment. Otherwise, this environmental regulation tool will not only fail to promote the green innovation capacity of enterprises but also may give rise to "environmental rent-seeking". In reality, due to differences in economic development and resource endowment, the degree of marketization varies greatly and unevenly among regions in China, leading to a mismatch of innovation factors and elements. Therefore, this paper proposes the following hypotheses:

H3: *MBER reduces the quantity of enterprises' green innovation.*

H4: *MBER reduces the quality of enterprises' green innovation.*

3.2. Mediating Effects of MEAs

Managers' environmental attitudes reflect their perceptions of environmental issues and the resulting reactions and actions that determine the production decisions and behaviors of the company. Rivera and De Leon [29] found that the attitudes of executives are particularly important for the environmental management practices of companies when they are under external pressure. Li Qiaohua et al. [30] argued that the higher the level of executives' concern for environmental protection, the more likely companies are to engage in green innovation activities. This indicates that when faced with external pressure from environmental regulations by government departments or the market, company executives' environmental awareness and concern for environmental issues are significantly higher, which leads to more investment in green innovation activities in terms of talent, capital, other innovation factors and resources, and thus enhances the green innovation capability of the company. Therefore, this paper proposes the following hypotheses:

H5: *MEA has mediating effects on the impact of CCER on the enterprises' green innovation capacity.*

H6: *MEA has mediating effects on the impact of MBER on the enterprises' green innovation capacity.*

4. Empirical Models and Data Sources

4.1. Sample Selection and Data Sources

This paper selects a sample of listed Chinese A-share companies in the Shanghai and Shenzhen stock exchange from 2011 to 2020, and pre-processes the sample according to the following methods based on data availability considerations: 1. exclude financial and insurance companies; 2. exclude companies with abnormal trading status, such as ST and *ST; 3. exclude companies with significant missing data on the core variables; 4. to avoid the influence of abnormal values on the analysis results, this paper also uses the Winsor2 command of the Stata17.0 software to process all numerical variables with a 1% and 99% tail reduction. After using the above methods, a total of 7316 valid samples were obtained.

The data sources for this paper are as follows: 1. The green patents are further divided into two categories, green utility model patents and green invention patents, according to the "Green List of International Patent Classification" proposed by the World Intellectual Property Organization (WIPO) in 2010. The data on the two types of green patents were obtained from the China Research Data Service Platform (CNRDS). 2. The frequency of environmental-protection-related terms, such as environment and energy consumption, used in the calculation of command-based environmental regulation intensity was obtained from the government reports of various cities. 3. The frequency of terms such as "total emission fees" used in the calculation of market-based environmental regulation intensity, and "energy saving and emission reduction" used in the measurement of MEA, were obtained from the annual social responsibility reports and financial reports of the companies in the sample. 4. Other data on the characteristics of the companies were obtained from the CSMAR and WIND databases.

4.2. Construction of the Model

The models constructed in this paper include the following two main types: a benchmark regression model used to quantitatively analyze the impact of CCER and MBER on the green innovation capability of enterprises and their differences, and a mediating effect test model used to empirically test the mediating effect of managers' environmental awareness in terms of the impact of different types of environmental regulations on the green innovation capability of enterprises.

4.2.1. Baseline Regression Model

In the baseline regression model, the enterprises' green innovation capability (GIC_{it}) is the dependent variable, and environmental regulation (ER_{it}) is the independent variable. Considering the lag of the impact of environmental regulation on the enterprises' green innovation capability, the independent variables in this model are the one-period and two-period lagged values of environmental regulation. Specifically, the baseline regression model is as follows:

$$GIC_{it} = \beta_0 + \beta_1 ER_{it} + \beta_j control_{jit} + \mu_i + \vartheta_t + \varepsilon_{it}, \quad (1)$$

where GIC_{it} represents the green innovation capability of the ith enterprise in the tth year. This paper measures the green innovation capacity by the following two aspects: the quantity of green innovation GP_{it} and the quality of green innovation GIP_{it}. ER_{it} represents environmental regulation; this paper analyzes the impact of two types of environmental regulations, including command-based ($CCER_{it}$) and market-based ($MBER_{it}$) regulations. $control_{jit}$ represents the control variables, including the enterprise size ($SIZE_{it}$), financial leverage ($ADRATIO_{it}$), etc. μ_i represents the industry fixed effects, ϑ_t represents the year fixed effects and ε_{it} represents the random disturbance term.

4.2.2. Mediation Effects Test Model

The pressure of environmental regulation often affects the business philosophy of enterprises and the environmental awareness of their managers to actively adapt to the requirements of environmental regulation; this leads enterprises to continuously carry out research and development of new technologies, products and processes and to continuously improve their technological innovation capability. To investigate the mechanisms and pathways of the impact of environmental regulation on the enterprises' green innovation capability and to test whether there is a mediating effect of managers' environmental awareness, following the method developed by Baron and Kenny [31], this paper sets up the regression models (2) and (3) together with the baseline regression model (1) to form a mediation effect test model. Given the lagged nature of the interaction between the variables, the core independent variables in the baseline regression model (1) are the one-period and two-period lagged values of environmental regulation, and the dependent variable in model (2) is the one-period lagged value of managers' environmental awareness.

$$MEA_{it-1} = \alpha_0 + \alpha_1 ER_{it-2} + \alpha_j control_{jit} + \mu_i + \vartheta_t + \varepsilon_{it}, \quad (2)$$

$$GIC_{it} = \gamma_0 + \gamma_1 ER_{it-2} + \gamma_2 MEA_{it-1} + \gamma_j control_{jit} + \mu_i + \vartheta_t + \varepsilon_{it}, \quad (3)$$

Here, MEA_{it-1} represents the one-period lagged value of managers' environmental awareness. The mediating effect of managers' environmental awareness is determined as follows: if the regression coefficients α_1 in model (2) and γ_2 in model (3) are significantly different from zero, it means that there is a mediating effect of managers' environmental awareness, which means environmental regulation will have an impact on the green innovation capability of enterprises by promoting the managers' environmental awareness. Further, if the coefficient γ_1 in model (3) is still significant, then there is a partial mediating effect of managers' environmental awareness regarding the effect of environmental regulation on enterprises' green innovation capability; conversely, if the coefficient in model (3) is not significant, then there is a full mediating effect of managers' environmental awareness regarding the effect of environmental regulation on enterprises' green innovation capability.

4.3. Variable Definitions

4.3.1. Dependent Variable

The dependent variable in the model constructed in this paper is the enterprises' green innovation capability (GIC_{it}), which consists of two main measurement dimensions. The first measurement dimension is the quantity of green innovation (GP_{it}). Griliches argued that the number of patents granted is subject to a high degree of subjective influence and uncertainty, and found that the number of patent applications is a more appropriate measurement of enterprise innovation capacity than the number of patents granted [32]. This paper draws on the methods of Bai Qun [33], Yang Chengxinge [34] and Liu Bai et al. [35] to measure the quantity of the enterprises' green innovation by calculating the natural logarithm of the sum of annual green invention patent and green utility model patent applications plus one. For the measurement of the quality of the enterprises' green innovation (GIP_{it}), as the originality of green utility model patents are insufficient, following the approach of Wang, F. and Sun, Z. [36], the quality of green innovation is measured using the natural logarithm of the sum of the annual number of green invention patent applications of enterprises plus one.

