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The Relationship between the Political Connections and Green Innovation Development of Chinese Enterprises—Empirical Analysis Based on Panel Data of Chinese A-Share Listed Companies

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Abstract: This paper uses the panel data of A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2008 to 2019 as the original sample and uses panel two-way fixed-effect, panel Tobit and mediation effect models to study the impacts of political connections of Chinese enterprises on the development of green innovation and the impact mechanism. The results show that political connections will inhibit the development of green innovation and have a greater inhibitory effect on the numbers of enterprises' alternative energy patents and administrative supervision design patents. This conclusion persists under a series of robustness tests. Further analysis shows that the impact of enterprises' political connections on green innovation has significant regional heterogeneity, and the inhibition of green innovation is mainly reflected in the manufacturing industry. In terms of mechanism, political connections influence green innovation capacity through the R&D investment and excessive debt of enterprises. Finally, the paper provides advice for the government to formulate policy and suggestions for enterprise development.

Keywords: political connection; green innovation development; R&D investment; excessive debt

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1. Introduction

With the continuous emergence of environmental problems, the international voice for sustainable development is increasing. High-emission industries not only lead to greenhouse effects and ecological deterioration but also overdraft the long-term vitality of the national economy [1]. The importance of green innovation has been widely accepted by governments. At the seventy-fifth session of the United Nations General Assembly, the United States proposed to achieve 'net zero emissions' by 2050, and the European Union proposed to become the first 'climate neutral' continent in the same year. China, as the largest developing country, also faces severe sustainable difficulties. According to BP World Energy Statistics Yearbook, China's total carbon emissions in 2020 is 9899.3 million tons, accounting for about 30.7% of the total global emissions, ranking first in the world. In order to solve the environmental problem, China's State Council issued the State Council Guidance on Accelerating the Establishment and Perfection of a Green Low-carbon Recycling Economic System in 2021, which clearly pointed out that we should adhere to the working principle of leading by innovation and improve the efficiency of energy allocation through the construction of green technology innovation, the making of laws and regulations support system and the building of green supply chain to pilot with some enterprises. The promotion from the national level makes improving the level of green innovation a popular topic discussed by scholars.

At present, scholars' research on green innovation mainly focuses on measuring methods and influencing factors. At the level of measuring methods, green innovation is measured by efficiency, such as enterprise R&D efficiency and achievement transformation

efficiency [2,3]. On the other hand, a very important branch of literature is to evaluate the influencing factors of green innovation including putting forward a variety of research perspectives. Based on the perspective of the market, some scholars discussed the common expected growth of market share related to new market segments and consumers' demand preference for green products [4,5]. Based on the perspective of the government, some scholars proposed that the government required enterprises to promote green innovation and development through administrative and legal means. However, due to the lack of financial capacity and other reasons, most enterprises lacked the motivation to carry out innovation practice [6]. In order to share the pressure of strict regulation, some enterprises began to turn to establishing effective political connections [7–9]. When scholars study green innovation in the context of China's economy, they must take into account the characteristics of China's special ownership and weak market mechanism, which is different from Western countries: political connection has become an indispensable factor in this context. In the study of the role of political connection on green innovation, it has been divided into three categories: promotion, inhibition, and U-shaped. Scholars who promote the theory believe that political connections can effectively minimize the risk of enterprise innovation and enhance confidence in enterprise green development [10–12]. Zhang et al. [13] analyzed the promoting effect of political connections from the perspective of entrepreneurial strategy. However, some studies have shown that political connections can also have a negative impact because in order to establish good political connections, enterprises need to pay more rent-seeking costs; this produces the 'crowding-out effect' of innovation resources [14]. At the same time, scholars have found that political connections in different types of enterprises also have different effects. For example, political connections in non-state-owned enterprises have an inverted U-shaped effect on enterprise innovation [15–17]. There are many discussions on the relationship between political connections and green innovation in the existing literature, but no consensus has been reached. In order to enrich the theoretical research in this field, this study will find out how political connections affect green technology innovation.

Compared with the previous studies, there are three innovation points in this paper. Firstly, this study attempts to examine the correlation between political connections and green innovation. This paper uses the panel data of all A-share listed companies on the Shanghai and Shenzhen stock markets from 2008 to 2019 as the original sample. During this period, China, the largest developing country in the world, has rapid economic growth but not a perfect market system. Moreover, China is in the process of reforming and upgrading its system, and it does take a certain amount time to improve the corresponding system, which stimulates the desire of enterprises to seek political connections [9,18]. China's economic system is dominated by public ownership which resulted in the government's irreplaceable role in economic development; therefore, the role of political connection is particularly important for enterprises. A huge amount of money and time will be spent by the enterprises to establish political connections each year [19]. The above shows that the particularity of Chinese samples during the above time period gives more profound significance to the study of political connections and green innovation than in other Asian countries.

Secondly, this study aims to solve the potential heterogeneous results brought by Chinese samples in different regions and industries. The industrial distribution is not the same in the east and west regions of China because of the current economic pattern and the unbalanced development. The industries are mainly energy, chemical industry and agriculture in the western regions, while the manufacturing and service industries in the east [20,21]. The study predicts that political connections have different degrees of impact on green innovation of enterprises in different regions and industries. Thirdly, the study attempts to examine the specific mediating role of R&D investment (RDexp) and excessive debt ($EXLEVB_{it}$) in the influencing mechanism, and further discuss the influencing mechanism. Most of the previous literature focuses on the role of political connections in green innovation. In contrast, there are few discussions on the impact

mechanism. This paper hopes to broaden the research perspective in this field by studying the mediating effect of different dimensions.

