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Original Research

The Influence of Marketization Process on Enterprise Green Innovation: Empirical Evidence from Chinese Listed Enterprises

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Abstract

How to promote enterprises to participate in green innovation is the key to alleviate environmental problems. Although this question has attracted increasing attention, there is a lack of in-depth discussion on the impact of the external environment on green innovation, especially the role of the marketization process. In view of this, taking Chinese listed companies from 2007 to 2019 as samples, this paper analyzes the relationship between the marketization process and enterprise green innovation, and further explores the moderating impact of environmental uncertainty and organizational slack. The results show that the marketization process has a positive impact on green innovation. In addition, environmental uncertainty enhances the positive relationship between the marketization process and green innovation, while organizational slack plays a negative moderating role. Therefore, it is necessary for the government to further improve the degree of marketization, which could create a good business environment for the development of enterprises.

Keywords: marketization process, enterprises green innovation, organizational slack, environmental uncertainty

Introduction

Tackling increasingly serious environmental problems and realizing sustainable economic development have become a global challenge. In this context, as the main market entity that provide products and services to society and the main source of environmental pollution, it has become a social consensus that enterprises need to practice the initiative of green development. For example, the European Union issued the Environmental Protection Directive in 2005, requiring companies to strengthen the supervision of production and service processes to reduce adverse effects on the environment. Correspondingly, enterprises have actively participated in environmental protection, such as donating to

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environmental organizations and using clean energy. Among these activities, green innovation, as a kind of technological innovation aiming at reducing environmental pollution to achieve sustainable development [1], has received much attention from stakeholders such as the government, consumers, and non-governmental organizations. According to the extant literature, green innovation can not only help enterprises improve their legitimacy and cope with environmental pressure from stakeholders, but also create competitive advantage by reducing production costs and establishing the advantage of product differentiation [2-4]. However, as green innovation requires long-term and continuous resource investment [5], the process of implementing green innovation is highly uncertain and risky [6-7]. Moreover, although green innovation has the dual externalities of reducing environmental pollution and increasing knowledge creation, it does not necessarily bring significant benefits to enterprises [4]. Therefore, enterprises aiming at profit maximization lack the enthusiasm to engage in green innovation, and how to promote enterprises to carry out green innovation has become a key problem that needs to be solved urgently.

Scholars have comprehensively explored multiple factors that influence enterprises' green innovation, including the government's environmental regulation policy, financial subsidy policy [8-9], pressure from consumers and suppliers [10], corporate strategy [11], corporate resources [12], corporate capability [13], and personal factors of top executives [14]. Among them, insufficient resource input is considered to be the key reason to hinder green innovation, and government financial subsidies, tax incentives, and other policies can compensate for the lack of resources, thus enhancing the enthusiasm of enterprises for green innovation [5,15]. Therefore, policy factors have become the focus of literature on green innovation. However, government support for corporate green innovation may have negative effects. According to Wallsten (2000) and Becker (2015), although the government can compensate for the resource shortage of enterprises and reduce the risk of innovation, it may have a crowding-out effect on R&D investments [16-17]. For example, some enterprises could engage in rent-seeking behavior to obtain government subsidy, and further crowd out the R&D investment of enterprises, which will not only reduce the effectiveness of government innovation policies but also affect the quality of green innovation [18].

In addition to examining the factors affecting green innovation from the government perspective, scholars' research in the field of innovation also emphasizes the role of "invisible hand", that is, the market mechanism. Arrow (1962) argued that in a perfectly competitive market, enterprises choose to alleviate external competition pressure by improving their level of innovation [19]. However, current empirical research on green innovation pays more attention to government factors, and few studies explore the influence of the market mechanism on enterprises. To fill this research gap, we explore the effect of marketization on firms' green innovation, which has not been empirically tested. The marketization process refers to the marketization level of the region where the enterprise is located, which mainly involves the relationship between the government and the enterprise, development of a non-state-owned economy, development of the product and factor markets, and improvement of the institutional environment [20]. Compared with developed economies, emerging economies lack a sophisticated institutional framework. For example, capital markets are underdeveloped and enterprises rely heavily on government policies in emerging economies [21].