4.3.2. Independent Variable

The independent variable in the empirical model of this paper is environmental regulation (ER_{it}). We analyze the impact of two different types of environmental regulations on the quantity and quality of enterprises' green innovationby following the methods of Y, Li [37], Hojnik, J. and Ruzzier, M. [38]. The first type is CCER ($CCER_{it}$), which mainly consists of emission standards and technical specifications with governmental compulsion. This paper draws on the methods of Chen et al. [39] and He Shan [40] to measure the intensity of command-based environmental regulations in each city by using a textual analysis to calculate the frequency of 15 environmental-protection-related terms in each city's government reports, including environment, energy consumption, pollution, emission reduction and environmental protection. The second category is MBER ($MBER_{it}$), which includes more flexible emission taxes, emission reduction subsidies, etc. At present, the following approaches have been used to measure market-based environmental regulations. Li Qingyuan and Xiao Zehua [41] and Guo Qiuqiu and Ma Xiaoyu [42] use the ratio of the total emission fees paid by enterprises to their total assets to calculate the intensity of the MBER; the larger the ratio, the higher the intensity of the MBER. Li Qingyuan and Xiao Zehua [41] and Xie Yizhang and Zou Dan [43] use the ratio of environmental subsidies to the total assets of the enterprise to calculate the intensity of the MBER. Third, Han Nan and Huang Yaping [19] use the natural logarithm of the government environmental subsidies received by the company to measure the intensity of the MBER. To reduce the impact of the company size and the possible heteroskedasticity problem, this paper draws on the approach adopted by Li Qingyuan and Xiao Zehua [41] and Guo Qiuqiu and Ma Xiaoyu [42] to collect annual data of the total amount of emission fees paid by enterprises from financial and social responsibility reports and calculate their ratio to total assets at the end of the period to measure market-incentive environmental regulation.

4.3.3. Mediating Variable

In order to further analyze the mechanism of the influence of environmental regulations on enterprises' green innovation capability and to clarify the reasons for the differences in the influence of different types of environmental regulations, this paper selects the managers' environmental awareness (MEA_{it}) as a mediating variable to analyze whether there is a mediating effect on the impact of environmental regulation on enterprises' green innovation capability. Though managers' environmental awareness is a well-studied concept, it is often difficult to measure directly. So, this concept can be measured using a textual analysis. According to the Whorf–Sapir hypothesis, an individual's cognition is revealed by the embedded vocabulary they use to engage in social activities, representing the individual's inner thoughts, i.e., the individual's cognition can be measured via the vocabulary that is frequently used [44]. Drawing on the method developed by Chen Shouming et al. [32] and Pan An'e and Guo Qiushi [45], the textual analysis method was used to measure managers' environmental awareness by statistically analyzing the frequency of eight terms, including "energy saving and emission reduction", "environmental protection strategy", "environmental protection philosophy", "environmental management organization", "environmental education", "environmental training", "environmental technology development" and "environmental audit" in the CSR reports and annual financial reports of the companies.

4.3.4. Control Variables

In addition to environmental regulation, other factors can also have an impact on enterprises' green innovation capability. Therefore, indicators related to enterprise characteristics are selected as control variables in this paper. Referring to Xie Yizhang and Zou Dan [43], Han Nan and Huang Yaping [19], Tan Jin and Xu Guangwei [21] and Wang Zhi and Peng Baichuan [46], the following control variables are introduced in the model. (1) Firm size ($SIZE_{it}$) is one variable, wherein the larger the enterprise, the more likely it is to have a positive impact on green innovation capacity due to its innovation factor advantage, and this variable is measured using the natural logarithm of the number of employees in the company. (2) Financial leverage ($ADRATIO_{it}$) reflects the capacity and level of indebtedness of a company and has an impact on the input of innovation factors and the capability of the company to achieve green innovation. (3) Return on assets (ROA_{it}) represents the profitability of a company; companies with a larger ROA tend to invest more in R&D activities, which has an impact on their green innovation capability. (4) The two-duty unification ($DUALITY_{it}$) represents whether the chairman of the board and the CEO are the same person; this may have an impact on the production and management decisions of the company. (5) The enterprise value ($TOBIN'S\ Q_{it}$), or *Tobin's Q*, is commonly used in the literature to reflect the enterprise value and performance; an enterprise with a higher value tends to have the ability to invest more in R&D activities, and therefore have a greater impact on green innovation capacity. (6) The enterprise growth capacity (SGR_{it}) represents the growth capacity of enterprises, which is represented by the sustainable growth rate in this paper; a higher sustainable growth rate means that the enterprises also have a higher sales growth rate, and thus, have the ability to invest more resources in R&D investment and influence their green innovation capacity. (7) The proportion of independent directors ($INDEPENDENT_{it}$) is another variable wherein a higher proportion of independent directors means that a company's board of directors has a higher degree of independence, which is conducive to its capability to achieve green innovation and improve its business performance. (8) The comprehensive tax rate ($TAXRATE_{it}$) shows that when companies bear a lower tax burden, they will have more money to invest in R&D activities, thus having an impact on green innovation capacity. (9) The nature of property rights ($PROPERTY_{it}$) shows that state-owned enterprises are subject to a higher degree of administrative intervention, while non-state-owned enterprises have more flexibility in their operations, resulting in greater differences in decision making and innovation activities.

The variables selected for the construction of the model and their calculation methods are summarized in Table 1.

Table 1. Definition of variables and their description.

Variable Type	Variable Name	Variable Symbol	Measurement of Variables
Dependent variable	Quantity of green innovation	GP_{it}	Ln (number of green utility model patent applications + number of green invention patent applications + 1)
	Quality of green innovation	GIP_{it}	Ln (number of green invention patent applications + 1)
Independent variable	Market-incentive-based environmental regulation	$MBER_{it}$	Total emission charges/total assets at end of period
	Command-and-control environmental regulation	$CCER_{it}$	Frequency of environmental-protection-related terms in government reports of each city, obtained via textual analysis
Mediating variable	Managers' environmental awareness	MEA_{it}	Frequency of occurrence of terms such as "energy saving and emission reduction" in CSR reports and annual financial reports obtained via textual analysis
Control variable	Firm size	$SIZE_{it}$	Logarithmic value of the number of employees
	Financial leverage	$ADRATIO_{it}$	Total liabilities/total assets
	Return on assets	ROA_{it}	Net profit/average total assets
	Two-duty unification	$DUALITY_{it}$	Whether the chairman of the board and the CEO are the same person; if yes, it is 1; otherwise, it is 0
	Corporate value	$TOBIN'Q_{it}$	(Market value of equity + book value of debt)/book value of total assets
	Business growth capability	SGR_{it}	(ROE × retention rate)/(1—ROE × etention rate)
	Percentage of independent directors	$INDEPENDENT_{it}$	Number of independent directors/number of board of directors
	Combined tax rate	$TAXRATE_{it}$	(Sales tax and surcharge + income tax expense)/total profit
	Nature of property rights	$PROPERTY_{it}$	Whether it is a state-owned enterprise; if yes, it is 1; otherwise, it is 0

5. Empirical Results

5.1. Descriptive Statistics

Before empirically analyzing the differences in the impact of different environmental regulations on enterprises' green innovation capability and testing the mediating effect of the MEA, descriptive statistical analyses of the variables were conducted to describe the current situation and characteristics of the enterprises' green innovation capability, MEA, CCER and MBER in China. The results of the descriptive statistical analysis of the relevant variables are shown in Table 2.

Table 2. Descriptive statistics of the variables.