The division of this paper is as follows. The Section 2 reviews the literature and proposes research hypotheses. The Section 3 introduces the research methods and establishes the research model. The Section 4 reports the empirical research results. Section 5 conducts robustness analysis. Section 6 draws the conclusion.

2. Literature Review and Hypotheses

2.1. The Political Connection of Enterprises

It is the fact that the ultimate goal of cultivating political connections for enterprises is to pursue economic benefits [22]. However, with the continuous accumulation of political connections, enterprises may rely too much on the favorable conditions that they brought [23,24]. From a macro point of view, politically connected enterprises without green innovation can still rely on their own political connections in a dominant position in the market competition, which will produce a 'resource curse' and reduce the motivation toward R&D innovation [25]. Due to the excessive dependence on the privileges provided by the government, enterprises may be conservative and tend to decline their preference for innovative behaviors with high uncertainty [26,27]. On the other hand, enterprises seeking to establish a good political connection will produce higher rent-seeking costs, resulting in resource transfer effect and squeezing R&D investment [28]. From the perspective of public opinion, enterprises are more likely to control media and journalists through political connections to escape public opinion pressure [29]. Considering the micro level, first, when analyzing the individual behavior of corporate executives, the study shows that political stakeholders pursue their own political goals to maximize, and this 'predatory hand' hinders the green innovation behavior of enterprises [30]. At the same time, political connections cause executives to neglect the management of innovation activities, induce opportunistic behavior and lead to partner conflict [31]. In addition, influenced by political connections, politicians will intervene in corporate decision-making, resulting in distorted incentives and improper resource allocation [32,33]. These factors eventually lead to a decline in politically connected companies' attention to green innovation. According to the above analysis, we put forward the following assumption:

H1. *The political connection of enterprises has an inhibitory effect on green innovation.*

2.2. Influence Mechanism

2.2.1. R&D Investment

How political connection affects the green innovation of enterprises has not been determined in the current academic circles. Some scholars believe that the influence mechanism has a mediating effect or moderating effect, for example that the degree of marketization plays a negative moderating role in the mechanism of political connection and green innovation [34,35]. High-frequency negative environmental media reports will increase the pressure of politically connected enterprises and effectively stimulate enterprises in fiercely competitive industries to attach importance to sustainable development [36]. In addition, in the construction industry, enterprises with political connection will show the social responsibility of the enterprise to the public, express their determination to green development and improve the reputation of enterprises [37]. The above studies have proved the promoting effect of mediating variables and moderator variables. On the contrary, other scholars believe that the inhibitory effect also exists. For example, Su Yi et al. [38] found the negative effect of tax incentives. Taking into account the above literature research perspective focused on the influence of external environmental factors of enterprises, the attention of internal factors of enterprises is not high, so the paper will focus on whether internal factors of enterprises play an intermediary role between political connection and green innovation or not. Political connection allows enterprises to achieve economic benefits without paying more R&D investment, triggering 'organizational inertia' and reducing the driving force of green innovation [39,40]. On the contrary, when enterprises prepare to

increase R&D investment, they need to consider the uncertainty of equipment replacement and R&D cycles. These problems make enterprises unable to obtain visual results in the short term, resulting in lack of innovation motivation [41]. In addition, in order to attract government subsidies and tax incentives, politically connected enterprises will increase a large number of less difficult innovation inputs [42]. This kind of simple quantity-seeking speculation increases the R&D investment of enterprises but is not conducive to the output of effective innovation achievements. Therefore, this paper will explore the mechanism of political connection and green innovation from the perspective of R&D investment. Based on the above analysis, we propose the following assumption:

H2.1. *R&D investment (RDexp) plays a mediating role in the impact of political connections on corporate green innovation.*

2.2.2. The Excessive Debt of Enterprises

In addition, referring to the discussions of Shahzad et al. [43] and Lee et al. [44], the behavior of enterprises can be endorsement by political connections, therefore, it is favored by various financial institutions. When financing constraints are reduced, it is more likely to cause excessive debt. At the management level, excessive debt induces a series of short-sighted behaviors such as aggressive debt and crowding out R&D investment [45]. At the strategic level, because the excessive debt caused a large amount of cash outflow, the financial risk is gradually amplified. Considering the risk balance, enterprises will reduce high-uncertainty R&D investment [46]. At the debtor level, even if the enterprise is successful in R&D, creditors can only obtain fixed interest payments. The more the enterprise invests in fixed assets, the more credit it can invest in mortgaged assets, which can also provide repayment guarantee for creditors. This is the very reason creditors question enterprise R&D, limit the use of enterprise funds and hope that enterprises invest in fixed assets [46,47]. Based on the above discussion, this paper makes a further assumption:

H2.2. *The excessive debt of enterprises ($EXLEVB_{it}$) plays an intermediary role in the process of the influence of political connections on green innovation of enterprises.*

3. Sample Selection and Empirical Design

3.1. Sample Selection and Data Source

Taking into account the availability of various indicators and the sample representation of enterprises, the paper uses all A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2008 to 2019 as the original sample. The original sample data of listed companies are from GuoTaiAn CSMAR database, and the data are merged. Further screening process of the samples is as follows. Firstly, since the financial statements of enterprises in the financial industry are quite different from those of other enterprises, the paper selects them according to the CSMAR industry code and excludes the differences in the financial statements of samples in the financial industry. Secondly, it excludes the sample of ST company during the study period. Thirdly, it excludes the sample of asset–liability ratios greater than 1; fourthly, in order to eliminate the influence of extreme value on empirical analysis, all continuous variables are processed by upper and lower 1% winsorize. Finally, it deletes the enterprise samples without the needed relevant variables.