As the world's largest emerging economy, China has implemented market-oriented reform since the year 1978. The most important goal of this reform is to transform the former planned economic system into a market-based economic system, so that the market mechanism can play a decisive role in resource allocation. However, owing to unbalanced regional development, the marketization process varies greatly from region to region. In regions where the marketization process is fast, the market mechanism, legal environment, and regulatory mechanisms are perfect, which can create a good business environment for enterprises. In contrast, the level of government intervention is higher and market allocation efficiency is lower in regions with a slower marketization process [20]. In view of this, scholars regard the marketization process as a typical feature of Chinese economy, and discuss the differences among enterprises in regions with different degrees of marketization [22, 23]. In the research of marketization process, how to coordinate the relationship between government and enterprises is the focus of discussion. However, under the background of strengthening environmental supervision, one reason why environmental problems can't be effectively solved is that some local governments collude with enterprises and sacrifice the environment for the goal of economic growth [24]. Therefore, this study explores the relationship between marketization process and enterprises' green innovation.

In addition, we further discuss which factors could moderate the relationship between marketization process and green innovation. Given that the external market environment faced by Chinese enterprises could also affect corporate decision making, we analyze the moderating effect of environmental uncertainty. Environmental uncertainty refers to a state in which enterprise managers cannot accurately predict environmental changes when they lack a sufficient understanding of external environmental information [25]. Panousi & Papanikolaou (2012) believed that environmental uncertainty could increase enterprises' risk aversion tendency and reduces investment in

high-risk projects, especially innovation activities [26]. Therefore, in the process of marketization affecting the green innovation of enterprises, what role will environmental uncertainty play? Moreover, organizational resources are also important for enterprises to cope with environmental challenges [27]. Organizational slack, as an underutilized resource within an enterprise, is considered by scholars to play the role of a resource pool, which can not only alleviate the negative impact of the external environment, but also help enterprises to better utilize the opportunities in the external environment [28]. Therefore, this study further explores whether organizational slack can enhance or weaken the marketization process's impact on corporate green innovation.

Compared with the existing literature, the marginal contributions of this research are reflected in the following three aspects. First, it discusses the impact of the marketization process on green innovation. Although scholars generally believe that market-oriented reform has profoundly changed the internal and external environments of Chinese enterprises [29], the research on the role of the marketization process is scarce, which cannot effectively explain the deep-seated reasons for the behavior of Chinese enterprises, including green innovation. Therefore, this study is an important supplement to the existing research. Second, this study explores the boundary conditions under which the marketization process affects green innovation, including environmental uncertainty and organizational slack. The research findings are helpful to further explain how enterprises in the volatility, uncertainty, complexity, and ambiguity (VUCA) areas can realize green innovation. Third, this study provides valuable references and suggestions for green innovation of enterprises and how the government can improve the green innovation ability of enterprises by promoting market-oriented reform. Our empirical findings have significant policy implications for environmental innovation in China and similar emerging countries.

The remainder of this paper is organized as follows. Section 2 presents the theoretical analysis and hypotheses. Section 3 describes the data and the methodology used. Section 4 reports the empirical procedures and major findings. The conclusions and discussion of the results are presented in section 5.

Theoretical Basis and Hypothesis

The Impact of Marketization Process on Green Innovation

In addition to the internal governance of the enterprise, risk preference of executives and other factors, firm innovation is also affected by the external market environment [30]. The degree of marketization process represents the competitive environment of the region in which the enterprise is located, and whether the market mechanism can play its due role in resource allocation. In the process of Chinese economic reform for more than 40 years, government intervention mechanism and market regulation mechanism coexist, which jointly affect the strategic choice of enterprises [22]. Therefore, the marketization process has become a pivotal factor that affects green innovation of enterprises. The specific reasons for this are as follows.