Variables	Observations	Average Value	Standard Deviation	Minimum Value	Maximum Value
GP_{it}	7316	15.5844	64.6066	1.0000	1869.0000
GIP_{it}	7316	9.2750	45.3091	0.0000	1371.0000
$MBER_{it}$	7316	0.0019	0.0017	0.0000	0.0245
$CCER_{it}$	7316	0.0035	0.0013	0.0003	0.0124
MEA_{it}	7316	0.9138	1.7642	0.0000	28.0000
$SIZE_{it}$	7316	7.6345	1.2966	1.9459	13.2228
$ADRATIO_{it}$	7316	0.4120	0.2782	−0.2272	18.8375
ROA_{it}	7316	0.0126	0.0280	−2.1611	0.8641
$DUALITY_{it}$	7316	0.2849	0.4514	0.0000	1.0000
$TOBIN'Q_{it}$	7316	2.1257	5.1513	0.6735	715.9448
SGR_{it}	7316	0.0450	0.6737	−19.7724	98.6938
$INDEPENDENT_{it}$	7316	0.3759	0.0559	0.1667	0.8000
$TAXRATE_{it}$	7316	0.0354	0.0929	−7.4859	6.9863
$PROPERTY_{it}$	7316	0.3478	0.4763	0.0000	1.0000

The results of the descriptive statistical analysis of the variables show that the quantity of green innovation GP_{it} and quality of green innovation GIP_{it} have mean values of 15.5844 and 9.2750, respectively, with standard deviations of 64.6066 and 45.3091, indicating that there are significant differences in the quantity and quality of green innovation among the listed enterprises in the sample. The means of $MBER_{it}$ and $CCER_{it}$ are 0.0019 and 0.0035, with standard deviations of 0.0017 and 0.0013, respectively, indicating that the intensity of the CCER is higher than that of the MBER, and that the latter has a greater volatility and variability. The MEA_{it} has a mean and standard deviation of 0.9138 and 1.7642, respectively, indicating that the managers' environmental awareness of listed companies in the sample is generally weak and varies widely across companies. In addition, the $DUALITY_{it}$ mean value of 0.2849 indicates that the chairman of the board and CEO positions of 28.49% of the listed companies in the sample are held by the same person, showing a relatively centralized leadership structure.

In addition, this paper further calculates the pairwise correlation coefficients of the independent variables in the empirical model to check whether the multicollinearity problem exists in the model. The correlation coefficient matrix of the independent variables is shown in Table 3.

Table 3 shows that the correlation coefficients between $CCER_{it-1}$ and $CCER_{it-2}$ and $MBER_{it-1}$ and $MBER_{it-2}$ are 0.561 and 0.670, respectively; they are significant at the 1% level, but the absolute value of the rest of the pairwise correlation coefficients between other independent variables are less than 0.30, which indicates that there are weak correlations between the independent variables and that the multicollinearity problem does not exist in the empirical model.

Table 3. Pairwise correlation coefficient matrix of the independent variables.

Variables	$CCER_{it-1}$	$MBER_{it-1}$	$CCER_{it-2}$	$MBER_{it-2}$	MEA_{it}	$SIZE_{it}$	$ADRATIO_{it}$	ROA_{it}	$DUALITY_{it}$	$TOBIN'Q_{it}$	SGR_{it}	$INDEPENDENT_{it}$	$TAXRATE_{it}$	$PROPERTY_{it}$
$CCER_{it-1}$	1.000													
$MBER_{it-1}$	0.093 ***	1.000												
$CCER_{it-2}$	0.561 ***	0.008	1.000											
$MBER_{it-2}$	0.084 ***	0.670 ***	0.056 ***	1.000										
MEA_{it}	0.018 ***	0.051 ***	0.010	0.055 ***	1.000									
$SIZE_{it}$	0.015 **	0.037 ***	0.017 **	0.038 ***	0.135 ***	1.000								
$ADRATIO_{it}$	−0.002	0.053 ***	0.002	0.039 ***	0.054 ***	0.239 ***	1.000							
ROA_{it}	0.009	−0.012 *	0.000	−0.002	−0.010 *	0.008	−0.208 ***	1.000						
$DUALITY_{it}$	−0.010	−0.085 ***	0.001	−0.074 ***	−0.064 ***	−0.127 ***	−0.121 ***	0.045 ***	1.000					
$TOBIN'Q_{it}$	0.020 ***	0.005	0.000	−0.010	−0.038 ***	−0.130 ***	−0.060 ***	−0.037 ***	0.018 ***	1.000				
SGR_{it}	−0.001	−0.006	0.004	−0.006	−0.002	0.009	−0.011 *	0.054 ***	−0.001	0.001	1.000			
$INDEPENDENT_{it}$	−0.005	−0.034 ***	0.002	−0.030 ***	−0.050 ***	−0.015 ***	−0.012 **	−0.014 ***	0.104 ***	0.021 ***	0.001	1.000		
$TAXRATE_{it}$	0.022 ***	0.010 *	0.013 *	0.008	−0.035 ***	−0.074 ***	−0.008	0.064 ***	−0.021 ***	0.007	0.016 ***	0.003	1.000	
$PROPERTY_{it}$	0.029 ***	0.083 ***	0.009	0.077 ***	0.089 ***	0.264 ***	0.242 ***	−0.071 ***	−0.298 ***	−0.046 ***	−0.008	−0.056 ***	0.026 ***	1.000

Note: ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

5.2. The Impact of CCER on the Quantity and Quality of Green Innovation

The regression results for the effects of CCER on the quantity and quality of enterprises' green innovation are shown in Table 4. The independent variables in models (1) and (3) include only the first and second lag of CCER, the other control variables are included in models (2) and (4) and all the models include the control variables for the year and industry fixed effects.

Table 4. Regression results of the effects of CCER on the quantity and quality of green innovation.

Variables	Quantity of Green Innovation (GP_{it})		Quality of Green Innovation (GIP_{it})	
	(1)	(2)	(3)	(4)
Constant	1.7031 *** (0.0968)	−1.7617 *** (0.3741)	1.1237 *** (0.0892)	−2.3852 *** (0.3557)
$CCER_{it-1}$	33.0455 ** (15.8850)	27.0422 ** (10.8354)	37.0513 ** (14.6636)	29.0878 ** (11.9856)
$CCER_{it-2}$	23.2336 * (12.1890)	19.0283 * (11.3941)	29.9546 *** (10.7937)	26.1410 ** (11.2193)
$SIZE_{it}$		0.3704 *** (0.0345)		0.3736 *** (0.0352)
$ADRATIO_{it}$		0.3166 * (0.1589)		0.1404 (0.1583)
ROA_{it}		0.6857 (1.4424)		0.5064 (1.6714)
$DUALITY_{it}$		0.0293 (0.0622)		0.0650 (0.0668)
$TOBIN'Q_{it}$		−0.0038 (0.0119)		0.0083 (0.0133)
SGR_{it}		0.0985 ** (0.0438)		0.0901 * (0.0491)
$INDEPENDENT_{it}$		0.6225 (0.3996)		0.7134 * (0.3679)
$TAXRATE_{it}$		1.4627 ** (0.7218)		1.5438 ** (0.7289)
$PROPERTY_{it}$		0.1431 ** (0.0560)		0.2290 *** (0.0553)
Observations	7316	7316	7316	7316
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
R-squared	0.1614	0.3367	0.1177	0.2855

Note: 1. Values in parentheses represent standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