3.2. The Green Innovation of Enterprises

Patent is the most important measure of enterprise innovation activities and output. Based on this theory, the paper uses the natural logarithm lnGPall, which is the sum of green invention patent authorization and green utility model patent authorization of listed companies in the year, to measure the output of innovation activities in the green environment of listed companies. These green patent data of listed companies come from the China National Intellectual Property Administration.

3.3. Political Connections of the Enterprises

Referring to the standard practice of the existing literature, the paper measures the political connection of enterprises by the experience of executives in listed companies; it constructs a binary variable enterprise political connection (PC): if either the chairman or the general manager of the enterprise, or both, is now or has been in the government department, the PC value is 1, otherwise it is 0.

3.4. Empirical Model Setting

In order to verify the above theoretical assumptions, the paper intends to construct a two-way fixed-effect model to discuss the influence of political connection of listed companies on the development of green innovation of enterprises. The specific empirical analysis model is shown in Equation (1):

$$lnGPall_{it} = \beta_0 + \beta_1 PC_{it} + \beta_2 X_{it} + YEAR\_FE + INDUSTRY\_FE + \varepsilon_{it} \quad (1)$$

Among them, the subscripts i, t, respectively, represent the enterprise and the year. The explained variable $lnGPall_{it}$ is the natural logarithm of the green patent authorization of listed company i in the year t, which measures the green innovation output level of listed companies. The core explanatory variable PC_{it} is a virtual variable of whether the listed companies have political connections. Therefore, β_1 is the core parameter to be estimated in this paper, and it is expected that β_1 is significantly negative by theoretical assumptions. In the model, X_{it} is the set of control variables at the enterprise level, which is set as follows. In order to control the macro external environment shock, the paper controls the year fixed effect $YEAR\_FE$. Considering the interference of potential unchanging factors of enterprise industry on causal inference, Equation (1) also controls the fixed effect of enterprise industry $INDUSTRY\_FE$. ε_{it} is a random perturbation term of the model. In order to prevent heteroscedasticity from affecting the reliability of empirical results in this paper, all statistical inferences are discussed based on heteroscedasticity robust standard errors. In summary, the paper will use the panel two-way fixed-effect model of China's A-share listed companies to make empirical analyses of the theoretical assumptions.

3.5. Selection of Control Variables

In terms of control variables, referring to the existing literature standards, in this paper, X_{it} specifically includes: (1) Size is the natural logarithm of the total assets of listed companies at the end of the current year; (2) Age is measured by the company's listed years; (3) Leverage is the ratio of total liabilities of listed companies to total assets in the current year; (4) ROA is the measurement of return on assets of listed companies in the year; (5) Fix is the measurement of fixed asset ratio of listed companies in the year; (6) Cash is the measurement of cash holdings ratio of listed companies in the year; (7) Indratio is the measurement of the proportion of independent directors of listed companies in the year; (8) Boardsize is the measurement of board of directors shareholding ratio of listed companies in that year; (9) Mshare is the measurement of management shareholding ratio of listed companies in that year; (10) Top1 is the measurement of the shareholding proportion of the largest shareholder of listed companies in the year; (11) SOE is a dummy variable. If the listed company is a state-owned enterprise, take 1, otherwise 0; (12) Growth is the income growth rate of listed companies. The variable types, names and definitions are detailed in Table A1 (See Appendix A. Same as below). Table A2 shows detailed descriptive statistics of the variables.

It is necessary to analyze the correlations between the main research variables before conducting empirical regression analysis to prevent the unrecognized problem caused by model misspecification. The correlation test results of control variables are shown in Table A3. It can be seen from Table A3 that the correlation coefficient between the core explanatory variables and each control variable is not large, so there is no systematic error caused by the highly col-linearity problem in this paper.

4. Basic Empirical Results

4.1. Baseline Regression Results

The benchmark stepwise regression results of empirical model (1) are shown in Table 1 below. Table 1 shows the stepwise regression results of the panel fixed-effect model in this paper. The explained variables are the natural logarithm lnGPall of the green patent grants of listed companies in the year. Column (1) is the one-dimensional OLS estimation result, which does not control any fixed effects and control variables; Column (2) adds a series of control variables X_{it}; and Column (3) further adds year fixed effect Year FE and industry fixed effect Industry FE. It can be seen that no matter under what kind of control, the estimated coefficients of all the core explanatory variables of the model's political connection PC are significantly negative at the significance level of 1%, and the coefficients are highly robust. That is, firms with political connections perform worse in green innovation output than firms without political connections. Therefore, the theoretical hypothesis of this paper is verified.

Table 1. Stepwise regression results of the baseline.

	(1)	(2)	(3)
Variable Being Explained	**lnGPall**	**lnGPall**	**lnGPall**
PC	−0.030 ***	−0.061 ***	−0.023 ***
	(0.009)	(0.008)	(0.008)
Size		0.170 ***	0.168 ***
		(0.006)	(0.006)
Leverage		−0.014	0.115 ***
		(0.024)	(0.024)
Age		−0.017 ***	−0.014 ***
		(0.001)	(0.001)
ROA		−0.004	0.027 ***
		(0.009)	(0.010)
Fix		−0.095 ***	−0.255 ***
		(0.025)	(0.028)
Cash		−0.010 ***	−0.005 ***
		(0.001)	(0.001)
Indratio		0.001 **	0.001 ***
		(0.000)	(0.000)
Boardsize		−0.007 ***	−0.007 ***
		(0.002)	(0.002)
Mshare		0.007 ***	0.007 ***
		(0.002)	(0.002)
Top1		−0.167 ***	−0.106 ***
		(0.031)	(0.030)
SOE		−0.025 ***	0.016
		(0.010)	(0.010)
Growth		−0.001 ***	−0.001 ***
		(0.000)	(0.000)

Table 1. *Cont.*

	(1)	(2)	(3)
Variable Being Explained	**lnGPall**	**lnGPall**	**lnGPall**
Year FE	NO	NO	YES
Industry FE	NO	NO	YES
Observations	28,771	28,771	28,771
R-squared	0.000	0.084	0.137

Note: The observation value is at the enterprise level. ***, **, 1%, 5% statistical significance, respectively. The values in parentheses are heteroscedastic robust standard errors. Year FE and Industry FE represent year fixed effect and industry fixed effect, respectively. 'NO' means not controlling the fixed effect, 'YES' means controlling the fixed effect.