Table 4 shows that in terms of the impact of the CCER on the quantity of the enterprises' green innovations, the regression coefficients of the lagged one period for $CCER_{it-1}$ and lagged two periods for $CCER_{it-2}$ of the baseline model are 33.0455 and 23.2336, respectively, which are significant at the 5% and 10% levels, respectively. When adding control variables such as firm size $SIZE_{it}$ and financial leverage $ADRATIO_{it}$ to the model, the regression coefficients of 27.0422 and 19.0283 are still significant at the 5% and 10% levels, respectively. This indicates that the inclusion of the control variables does not affect the sign and significance of the effect of command-based environmental regulation on the quantity of enterprises' green innovations, and the model is stable. The results indicate that there is a significant positive effect of the CCER on the quantity of enterprises' green innovation in China, and the increase in the intensity of the CCER tends to an increase in the quantity of green patents of enterprises. Thus, the H_1 hypothesis proposed in this paper is verified. In terms of the impact on the quality of green innovation, in the baseline model, the regression coefficients of the lagged one period for $CCER_{it-1}$ and lagged two periods for $CCER_{it-2}$ are 37.0513 and 29.9546, and they are significant at the 5% and 1% levels, respectively. When other control variables such as the firm size $SIZE_{it}$, and financial leverage $ADRATIO_{it}$ are included in the model, the regression coefficients for $CCER_{it-1}$ and $CCER_{it-2}$ are 29.0878 and 26.1410, respectively, and both are significant at the 5% level, indicating that there is also a significant positive effect of the CCER on the quality of green innovation of Chinese enterprises; the inclusion of the control variables does not change the sign and significance of the coefficients. Thus, H_2 is also verified. This conclusion is consistent with the results of the research conducted by Han Nan and Huang Yaping [19] and Tan Jin and Xu Guangwei [21]. When faced with the external pressures imposed by the command–control environmental regulation tools such as emission standards, enterprises will invest more resources in R&D activities to improve their green innovation capabilities to meet regulatory requirements, and gain operating legitimacy and avoid penalties in the case of non-compliance.

5.3. The Impact of MBER on Green Innovation

The regression results for the effects of the MBER on the quantity and quality of the enterprises' green innovation are shown in Table 5. The independent variables in models (1) and (3) include only the first and second lag of market-based environmental regulation; models (2) and (4) include the other control variables, and all the models include the control variables for the year and industry fixed effects.

Table 5. Regression results of the effect of MBER on the quantity and quality of green innovation.

Variables	**Quantity of Green Innovation (GP_{it})**		**Quality of Green Innovation (GIP_{it})**	
	(1)	**(2)**	**(3)**	**(4)**
Constant	1.9776 *** (0.0302)	−1.4661 *** (0.3364)	1.4400 *** (0.0317)	−2.0608 *** 0.3405
$MBER_{it-1}$	−17.7725 ** (7.1993)	−24.1928 *** (7.5397)	−10.8536 * (7.6471)	−17.3764 * (8.8090)
$MBER_{it-2}$	−14.5550 * (7.3762)	−10.2614 * (5.0226)	−20.9634 ** (9.3505)	−16.9300 * (9.6347)
$SIZE_{it}$		0.3622 *** (0.0344)		0.3663 *** (0.0353)
$ADRATIO_{it}$		0.3112 * (0.1599)		0.1349 (0.1617)
ROA_{it}		0.6848 (1.5776)		0.5594 (1.8522)
$DUALITY_{it}$		0.0177 (0.0591)		0.0509 (0.0647)
$TOBIN'Q_{it}$		−0.0020 (0.0129)		0.0095 (0.0139)
SGR_{it}		0.1111 ** (0.0449)		0.1012 ** (0.0504)
$INDEPENDENT_{it}$		0.6555 (0.3964)		0.7576 * (0.3552)
$TAXRATE_{it}$		1.4173 * (0.7631)		1.5057 * (0.7725)
$PROPERTY_{it}$		0.1488 *** (0.0543)		0.2318 *** (0.0546)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316
R-squared	0.1616	0.3312	0.1159	0.2793

Note: 1. Values in parentheses represent standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

The regression results show that for the effect of the MBER on the quantity of the enterprises' green innovations, the regression coefficients of the lagged one period $MBER_{it-1}$ and lagged two periods $MBER_{it-2}$ are -17.7725 and -14.5550 in model (1), and they are significant at the 5% and 10% levels, respectively. When other control variables such as the firm size $SIZE_{it}$ and financial leverage $ADRATIO_{it}$ are included in the model, the regression coefficients of $MBER_{it-1}$ and $MBER_{it-2}$ in model (2) are -24.1928 and -10.2614, and they are still significant at the 1% and 10% levels, respectively. This indicates that the inclusion of control variables does not affect the sign and significance of the influence of market-based environmental regulations on the quantity of green innovations of enterprises, and the regression results are stable. The MBER has a significant negative influence on the quantity of green innovations of enterprises in China; thus, hypothesis H_3 is also verified. As for the impact of the MBER on the quality of green innovation, the regression coefficients of the lagged one period $MBER_{it-1}$ and lagged two periods $MBER_{it-2}$ are -10.8536 and -20.9634, which are significant at 10% and 5% levels, respectively. When including other control variables such as the firm size $SIZE_{it}$ and financial leverage $ADRATIO_{it}$ in the model, the regression coefficients of $MBER_{it-1}$ and $MBER_{it-2}$ in model (4) change to -17.3764 and -16.9300, and both are significant at the 10% level. The result is quite different from the findings of Tan Jin and Xu Guangwei [21], in which the dynamic structure of the model is not the same with this paper. Meanwhile, this result is consistent with the findings of the research conducted by Zhou Pengfei and Shen Yang [20], in which the industrial green total factor productivity is employed as the dependent variable, indicating the robustness of the empirical analysis. Thus, hypothesis H_4 is validated. The possible explanation for the negative impact of the MBER on the enterprises' green innovation are as follows: on the one hand, the MBER in the form of emission taxes, emission reduction subsidies and tradable emission permits increases the enterprises' operating costs by internalizing negative external factors, thus discouraging them from pursuing green innovation. On the other hand, although the MBER allows for enterprises to have greater autonomy, its function often requires a high degree of marketization as a prerequisite and guarantee, and it is difficult for the MBER to promote the quantity and quality of green innovation in an underdeveloped market system. At present, China's market system is in a transition period, which leads to a significant inhibiting effect of the MBER on the quantity and quality of enterprises' green innovation. In addition, some control variables like the firm size $SIZE_{it}$, sustainable growth rate SGR_{it}, comprehensive tax rate $TAXRATE_{it}$ and the nature of property rights $PROPERTY_{it}$ have a significant positive effect on both the quantity and quality of green innovation. Financial leverage $ADRATIO_{it}$ significantly promotes the quantity of green innovation, while the proportion of independent directors $INDEPENDENT_{it}$ has a significant positive impact on the quality of green innovation.

5.4. Robustness Test

5.4.1. Replacement with the Independent Variables

To test the robustness of the empirical results of regression, this paper further uses different methods to calculate the intensity of the CCER and MBER, and then analyzes their impact on the quantity and quality of enterprise innovation. Specifically, this paper employs the method developed by Lai Xiaodong et al. [47] in which the weighted average of industrial wastewater, sulfur dioxide and dust emissions per GDP are calculated to measure the intensity of the CCER, and the method of Xie Yizhang and Zou Dan [43] in which the environmental subsidies received by the enterprise are divided by the total assets to measure the intensity of the MBER, respectively. The regression results of the impact of the CCER and MBER on the quantity and quality of the enterprises' green innovation are shown in Tables 6 and 7.

Table 6. Robustness test results of the effects of CCER on the quantity and quality of green innovation.

Variables	Quantity of Green Innovation (GP_{it})		Quality of Green Innovation (GIP_{it})	
	(1)	(2)	(3)	(4)
Constant	1.9253 ***	1.5776 ***	1.3868 ***	2.1797 ***
	(0.0354)	(0.3381)	(0.0346)	(0.3400)
$CCER_{it-1}$	0.3657 ***	0.1117 **	0.7866 **	0.3700 ***
	(0.0349)	(0.0475)	(0.3456)	(0.0356)
$CCER_{it-2}$	1.3750 *	0.6864 *	0.2246 ***	0.1020 *
	(0.7443)	(0.3872)	(0.0575)	(0.0532)
Control variables	No	Yes	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316
R-squared	0.1601	0.3291	0.1148	0.2779

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

Table 7. Robustness test results of the effects of MBER on the quantity and quality of green innovation.

Variables	Quantity of Green Innovation (GP_{it})		Quality of Green Innovation (GIP_{it})	
	(1)	(2)	(3)	(4)
Constant	2.4070 ***	1.4789 ***	1.9143 ***	2.0759 ***
	(0.3703)	(0.3945)	(0.3655)	(0.4344)
$MBER_{it-1}$	−0.1249 ***	−0.2039 ***	−0.1490 ***	−0.1796 ***
	(0.0364)	(0.0763)	(0.0497)	(0.0460)
$MBER_{it-2}$	−0.1312 **	−0.1587 ***	−0.1431 ***	−0.2288 ***
	(0.0537)	(0.0478)	(0.0357)	(0.0704)
Control variables	No	Yes	No	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316
R-squared	0.1638	0.3303	0.1194	0.2795

Note: 1. Values in parentheses are standard deviations. 2. *** and ** represent that a parameter is significant at the 1% and 5% levels, respectively.

Table 6 shows that the estimated coefficients for $CCER_{it-1}$ and $CCER_{it-2}$ are both positively statistically significant whether the control variables are introduced in the regression model or not, which means that the command–control environmental regulation has a significant promoting effect on the quantity and quality of enterprises' green innovation. This is consistent with the regression result in Section 5.3, indicating that the empirical model constructed in this paper is robust.

Table 7 shows that the estimated coefficients for $MBER_{it-1}$ and $MBER_{it-1}$ are both negatively statistically significant in all models when the control variables are excluded and included, which means that market-incentive environmental regulation has a negative impact on the quantity and quality of enterprises' green innovation in China. This is also consistent with the result obtained in Section 5.3, verifying the robustness of the model constructed in this paper.

5.4.2. Heckman Test

The missing data on the number of enterprises' patent applications may lead to the problem of sample selection bias. This paper further examines the impact of this problem on the results of the empirical analysis by using the Heckman test. For simplicity, only the impact of $CCER_{it-1}$ and $MBER_{it-1}$ are considered in the Heckman test. The Heckman test consists of two steps; in the first step, a dummy variable DUMMY is constructed as the dependent variable. The variable DUMMY is equal to 1 if there are no missing data on the number of patent application of enterprises in the sample; on the contrary, DUMMY is equal to 0 if there are missing data on the enterprises' patent application in the sample. Meanwhile, the average of the MBER of the other enterprises in the same industry of the same year $MBER\_mean$ (the average of the CCER of the other cities in the same year is $CCER\_mean$) is selected as the instrumental variable to run the regression, and the inverse mills ratio is obtained. In the second step, the inverse mills ratio obtained in step one is added to the independent variables of the baseline regression model (1), and the regression is run. The regression results of step two of the Heckman test are shown in Table 8.

Table 8. Results of step two of the Heckman test.

Variables	**Quantity of Green Innovation (GP_{it})**		**Quality of Green Innovation (GIP_{it})**	
	(1)	**(2)**	**(3)**	**(4)**
Constant	1.7315 *** (0.4211)	1.5925 *** (0.3453)	2.5128 *** (0.4425)	2.1463 *** (0.3358)
$CCER_{it-1}$	33.6074 *** (9.7691)		32.2391 *** (11.4698)	
$MBER_{it-1}$		−38.1752 *** (13.3762)		−42.1708 *** (13.7852)
IMR	1.8716 ** (0.7504)	7.2192 *** (1.4675)	3.0177 * (1.6866)	6.9339 *** (1.9858)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316
R-squared	0.3202	0.3264	0.2681	0.2738

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

The results of the step two regression of the Heckman test show that the estimated coefficients for $CCER_{it-1}$ on the quantity and quality of the enterprises' green innovation are 33.6074 and 32.2391, and they are significant at the 1% level. Meanwhile, the estimated coefficients for $MBER_{it-1}$ on the quantity and quality of the enterprises' green innovation are −38.1752 and −42.1708, respectively, and they are significant at the 1% level. This shows the robustness of the empirical results of this paper after considering the effect of the potential sample selection bias problem; the CCER can promote the quantity and quality of the enterprises' green innovation, and the MBER has a negative impact on the enterprises' green innovation capability.

5.5. Mechanistic Analysis: The Mediating Effect of MEA

In order to clarify the mechanism of the impact of environmental regulations on the enterprises' capability to achieve green innovation, and to further analyze the reasons for the difference in the impact of the CCER and MBER, this paper examines the mediating effect of MEA by constructing a mediating effect testing model.

5.5.1. Results of the Influence Mechanisms of CCER on Enterprises' Green Innovation

The results of the analysis of the mediating effect of MEA on the impact of the CCER on the quantity and quality of enterprises' green innovation are shown in Table 9.

Table 9. Results of the test for mediating effects of MEA (CCER).

Dependent Variable/ Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
	GP_{it}	MEA_{it-1}	GP_{it}	GIP_{it}	MEA_{it-1}	GIP_{it}
Constant	−1.7209 *** (0.3645)	0.3667 (0.2657)	−1.7635 *** (0.3702)	−2.3483 *** (0.3490)	0.3667 (0.2657)	−2.3784 *** (0.3553)
$CCER_{it-2}$	33.8518 ** (14.5003)	36.4433 ** (15.0790)	32.3314 ** (15.1892)	42.4031 *** (14.3778)	36.4433 ** (15.0790)	40.7735 *** (14.9198)
MEA_{it-1}			0.0229 ** (0.0094)			0.0197 * (0.0108)
$SIZE_{it}$	0.3749 *** (0.0346)	0.1029 *** (0.0278)	0.3686 *** (0.0347)	0.3771 *** (0.0354)	0.1029 *** (0.0278)	0.3723 *** (0.0354)
$ADRATIO_{it}$	0.2769 * (0.1562)	−0.0257 (0.1246)	0.3229 ** (0.1605)	0.1111 (0.1541)	−0.0257 (0.1246)	0.1458 (0.1598)
ROA_{it}	0.3243 (1.4324)	−1.7486 (1.3747)	1.0474 (1.4054)	0.3092 (1.6043)	−1.7486 (1.3747)	0.8685 (1.5869)
$DUALITY_{it}$	0.0293 (0.0609)	−0.0931 ** (0.0462)	0.0279 (0.0624)	0.0641 (0.0656)	−0.0931 ** (0.0462)	0.0600 0.0671
$TOBIN'Q_{it}$	−0.0039 (0.0118)	−0.0238 *** (0.0084)	−0.0020 (0.0126)	0.0082 (0.0129)	−0.0238 *** (0.0084)	0.0108 (0.0139)
SGR_{it}	0.0982 ** (0.0420)	0.0008 (0.0426)	0.0941 ** (0.0429)	0.0819 * (0.0450)	0.0008 (0.0426)	0.0884 * (0.0486)
$INDEPENDENT_{it}$	0.5950 (0.3984)	−0.8592 *** (0.2817)	0.7218 * (0.3988)	0.7084 * (0.3665)	−0.8592 *** (0.2817)	0.7951 ** (0.3657)
$TAXRATE_{it}$	1.4272 * (0.7281)	0.0247 (0.1484)	1.4603 * (0.7415)	1.5188 ** (0.7248)	0.0247 (0.1484)	1.5589 ** (0.7484)
$PROPERTY_{it}$	0.1379 ** (0.0556)	0.0802 (0.0570)	0.1367 ** (0.0558)	0.2231 *** (0.0550)	0.0802 (0.0570)	0.2215 *** (0.0564)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316	7316	7316
R-squared	0.3315	0.1310	0.3380	0.2840	0.1310	0.2862