4.2. Robustness Test

In order to prevent the endogeneity problem caused by reverse causality, the paper treats the explained variable lnGPall with a one-period lag, and the specific regression model is modified to Equation (2):

$$lnGPall_{it+1} = \beta_0 + \beta_1 PC_{it} + \beta_2 X_{it} + YEAR\_FE + INDUSTRY\_FE + \varepsilon_{it} \quad (2)$$

The estimation results of Equation (2) are shown in Table A4, which shows the stepwise regression results of Equation (2) in detail. Similarly, the explained variables are the natural logarithm lnGPall of the green patent grants of listed companies in that year. The methods used in the columns in Table A4 are consistent with Table 1. It can be seen that no matter under what kind of control, the estimated coefficients of the core explanatory variable PC of all models are significantly negative at 1%, and the coefficients are highly robust. This is highly consistent with the conclusion of Table 1 benchmark regression. Therefore, after considering the potential reverse causality, the conclusion of this paper still exists.

Secondly, the paper replaces the model to estimate in order to ensure the robustness of the conclusions. Since the number of green patents granted by enterprises is not negative, in addition to the traditional two-way fixed-effect model, this paper also adopts the panel-limit dependent-variable Tobit model for estimation. The estimated results of the panel Tobit are also shown in Table A4. The estimated coefficients of core explanatory variables PC were −0.055, −0.035 and −0.022, which were significantly negative at 1%. Therefore, the estimation results of panel Tobit are highly consistent with the panel two-way fixed-effect model. The conclusion of the paper has strong robustness.

Thirdly, green innovation in different dimensions of enterprises is further refined. In this paper, the enterprise green invention patent authorization is refined into alternative energy patent authorization, energy saving patent authorization, waste management patent authorization and administrative supervision design patent authorization and subject to logarithmic processing, and then we discuss the influence of political connection on the development of green innovation in different dimensions.

The impact of political connections on green innovation development in different dimensions is shown in Table A5. Columns (1)–(4) control all control variables and bidirectional fixed effects. As can be seen from the estimation coefficient and aboriginality level of core explanatory variable PC, the inhibition of political connection on enterprise green innovation development is mainly reflected in two areas: alternative energy and administrative regulatory design. The inhibition of enterprise alternative energy patent authorization is greater, while there is no significant impact on the amount of patent authorization for energy conservation and waste management.

5. Further Discussion

5.1. Heterogeneity Analysis

Through the above empirical analysis, the paper has reached a preliminary and robust basic conclusion that the green innovation performance of enterprises with political

connections is significantly worse than that of enterprises without political connections. Then a more important question is, what kind of enterprises will be more affected by this kind of inhibition? This requires further heterogeneity analysis.

Firstly, the influence of the location of the enterprise is considered. China is a vast country with great differences in economic development, social systems and business environments among regions. Compared with the central and western region, the eastern region of China has more enterprises and is more developed. A further question is whether there would be significant differences in different regions where businesses are located. Table 2 examines the impact of political connections on firms' green innovation in the eastern, central, western and northeastern regions. Among them, the subsamples in Columns (1)–(4) are enterprises in the eastern region, the central region, the western region and the northeastern region, respectively. All columns control all control variables and bidirectional fixed effects. It can be seen from the estimated coefficient of the core explanatory variable PC that in the most developed enterprises in the eastern region, the factor of political connection significantly inhibits the green innovation level of enterprises. For the enterprises in the western region, the conclusion is just the opposite: political connection promotes the green innovation level of enterprises. For listed companies in the central and northeastern regions, political connections do not affect the level of green innovation. Therefore, the impact of political connections on corporate green innovation has significant regional heterogeneity.

Table 2. Region and industry heterogeneity analysis.

	Region				**Industry**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable Being Explained	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**
	the eastern region	the central region	the western region	the northeastern region	manufacturing	non-manufacturing
PC	−0.039 ***	−0.017	0.038 **	−0.003	−0.020 *	−0.009
	(0.011)	(0.021)	(0.019)	(0.028)	(0.011)	(0.012)
Size	0.165 ***	0.190 ***	0.134 ***	0.129 ***	0.226 ***	0.099 ***
	(0.007)	(0.012)	(0.011)	(0.018)	(0.008)	(0.007)
Leverage	0.107 ***	0.391 ***	0.192 ***	−0.356 ***	0.287 ***	−0.161 ***
	(0.032)	(0.065)	(0.050)	(0.085)	(0.034)	(0.034)
Age	−0.012 ***	−0.011 ***	−0.021 ***	−0.003	−0.020 ***	−0.011 ***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)
ROA	0.011	0.005	0.079 ***	−0.052 **	0.031 **	0.029 *
	(0.013)	(0.023)	(0.024)	(0.024)	(0.013)	(0.015)
Fix	−0.171 ***	−0.630 ***	−0.133 **	0.005	−0.454 ***	−0.016
	(0.040)	(0.079)	(0.052)	(0.090)	(0.041)	(0.035)
Cash	−0.005 ***	0.005	0.005	−0.010	0.001	−0.015 ***
	(0.002)	(0.005)	(0.004)	(0.008)	(0.002)	(0.002)
Indratio	0.001	0.002	0.003 ***	0.004 **	0.002 ***	−0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Boardsize	−0.008 ***	−0.005	−0.002	0.006	−0.007 ***	−0.004
	(0.002)	(0.006)	(0.008)	(0.007)	(0.003)	(0.003)
Mshare	0.008 ***	0.006	−0.000	−0.005	0.007 ***	0.005