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

Models (1)–(3) in Table 9 show the results of the analysis of the mediating effect of MEA on the effect of the CCER on the quantity of green innovations of enterprises. In models (2) and (3), the coefficients of $CCER_{it-2}$ and $TMEA_{it-1}$ are 36.4433 and 0.0229, respectively, and they are both significant at the 5% level. The regression coefficient of $CCER_{it-2}$ in model (3) is 32.3314, and it is significant at the 5% level, which indicates that CCER promotes the improvement of managers' environmental awareness, which, in turn, has a positive effect on the quantity of green innovations of enterprises. Thus, there is a partial mediating effect of managers' environmental awareness in the effect of CCER on the quantity of green innovations of enterprises, and the magnitude of the mediating effect is 36.4433 × 0.0229 = 0.8346. Models (4)–(6) show the results of whether there is a mediating effect of managers' environmental awareness regarding the effect of CCER on the quality of green innovation. In models (5) and (6), the regression coefficients of $CCER_{it-2}$ and $TMEA_{it-1}$ are 36.4433 and 0.0197, which are significant at the 5% and 10% levels, respectively; the regression coefficient of $CCER_{it-2}$ 40.7735 in model (6) is still significant at the 1% level, which indicates that the CCER promotes the improvement of managers' environmental awareness, which, in turn, has a positive impact on the quality of enterprises' green innovation. Thus, there is also a partial mediating effect of managers' environmental awareness in the impact of CCER on the quality of enterprises' green innovation, with the magnitude of the mediating effect being 36.4433 × 0.0197 = 0.7179. Therefore, there is a partial mediating effect of MEA in the influence of CCER on the quantity and quality of green innovation, and the CCER can improve the managers' environmental awareness and thus promote the quantity and quality of green innovation. This is consistent with the findings of Gholami et al. [48], who believed that regulatory isomorphic pressure could promote the environment-protecting practices of enterprises by raising their managers' environmental awareness. When enterprises do not comply with the requirements of command-and-control environmental regulation, they may be exposed to the risk of penalties and lawsuits. Conversely, when enterprises operate in compliance with environmental regulations, they can gain a good social reputation. Therefore, command-and-control environmental regulation tends to increase the managers' environmental awareness and conduct environment-protecting behavior in response to regulatory pressure from external stakeholders such as governments. Thus, hypothesis H_5 proposed in this paper is validated.

5.5.2. Results of the Influence Mechanisms of MBER on Enterprises' Green Innovation

The results of the test for the mediating effect of managers' environmental awareness regarding the effect of market-based environmental regulation on the quantity and quality of enterprises' green innovation are shown in Table 10.

Table 10. Results of the test for mediating effects of MEA (MBER).

Dependent Variable/ Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
	GP_{it}	MEA_{it-1}	GP_{it}	GIP_{it}	MEA_{it-1}	GIP_{it}
Constant	−1.4808 *** (0.3327)	0.5156 ** (0.2398)	−1.5356 *** (0.3408)	−2.0771 *** (0.3392)	0.5156 ** (0.2398)	−2.1125 *** (0.3486)
$MBER_{it-2}$	−26.4473 ** (10.1891)	8.2188 (15.0019)	−25.3795 ** (10.5785)	−28.4872 ** (11.7592)	8.2188 (15.0019)	−28.0614 ** (12.1926)
MEA_{it-1}			0.0229 ** (0.0093)			0.0186 * (0.0108)
$SIZE_{it}$	0.3668 *** (0.0344)	0.1007 *** (0.0272)	0.3606 *** (0.0345)	0.3698 *** (0.0356)	0.1007 *** (0.0272)	0.3649 *** (0.0355)
$ADRATIO_{it}$	0.2688 * (0.1568)	−0.0044 (0.1251)	0.3230 ** (0.1605)	0.1047 (0.1570)	−0.0044 (0.1251)	0.1476 (0.1624)
ROA_{it}	0.3332 (1.5601)	−1.4348 (1.3750)	0.9703 (1.5470)	0.3724 (1.7784)	−1.4348 (1.3750)	0.8329 (1.7842)
$DUALITY_{it}$	0.0183 (0.0585)	−0.1084 ** (0.0492)	0.0190 (0.0596)	0.0503 (0.0641)	−0.1084 ** (0.0492)	0.0484 (0.0653)
$TOBIN'Q_{it}$	−0.0024 (0.0129)	−0.0268 *** (0.0088)	−0.0004 (0.0137)	0.0091 (0.0137)	−0.0268 *** (0.0088)	0.0116 (0.0147)
SGR_{it}	0.1092 ** (0.0418)	−0.0114 ** (0.0054)	0.1074 ** (0.0432)	0.0922 ** (0.0453)	−0.0114 ** (0.0054)	0.1001 ** (0.0490)
$INDEPENDENT_{it}$	0.6227 (0.3902)	−0.8314 *** (0.2707)	0.7415 * (0.3901)	0.7443 ** (0.3496)	−0.8314 *** (0.2707)	0.8170 ** (0.3477)
$TAXRATE_{it}$	1.3475 * (0.7556)	0.0005 (0.1362)	1.4013 * (0.7713)	1.4434 * (0.7582)	0.0005 (0.1362)	1.5087 * (0.7822)
$PROPERTY_{it}$	0.1394 ** (0.0544)	0.0724 (0.0574)	0.1395 ** (0.0542)	0.2220 *** (0.0548)	0.0724 (0.0574)	0.2221 *** (0.0556)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7316	7316	7316	7316	7316	7316
R-squared	0.3294	0.1325	0.3328	0.2782	0.1325	0.2807

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% levels, respectively.

Models (1) to (6) in Table 10 show the test results of the mediating effect of MEA regarding the effect of the MBER on the quantity and quality of enterprises' green innovation. The results show that although the regression coefficients of $MBER_{it-2}$ in model (2) and (5) are positive, they are not significant, which indicates that there is no mediating effect of MEA regarding the influence of the MBER on the quantity and quality of enterprises' green innovation, meaning the MBER cannot significantly improve MEA, and thus, promote the enterprises' green innovation capability. So, hypothesis H_6 is not valid. The regression coefficients for MEA_{it-1} in models (3) and (6) are 0.0229 and 0.0186, and they are significant at the 5% and 10% levels, respectively, indicating that the increase in managers' environmental awareness can promote the quantity and quality of enterprises' green innovation; however, the market-based environmental regulation does not have a significant positive effect on MEA. While market-incentive environmental regulation provides more flexibility and choices for enterprises than command-and-control environmental regulation, it also often requires the support from a high degree of marketization and sound managers' ethics. When the market lacks an effective monitoring mechanism, the managers are often short-sighted when faced with the pressure of environmental regulation, and give up green innovation practices that are beneficial to the long-term development of the enterprises in order to pursue short-term benefits. In addition, even if they carry out green innovation activities, they tend to meet the environmental regulation requirements of governments by conducting research on green utility model patents with low R&D costs and risks, rather than paying attention to the increase in environmental awareness and the quality of green innovation. The difference in the impact of these two types of environmental regulations on MEA may further explain the different effects of the CCER and MBER on the quantity and quality of enterprises' green innovation.