Table 2. *Cont.*

	Region				Industry	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable Being Explained	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**	**lnGPall**
	the eastern region	the central region	the western region	the northeastern region	manufacturing	non-manufacturing
	(0.002)	(0.006)	(0.008)	(0.006)	(0.002)	(0.003)
Top1	−0.108 ***	−0.034	−0.216 ***	0.330 ***	−0.252 ***	0.137 ***
	(0.039)	(0.077)	(0.061)	(0.115)	(0.042)	(0.036)
SOE	0.013	0.061 **	0.049 **	0.066 ***	0.057 ***	−0.043 ***
	(0.013)	(0.026)	(0.021)	(0.024)	(0.014)	(0.011)
Growth	−0.000 ***	−0.001 **	−0.001 ***	−0.001 ***	−0.001 ***	−0.000 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	19,291	4026	4056	1397	17,887	10,884
R-squared	0.145	0.178	0.160	0.159	0.134	0.178

Note: The observation value is at the enterprise level. ***, **, * 1%, 5%, 10% statistical significance, respectively. The values in parentheses are heteroscedastic robust standard errors. Year FE and Industry FE represent year fixed effect and industry fixed effect, respectively. 'NO' means not controlling the fixed effect, 'YES' means controlling the fixed effect.

Secondly, the paper takes the industry heterogeneity into consideration. It further divides the listed companies into the two categories of manufacturing and nonmanufacturing according to the CSRC industry classification code for heterogeneity analysis at the industry level. Table 2 also shows the results of industry heterogeneity analysis. Among them, the subsample of Column (5) is manufacturing enterprises, and the subsample of Column (6) is nonmanufacturing enterprises. The estimated coefficient of the core explanatory variable PC is only significantly negative in Column (5), indicating that the inhibition of political connection on corporate green innovation is mainly reflected in the manufacturing industry.

5.2. Mechanism Analysis

Why do politically connected firms have worse green innovation performance than nonpolitically connected firms? According to the above theoretical hypothesis, the paper argues that less investment in R&D and potential excessive debt are two important mechanisms for the politically connected firms. Based on the above assumption, the paper further analyzes the intermediate effect. The specific mediating effect model is set as Equations (3) and (4):

$$Z_{it} = \gamma_0 + \gamma_1 PC_{it} + \gamma_2 X_{it} + YEAR\_FE + Industry\_FE + \mu_{it} \quad (3)$$

$$lnGPall_{it} = \delta_0 + \delta_1 PC_{it} + \rho Z_{it} + \delta_2 X_{it} + YEAR\_FE + Industry\_FE + v_{it} \quad (4)$$

Among them, Equation (3) is the first step of the mediating effect analysis, and Equation (4) is the second step. If the estimation coefficients γ_1 and ρ are both distinct, then Z_{it} is an important mediating variable.

The paper first takes the R&D investment into consideration. By constructing the natural logarithm of R&D investment RDexp of listed companies in the year as an intermediary variable to identify, the analysis of the mediating mechanism of corporate R&D investment is shown in Table 3. Column (1) is the estimated result of Equation (3) with

R&D investment as the mediating variable. It can be seen from the PC estimation coefficient that it is significantly negative at the 1% significance level. Therefore, the R&D investment of enterprises with political connections is significantly lower than that of enterprises without political connections. The estimated results of Equation (4) in the second step of the mediating effect test are shown in Column (2): the estimated coefficient of RDexp is 0.118, which is significantly positive at 1%. To sum up, political connection reduces the R&D expenditure of enterprises, and the intermediary mechanism of inhibiting green innovation performance is verified.

Table 3. Mechanism Analysis.

	Enterprise R&D Investment		**Excessive Debt of Enterprises**	
	(1)	**(2)**	**(3)**	**(4)**
Variable Being Explained	**RDexp**	**lnGPall**	**EXLEVB**	**lnGPall**
RDexp		0.118 ***		−0.172 ***
		(0.004)		(0.054)
PC	−0.064 ***	−0.020 *	0.002 ***	−0.017 *
	(0.016)	(0.010)	(0.001)	(0.009)
Size	0.873 ***	0.097 ***	−0.051 ***	0.162 ***
	(0.009)	(0.007)	(0.000)	(0.006)
Leverage	−0.726 ***	0.302 ***	0.840 ***	0.227 ***
	(0.055)	(0.032)	(0.003)	(0.052)
Age	−0.027 ***	−0.015 ***	−0.000 ***	−0.015 ***
	(0.002)	(0.001)	(0.000)	(0.001)
ROA	0.483 ***	−0.027 **	0.019 ***	0.041 ***
	(0.029)	(0.014)	(0.001)	(0.011)
Fix	−0.765 ***	−0.205 ***	−0.030 ***	−0.234 ***
	(0.064)	(0.038)	(0.003)	(0.030)
Cash	−0.011 ***	−0.002	0.002 ***	−0.007 ***
	(0.003)	(0.002)	(0.000)	(0.002)
Indratio	0.002 **	0.001 *	−0.000	0.001 ***
	(0.001)	(0.001)	(0.000)	(0.001)
Boardsize	−0.011 ***	−0.005 **	−0.001 ***	−0.009 ***
	(0.003)	(0.002)	(0.000)	(0.003)
Mshare	0.013 ***	0.005 **	0.002 ***	0.009 ***
	(0.003)	(0.002)	(0.000)	(0.003)
Top1	−0.323 ***	−0.099 ***	0.078 ***	−0.084 **
	(0.056)	(0.037)	(0.003)	(0.033)
SOE	−0.034	0.027 **	−0.027 ***	0.018 *
	(0.023)	(0.013)	(0.001)	(0.010)
Growth	0.001 **	−0.001 ***	0.000 ***	−0.001 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Table 3. *Cont.*

	Enterprise R&D Investment		Excessive Debt of Enterprises	
	(1)	(2)	(3)	(4)
Variable Being Explained	**RDexp**	**lnGPall**	**EXLEVB**	**lnGPall**
Observations	22,184	22,184	24,741	24,741
R-squared	0.511	0.163	0.809	0.144

Note: The observation value is at the enterprise level. ***, **, * 1%, 5%, 10% statistical significance, respectively. The values in parentheses are heteroscedastic robust standard errors. Year FE and Industry FE represent year fixed effect and industry fixed effect, respectively. 'NO' means not controlling the fixed effect, 'YES' means controlling the fixed effect.

Secondly, expect that for more political resources and information advantages, enterprises with political connections will also have more opportunities to get loans from financial institutions. Will this advantage bring excessive debt to enterprises, thereby dragging on their green innovation performance? In order to verify this mechanism, based on the discussion of Lu et al. [48], the paper identifies the excessive debt level of enterprises: considering the noise of market debt in China's stock market, the book debt ratio is used to measure the asset–liability ratio of enterprises. To put it more clearly, according to Harford et al. [49] and Denis and Mckeon [50], the annual Tobit regression of the sample of listed companies is used to predict the target debt ratio of enterprises. The benchmark prediction model is as follows:

$$levb_{it} = \alpha_0 + \alpha_1 soe_{t-1} + \alpha_2 roa_{t-1} + \alpha_3 ind\_levb_{t-1} + \alpha_4 growth_{t-1} + \alpha_5 fata_{t-1} + \alpha_6 size_{t-1} + \alpha_7 shrcr1_{t-1} \quad (5)$$

The control variable selection of Formula (5) is based on Chang et al. [38], and the Bayesian information criterion is used to select several important factors that affect the stability and reliability of China's asset–liability ratio. This includes profitability (ROA_{t-1}), the median debt ratio (IND_LEVB_{t-1}), the growth rate of total assets ($Growth_{t-1}$), the proportion of fixed assets to total assets ($FATA_{t-1}$), the size of total assets ($SIZE_{t-1}$) and the ownership concentration: shareholding ratio of the first shareholder ($SHRCR1_{t-1}$). All factors were dealt with in a lag phase.

According to Formula (5), the target debt ratio ($L\hat{E}VB_{it}$) predicted by the enterprise is obtained. After that, the actual debt ratio of the enterprise is subtracted from the actual debt ratio ($L\hat{E}VB_{it}$), which is the excessive asset–liability ratio, as shown in Formula (6). The larger the index ($EXLEVB_{it}$) is, the higher the level of excessive debt of listed companies in the current year:

$$EXLEVB_{it} = True\_LEVB_{it} - L\hat{E}VB_{it} \quad (6)$$

The intermediary mechanism analysis of excessive debt of enterprises is also shown in Table 3. Column (3) is the estimated result of Equation (3) with excessive debt as the mediating variable. It can be seen from the PC estimation coefficient that it is significantly positive at the 1% significance level. Therefore, the over-debt level of enterprises with political connections is higher. The estimated results of Equation (4) in the second step of the mediating effect test are shown in Column (4) of Table 3: the estimated coefficient of EXLEVB is −0.172, which is significantly negative at 1%. Therefore, excessive debt reduces the green innovation performance of enterprises. To sum up, political connection increases the over-debt ratio of enterprises, and the mediating mechanism of inhibiting the green innovation performance of enterprises is verified.

6. Conclusive Comments and Discussions

This paper discusses the influence of political connections on enterprise green innovation and its influencing mechanism. As a consequence, political connections inhibit the level of green innovation, which confirms our hypothesis and is consistent with the results of previous empirical studies [29,51]. In addition, the mechanism analysis is in line with our

hypothesis, i.e., R&D investment and excessive debt ratio play a mediating role, which can also be supported by the existing literature [52–55]. All these conclusions have passed the robustness test. Meanwhile, we conduct a series of heterogeneity analyses for regions and industries for which the results show that political association will have different impacts on green innovation in the East, West, and different industries in China.

In the existing studies, scholars from all over the world generally believe that among all the emerging markets (BRICS and other emerging markets), China is equipped with more sufficient funds and more convenient financial institutions, where fewer financing constraints are required for enterprises. Correspondingly, the whole financing process must be supported by relevant laws and regulations to ensure the good operation of capital flow. However, compared with developed countries, China's domestic market system is not perfect at present, with some laws still in the pilot stage, giving enterprises the motivation to pursue political connections. Enterprises can enjoy efficient financing conditions and ensure profitability through political and business relations. On the contrary, the lack of political connections of SMEs, together with the difficulty of financing, is always a problem to be solved in China's economic system. Under these circumstances, the important role of political connections breeds a series of nonmarket strategies, such as corruption. Daily capital operation and production behavior can be ensured by enterprises through sound political connections, without which the resulting 'organizational inertia' has a destructive impact on green innovation. Therefore, it is just because of the existence of China's efficient financing environment that the conclusion obtained in this paper is different from that obtained [28] when the observation object is set as other emerging markets.