5.6. Heterogeneity Analysis

5.6.1. Heterogeneity of Enterprise Property Rights

The impact of environmental regulations on the green innovation capability of enterprises with different property rights may differ. Therefore, this paper divides the sample into two sub-samples of state-owned enterprises and non-state-owned enterprises according to the nature of property rights in order to further analyze the difference in the influence of command-based and market-based environmental regulations on the green innovation capability of enterprises with different property rights. The regression results are shown in Table 11.

Table 11. Analysis results of the heterogeneity of enterprise property rights.

Independent Variable	State-Owned Enterprises		Non-State-Owned Enterprises	
	GP_{it}	GIP_{it}	GP_{it}	GIP_{it}
Constant	−2.9302 ***	−3.4924 ***	−0.8900 **	−1.4589 ***
	(0.4525)	(0.4553)	(0.4027)	(0.3922)
$CCER_{it-1}$	56.2633 ***	44.7282 **	6.3449	15.0314
	(17.4814)	(16.9128)	(10.4415)	(12.7340)
$CCER_{it-2}$	33.8955 *	47.1232 **	0.2065	7.2758
	(18.4754)	(18.3472)	(12.9881)	(12.8144)
$MBER_{it-1}$	−13.2197	−13.4697	−27.9177 **	−14.4634 *
	(8.6550)	(10.7721)	(11.5617)	(7.8962)
$MBER_{it-2}$	−11.9041	−17.3087	1.9803	−8.5215
	(11.6113)	(12.6845)	(13.1883)	(12.8967)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	2941	2941	4375	4375
R-squared	0.4307	0.3908	0.2843	0.2183

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% significance levels, respectively.

The analysis of the heterogeneity of property rights shows that the CCER has a significant positive effect on the quantity and quality of the green innovation of state-owned enterprises (SOEs), while the effect on non-state-owned enterprises is not significant. The MBER has a significant negative impact on the quantity and quality of the green innovation of non-SOEs, while the impact on the green innovation capability of SOEs is insignificant. The possible reasons for this are that state-owned enterprises are more administrative in nature and tend to be subjected to higher levels of bureaucratic intervention, thus favoring the role of the CCER, which is supported by government enforcement. Non-state-owned enterprises have more flexibility and autonomy in their operations, and their green innovation behavior is more likely to be regulated and influenced by the MBER.

5.6.2. Heterogeneity Analysis of Pollution Degree

Heavily polluting enterprises are generally less aware of environmental issues and devote fewer resources to environmental protection than lightly polluting enterprises. At the same time, as the concepts of environmental protection and sustainable development become increasingly important, heavily polluting enterprises are also subject to stricter supervision by laws and regulations, such as the Environmental Protection Law. Therefore, there may be differences in the impact of environmental regulations on the quantity and quality of green innovation between heavily polluting and lightly polluting enterprises. Therefore, based on the approach by Yang Chengxinge [34], this paper classifies enterprises in the following 18 industries, including industrial codes named B06, B07 and so on, as heavily polluting enterprises, and classifies enterprises in the other industries as lightly polluting enterprises according to the Industry Classification Guidelines for Listed Companies revised by the CSRC in 2012, and then empirically analyzes the impact of the CCER and MBER on the two types of enterprises in a sub-sample. The results of the heterogeneity analysis of pollution degrees are shown in Table 12.

Table 12. Analysis results of the heterogeneity of pollution degree.

Independent Variable	Heavily Polluting Enterprises		Lightly Polluting Enterprises	
	GP_{it}	GIP_{it}	GP_{it}	GIP_{it}
Constant	−2.3369 **	−2.8772 ***	−1.8003 ***	−2.4371 ***
	(0.8142)	(0.8751)	(0.4365)	(0.4028)
$CCER_{it-1}$	23.2508	21.0780	28.4199 **	31.4772 **
	(13.8983)	(13.8947)	(13.4665)	(14.4694)
$CCER_{it-2}$	49.4614 **	59.7354 ***	1.8238	8.2120
	(20.0409)	(16.4845)	(11.5906)	(12.2843)
$MBER_{it-1}$	−17.7545 **	−13.5827	−23.5709 **	−16.1427
	(6.1650)	(10.3757)	(11.6705)	(13.9929)
$MBER_{it-2}$	−35.8997 ***	−45.4811 ***	14.2214	11.9319
	(10.8009)	(12.8367)	(10.7441)	(9.1015)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	1778	1778	5538	5538
R-squared	0.3601	0.3050	0.3499	0.2976

Note: 1. Values in parentheses are standard deviations. 2. *** and ** represent that a parameter is significant at the 1% and 5% significance levels, respectively.

The analysis results of the heterogeneity of pollution degree show that the CCER has a significant positive effect on the quantity and quality of heavily polluting enterprises' green innovation, and the MBER has a significant negative impact on the quantity of lightly polluting enterprises' green innovation, respectively. Meanwhile, the CCER significantly promotes the green innovation quality of lightly polluting enterprises; however, the effect of the MBER on the quality of lightly polluting enterprises' green innovation is not significant. The possible reason for this is that heavily polluting enterprises are subject to stricter regulation and public attention, and it is easier for command-based environmental regulations to play a role in promoting the quantity and quality of heavily polluting enterprises' green innovation. However, it takes a longer time for the MBER to play a promoting role compared with lightly polluting enterprises. Similarly, the negative impact of the MBER on heavily polluting enterprises also takes longer time than for lightly polluting enterprises.

5.6.3. Heterogeneity of Enterprises' Green Innovation Capabilities

There are significant differences in environmental awareness, operating costs and governance structure among enterprises, and thus, the CCER and MBER may have different impacts on their green innovation capabilities. Therefore, in this paper, the enterprises are re-grouped according to the number of invention patent applications. If the number of invention patent applications of an enterprise is greater than the average of all the enterprises in the sample, it is defined as an enterprise with a high green innovation capability; conversely, if the number of invention patent applications of an enterprise is lower than the average of all the enterprises in the sample, it is defined as an enterprise with a low green innovation capability. The analysis results of the heterogeneity of the effects of the CCER and MBER on enterprises with different green innovation capabilities are shown in Table 13.

Table 13. Analysis results of the heterogeneity of enterprises' green innovation capabilities.

Independent Variable	High Green Innovation Capability Enterprise		Low Green Innovation Capability Enterprise	
	GP_{it}	GIP_{it}	GP_{it}	GIP_{it}
Constant	0.7906 **	−0.2996	0.3316 ***	−0.1981
	(0.3588)	(0.4509)	(0.1247)	(0.1194)
$CCER_{it-1}$	45.9302 ***	57.3469 ***	−6.1580	−7.2726
	(14.3142)	(12.4479)	(7.0480)	(9.1090)
$CCER_{it-2}$	−11.0680	12.6145	14.0104 **	17.8403 **
	(21.3777)	(26.3751)	(6.7898)	(7.2874)
$MBER_{it-1}$	15.5827	37.3120 **	−5.6413	−1.9695
	(12.1318)	(16.0594)	(4.3452)	(6.5622)
$MBER_{it-2}$	35.1802 *	43.6458 *	−1.6539	−7.2846
	(17.9844)	(24.9576)	(6.4439)	(6.7637)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	1431	1431	5885	5885
R-squared	0.3430	0.3584	0.1387	0.1218

Note: 1. Values in parentheses are standard deviations. 2. ***, ** and * represent that a parameter is significant at the 1%, 5% and 10% significance levels, respectively.

Table 13 shows that both the CCER and MBER have a significant positive effect on the quantity and quality of green innovation for enterprises with a high green innovation capacity. For the low green innovation capability enterprises, the CCER has a significant positive effect on the quantity and quality of green innovation; however, the MBER does not have a significant effect. The possible reason for this is that the enterprises with a high green innovation capability usually have high-quality R&D talents, sufficient financial supporting, higher operational flexibility and lower operating costs, which are important to facilitate the performance of the CCER and MBER. Enterprises with a low green innovation capability may be less environmentally conscious and may focus their attention on economic efficiency. Therefore, the CCER, which involves government coercion, can effectively promote the quantity and quality of low green innovation capability enterprises' green innovation, while the MBER is not so effective.