Our study is subject to several limitations. (1) Based on the mediating effect of R&D investment and excessive debt ratio, this paper empirically analyzes the influence mechanism of political connections on corporate green innovation. However, the perspective of this paper mainly focuses on the internal governance of enterprises, with insufficient attention paid to the external environment. For instance, the relationship between political connections and green innovation may also be influenced by external factors such as political turnover [56] and negotiation intentions [57], which may have moderating effects on the two. (2) Due to the differences in political connections in different economic environments and political systems, political connections and green innovation are highly bound to China's socialist market economic system, so this paper lacks comparative analysis with different economic environments.

Combined with the limitations of this study, the key areas of future research are as follows: (1) Enrich the research perspective, incorporate the external environment into the consideration of mechanism analysis, and test whether internal and external factors can interact with the relationship between political connections and green innovation. (2) Researchers need to compare and analyze the influence of political connections on green innovation in different economic environments and further verify the influencing mechanism of political connections on enterprise green innovation.

In general, we focus on China, an emerging economy that is undergoing industrial transformation and rising economic strength, hoping to contribute to the green innovation field. It is worth mentioning that our study found that the inhibition of political connections on enterprise green innovation was mainly reflected in the manufacturing industry rather than in the nonmanufacturing industry. However, it is precisely the manufacturing industry that urgently needs to carry out green innovation and reduce pollution levels, which suggests that countries should weaken the political connections of their manufacturing industries and reduce their protection. Such a strategy can, in return, force manufacturing enterprises to improve their green innovation ability.

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Appendix A

Table A1. Variable description.

Variable Type	Variable Name	Variable Definition Description
Variable being explained	lnGPall	The sum of natural logarithms of all green invention patents and green utility models granted by listed companies
Core explanatory variable	PC	Virtual variable: If a listed company has a political connection then take 1, otherwise 0
Control variables	Size	ln (Total assets of listed companies at the end of the year)
	Leverage	The proportion of total liabilities to total assets of listed companies
	Age	Listing years of listed companies
	ROA	Return on assets of listed companies in the year
	Fix	The proportion of fixed assets in total assets of listed companies in the year
	Cash	The cash holding ratio of listed companies in the year
	Indratio	The proportion of independent directors of listed companies in the year
	Boardsize	Shareholding ratio of board of directors of listed companies
	Mshare	Shareholding ratio of management in listed companies
	Top1	Shareholding ratio of the largest shareholder of listed companies in the year
	SOE	Whether the listed companies are the state-owned enterprises
	Growth	Growth rate of operating income of listed companies in the year

Table A2. Descriptive statistics of variables.

	Obs	Mean	Std.	Min	Median	Max
lnGPall	28,771	0.291	0.702	0	0	6.771
PC	28,771	0.35	0.477	0	0	1
Size	28,771	22.05	1.288	19.35	21.868	26.395
Leverage	28,771	0.423	0.209	0.027	0.415	0.936
Age	28,771	9.37	7.084	0	8	27
ROA	28,771	0.485	0.465	−0.581	0.407	3.037
Fix	28,771	0.217	0.164	0.002	0.183	0.769
Cash	28,771	1.228	2.217	0.036	0.559	30.123
Indratio	28,771	38.611	10.073	0	37.5	66.667
Boardsize	28,771	10.88	18.578	0	0.058	68.606
Mshare	28,771	11.545	19.494	0	0.082	70.869
Top1	28,771	0.351	0.149	0.082	0.332	0.758

Table A2. *Cont.*

	Obs	Mean	Std.	Min	Median	Max
SOE	28,771	0.369	0.482	0	0	1
Growth	28,771	15.346	32.188	−57.228	11.001	166.265

Data Source: Authors' calculations.

Table A3. Correlation coefficient matrix.

	PC	Size	Leverage	Age	ROA	Fix	Cash	Indratio	Boardsize	Mshare	Top1	SOE	Growth
PC													
Size	0.03 ***												
Leverage	0.01	0.50 ***											
Age	−0.06 ***	0.37 ***	0.38 ***										
ROA	0.04 ***	−0.02 ***	0.11 ***	−0.02 ***									
Fix	0.03 ***	0.10 ***	0.10 ***	0.08 ***	0.07 ***								
Cash	−0.02 ***	−0.26 ***	−0.52 ***	−0.25 ***	−0.08 ***	−0.18 ***							
Indratio	0.04 ***	−0.05 ***	−0.03 ***	−0.07 ***	0.14 ***	−0.01 **	0.06 ***						
Boardsize	0.02 ***	−0.31 ***	−0.33 ***	−0.50 ***	−0.01	−0.16 ***	0.24 ***	0.07 ***					
Mshare	0.02 ***	−0.32 ***	−0.33 ***	−0.51 ***	−0.01	−0.16 ***	0.25 ***	0.07 ***	0.99 ***				
Top1	0.01 **	0.20 ***	0.06 ***	−0.07 ***	0.11 ***	0.08 ***	0.00	0.05 ***	−0.08 ***	−0.09 ***			
SOE	−0.03 ***	0.35 ***	0.31 ***	0.42 ***	0.12 ***	0.22 ***	−0.15 ***	−0.04 ***	−0.43 ***	−0.43 ***	0.23 ***		
Growth	0.01 **	0.02 ***	0.00	−0.11 ***	0.08 ***	−0.10 ***	−0.01 *	0.01	0.12 ***	0.12 ***	−0.03 ***	−0.11 ***	

Note The observation value is on the enterprise level. ***, **, * 1%, 5%, 10% statistical significance, respectively.

Table A4. Robustness test 1,2. Solution to the problem of reverse causality and estimation of panel Tobit model.

	Reverse Causality			Tobit		
	(1)	(2)	(3)	(1)	(2)	(3)
Variable Being Explained	F.lnGPall	F.lnGPall	F.lnGPall	F.lnGPall	F.lnGPall	F.lnGPall
PC	−0.025 ***	−0.061 ***	−0.024 ***	−0.055 ***	−0.035 ***	−0.022 ***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Size		0.182 ***	0.180 ***		0.103 ***	0.086 ***
		(0.006)	(0.006)		(0.005)	(0.005)
Leverage		−0.050 *	0.080 ***		0.013	0.075 ***

Table A4. *Cont.*

	Reverse Causality			Tobit		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Variable Being Explained	**F.lnGPall**	**F.lnGPall**	**F.lnGPall**	**F.lnGPall**	**F.lnGPall**	**F.lnGPall**
		(0.027)	(0.028)		(0.025)	(0.025)
Age		−0.018 ***	−0.015 ***		0.001	−0.009 ***
		(0.001)	(0.001)		(0.001)	(0.001)
ROA		0.032 ***	0.042 ***		−0.041 ***	−0.026 **
		(0.010)	(0.011)		(0.008)	(0.011)
Fix		−0.095 ***	−0.270 ***		0.076 **	0.078 **
		(0.028)	(0.031)		(0.031)	(0.031)
Cash		−0.010 ***	−0.006 ***		−0.004 **	−0.001
		(0.002)	(0.002)		(0.002)	(0.002)
Indratio		0.001 **	0.001 ***		0.001 ***	0.001 ***
		(0.000)	(0.000)		(0.000)	(0.000)
Boardsize		−0.007 ***	−0.006 ***		−0.001	−0.002
		(0.002)	(0.002)		(0.002)	(0.002)
Mshare		0.007 ***	0.006 ***		0.002	0.002
		(0.002)	(0.002)		(0.002)	(0.002)
Top1		−0.181 ***	−0.123 ***		−0.144 ***	−0.097 ***
		(0.034)	(0.032)		(0.037)	(0.037)
SOE		−0.015	0.022 **		−0.057 ***	0.017
		(0.010)	(0.011)		(0.015)	(0.016)
Growth		−0.000 ***	−0.000 **		−0.001 ***	−0.001 ***
		(0.000)	(0.000)		(0.000)	(0.000)
Year FE	NO	NO	YES	NO	NO	YES
Industry FE	NO	NO	YES	NO	NO	YES
Observations	24,936	24,936	24,935	28,771	28,771	28,771
R-squared	0.000	0.087	0.142	3624	3624	3624

Note: The observation value is at the enterprise level. ***, **, * 1%, 5%, 10% statistical significance, respectively. The values in parentheses are heteroscedastic robust standard errors. Year FE and Industry FE represent year fixed effect and industry fixed effect, respectively. 'NO' means not controlling the fixed effect, 'YES' means controlling the fixed effect.

Table A5. Robustness Test 3. The impact of political connection on green innovation in different dimensions of enterprises.

	(1)	(2)	(3)	(4)
Variable Being Explained	**log(1 + Alternative Energy Patent Authorization)**	**log(1 + Energy Saving Patent Authorization)**	**log(1 + Waste Management Patent Authorization)**	**log(1 + Administrative Supervision Design Patent Authorization)**
PC	−0.010 **	−0.006	0.003	−0.004 **
	(0.004)	(0.006)	(0.005)	(0.002)
Size	0.070 ***	0.085 ***	0.079 ***	0.017 ***
	(0.004)	(0.004)	(0.004)	(0.001)
Leverage	0.007	0.020	0.017	−0.010 *
	(0.013)	(0.016)	(0.015)	(0.006)
Age	−0.004 ***	−0.006 ***	−0.005 ***	−0.000 **
	(0.000)	(0.000)	(0.000)	(0.000)
ROA	0.012 *	0.001	0.041 ***	0.001
	(0.006)	(0.006)	(0.007)	(0.002)
Fix	0.028 *	−0.217 ***	0.041 **	−0.059 ***
	(0.015)	(0.019)	(0.018)	(0.006)
Cash	−0.001 *	−0.003 ***	0.001	−0.001 ***
	(0.001)	(0.001)	(0.001)	(0.000)
Indratio	0.001 **	0.001 ***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Boardsize	−0.001	−0.005 ***	−0.002 **	−0.001 *
	(0.001)	(0.002)	(0.001)	(0.001)
Mshare	0.000	0.005 ***	0.002 **	0.001 **
	(0.001)	(0.002)	(0.001)	(0.001)
Top1	−0.020	−0.055 ***	−0.030 *	0.001
	(0.016)	(0.021)	(0.018)	(0.007)
SOE	−0.014 ***	−0.001	0.018 ***	0.007 ***
	(0.005)	(0.007)	(0.005)	(0.003)
Growth	−0.000 ***	−0.000 ***	−0.000 ***	−0.000 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	28,771	28,771	28,771	28,771
R-squared	0.077	0.071	0.107	0.037

Note: The observation value is at the enterprise level. ***, **, * 1%, 5%, 10% statistical significance, respectively. The values in parentheses are heteroscedastic robust standard errors. Year FE and Industry FE represent year fixed effect and industry fixed effect, respectively. 'NO' means not controlling the fixed effect, 'YES' means controlling the fixed effect.

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