5.6.4. Heterogeneity in the Class of Cities Where Enterprises Are Located

Central cities tend to be more attractive to various innovation factors and resources due to their higher level of economic development, more rational rules and regulations and higher degree of marketization. As a result, the impact of environmental regulations on enterprises' green innovation located in central cities may differ from those of non-central cities. Therefore, this paper classifies enterprises located in provincial capitals, sub-provincial capitals and municipalities directly under the central government as central city enterprises, and classifies enterprises located in other cities as non-central city enterprises. The impact of the CCER and MBER on the quantity and quality of green innovation in these two geographical groups of enterprises are analyzed. The analysis results of the heterogeneity in the class of cities where enterprises are located are shown in Table 14.

Table 14. Analysis results of the heterogeneity in the class of cities where enterprises are located.

Independent Variable	Central City Enterprises		Non-Central City Enterprises	
	GP_{it}	GIP_{it}	GP_{it}	GIP_{it}
Constant	−1.9424 *** (0.4577)	−2.6411 *** (0.4467)	−1.6367 *** (0.5709)	−2.0662 *** (0.6332)
$CCER_{it-1}$	44.9792 *** (15.0012)	44.8750 *** (14.0115)	−9.3153 (11.6835)	−3.6608 (14.4399)
$CCER_{it-2}$	23.2881 (19.3462)	34.5401 * (20.6254)	−7.1044 (16.6113)	−6.1646 (17.8242)
$MBER_{it-1}$	29.8005 *** (10.0399)	19.6771 * (11.2711)	−9.5776 (11.1083)	−12.2076 (12.2907)
$MBER_{it-2}$	−9.2175 (11.7257)	−15.0947 (12.1593)	−1.5371 (12.1652)	−8.3364 (12.8694)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	4634	4634	2682	2682
R-squared	0.3815	0.3253	0.3163	0.2786

Note: 1. Values in parentheses are standard deviations. 2. *** and * represent that a parameter is significant at the 1% and 10% significance levels, respectively.

Table 14 shows that the CCER and MBER have a significant positive impact on the quantity and quality of enterprises' green innovation in central cities, and the increase in the intensity of environmental regulations helps to promote the enterprises' green innovation capability. However, neither the CCER nor the MBER has a significant impact on the quantity and quality of non-central city enterprises' green innovation. The possible reason for this is that enterprises in central cities can attract various innovation resources and factors, such as talents and capital at a lower cost, thus, effectively compensating for the operational costs associated with the CCER. In addition, central cities have a higher degree of marketization, and enterprises in these cities have more autonomy in their operations, which is helpful to promote the enterprises' green innovation capability by the MBER. On the contrary, non-central cities are less attractive in terms of innovation factors and have a lower degree of marketization, resulting in an insignificant impact of environmental regulations on green innovation capabilities.

6. Conclusions

6.1. Research Findings

This paper empirically analyzes the impact of command-and-control and market-incentive environmental regulations on the quantity and quality of enterprises' green innovation and identifies whether there is a mediating effect of MEA, using a sample of Chinese A-share companies listed in the Shanghai and Shenzhen Stock Exchange from 2011 to 2020. The results are as follows:

1. The quantity of enterprises' green innovation GP_{it} and quality of enterprises' green innovation GIP_{it} had means of 15.5844 and 9.2750 and standard deviations of 64.6066 and 45.3091, respectively, showing a wide variation in the quantity and quality of green innovation among listed enterprises in the sample. The $MBER_{it}$ and $CCER_{it}$ had means of 0.0019 and 0.0035, with standard deviations of 0.0017 and 0.0013, respectively, showing that the intensity of the CCER is higher than that of the MBER, but the latter had a greater volatility and variability. The MEA_{it} had a mean and standard deviation of 0.9138 and

1.7642, respectively, indicating that the MEA of the listed companies in the sample was weak and varied widely.

2. Heterogeneity exists in the impact of different types of environmental regulations on the enterprises' green innovation capabilities. Specifically, the CCER has a significant positive impact on the quantity and quality of enterprises' green innovation, with a greater impact on quality, while the MBER has a significant negative impact on the quantity and quality of enterprises' green innovation.

3. There is heterogeneity in the mediating effect of managers' environmental awareness regarding the impact of different environmental regulations on enterprises' green innovation capabilities. The effect of the CCER on managers' environmental awareness is significantly positive, which, in turn, has a significant promotion effect on the quantity and quality of enterprises' green innovation, with a greater mediating effect of managers' environmental awareness regarding the effect of the CCER on the quantity of enterprises' green innovation. However, the impact of the MBER on managers' environmental awareness is not significant, and there is no mediating effect of MEA regarding the impact of market-incentive environmental regulation on the quantity and quality of enterprises' green innovation.

4. There is heterogeneity in the impact of environmental regulation on the green innovation capacity of different types of enterprises. The CCER has a strong promoting effect on the quantity and quality of heavily polluting stated-owned enterprises' green innovation, with a high innovation capacity located in central cities, while the MBER has a significant negative impact on the green innovation capacity of heavily polluting non-state-owned enterprises, but can significantly promote the quantity and quality of enterprises' green innovation, with a high innovation capacity located in central cities.

6.2. Policy Insights

Based on the results of the empirical analysis, this paper proposes the following recommendations:

1. Government departments should choose the appropriate environmental regulatory instruments according to the current situation of China's social and economic development. China's economic development is currently at a critical stage of transition, with the market system still under development, and the degree of marketization is relatively limited; thus, the CCER will play an important role in promoting the enterprises' green innovation capability, while the MBER will have an inhibiting effect. Therefore, when choosing environmental regulation instruments, government departments should take into account the current situation of China's economic development, establish and improve command-based environmental regulations that are mandatory and effective, and improve the monitoring mechanism for the implementation of policies and tools to ensure that they can effectively raise the environmental awareness of managers, and thus, promote the quantity and quality of enterprises' green innovation.

2. The design of the MBER should be optimized to give enterprises more options and flexibility. Empirical research has shown that the MBER has a significant positive impact on the quantity and quality of enterprises' green innovation, with a high innovation capacity located in central cities. Therefore, it is important to design and provide a variety of MBER instruments for these enterprises to encourage them to invest more in innovation resources and factors, and to promote their green innovation capabilities through market-incentive regulation mechanisms.

3. The managers' environmental awareness should be targeted to promote the green innovation capabilities of enterprises. The results of the empirical analysis show that MEA can significantly improve the quantity and quality of green innovation, and there is a mediating effect regarding the influence of MEA in the impact of CCER on the green innovation capacity of enterprises. Therefore, it is necessary to actively cultivate the environmental protection concept and social responsibility of enterprise managers, enhance their environmental protection awareness and integrate the concept of energy conservation,

emission reduction and green development into corporate development strategies so as to promote the performance of enterprises' green innovation.

4. By gradually improving the market system as well as the degree and level of marketisation, the function of the MBER will be bolstered. The MBER, which is based on market regulation mechanisms, requires a strong market system as a prerequisite to guide the reasonable and smooth flow of various innovation resources and achieve the optimal allocation of resources. At the same time, the improvement of the marketization can enhance the attractiveness of innovation resources such as talents and capital, thus creating conditions for enterprises to attract high-quality talents and capital at a lower cost, and promoting the performance of green innovation capacity.

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