On the one hand, from the perspective of improving the willingness and enthusiasm of enterprises for green innovation, when the degree of marketization is high, the institutional environment in the regions could be more perfect, and there is a higher transparency of market information, which can help the public obtain more comprehensive enterprise information, especially meet the public's concern about environmental protection activities of enterprises. Therefore, the marketization process will cause enterprises to face higher pressure for environmental protection. Enterprises must achieve clean production, reduce pollution emissions, and improve energy utilization through green innovation to meet stakeholders' expectations for environmental protection [31]. Li et al. (2018) pointed out that legality pressure related to environmental protection could positively affect enterprises' willingness to undertake green innovation [32]. In addition, with the improvement in marketization, there will be less government intervention. The supply and price of products are determined primarily by market mechanisms rather than by government officials. At this time, the competition among firms could become more intense, prompting enterprises to improve the quality of products and services to meet the needs of consumers [33]. Green innovation is considered to be an important method to improve product advantage and market competitiveness because it can shape the good image of enterprises and the differentiated characteristics of products [32]. Consequently, the market competition faced by enterprises can increase their willingness to engage in green innovation.

On the other hand, from the perspective of meeting the resources required for green innovation, obtaining sufficient resource support is the basis for improving the performance of green innovation and achieve sustainable development of enterprises [34]. This is also an important reason why some studies believe that government support can enhance the green innovation of enterprises. As an important factor affecting the allocation of resources and circulation of elements, the degree of marketization is related to the impact of government administrative intervention on the development of enterprises. In areas with high marketization processes, sufficient market competition can achieve the survival of the fittest, optimize the allocation of innovative resources, promote the efficient flow of production factors, such as manpower, capital, and technology, and meet the resource needs of

enterprises in innovative activities [35]. For example, Wu et al. (2020) [36] found that in regions with a high degree of marketization, enterprises are more likely to obtain credit funds and venture capital and attract R&D personnel, which can improve technological innovation ability. Therefore, we propose the following hypothesis:

Hypothesis 1: Marketization process can promote green innovation.

The Moderation Effect of Environmental Uncertainty

In the process of economic reform, the government's intervention in enterprise management has gradually decreased, and the strategic decisions of enterprises are often more affected by the external environment. Since the improvement of marketization means that the market mechanism plays a much more important role, the change in the market environment may have a profound impact on enterprises. For example, empirical work shows that if a company is located in a region with a high degree of marketization, it is more likely that the company will experience a fall in stock prices and undervalued market value before adapting to fluctuations in the external environment [37]. Therefore, it can be considered that market environment is a boundary condition that affects the relationship between the marketization process and green innovation.

Environmental uncertainty refers unpredictable and frequent changes in the external market environment faced by firms, which explains the degree of environmental instability, complexity, and unpredictability [38-39]. When the enterprise is in an external environment with high uncertainty, the knowledge and technology that the enterprise has in the past would be quickly eliminated, thus prompting the enterprise to improve the ability to cope with changes in the external environment through continuous technological innovation. Chan (2005) found that enterprises in a dynamic environment are more inclined to increase resource input to improve organizational capabilities, thereby reducing the negative impact of environmental changes [40]. In addition, the rapid change of external environment will increase the uncertainty of market demand. Enterprises must meet the diversified needs of consumers by providing new products and services and effectively seizing more market opportunities. At present, consumer demand for green products and services, such as new energy vehicles and green home appliances, is gradually increasing [41], prompting enterprises to carry out green innovation under the influence of market-oriented mechanisms. Finally, competition in a fast-changing environment could be more intense, making it difficult for enterprises to maintain their original market position by relying on traditional business operations. Enterprises must engage in more innovative strategies to establish competitive market advantages and maintain the survival and development of enterprises. As noted earlier, green innovation is one of the main paths for enterprises to establish competitive advantage [42]. Therefore, we propose:

Hypothesis 2: Environmental uncertainty positively moderates the impact of the marketization process on green innovation.

The Moderation Effect of Organizational Slack

The resource-based view holds that the key to enterprise innovation lies in having enough resources [43]. Among the types of organizational resources, organizational slack is defined as resources "that are currently uncommitted and can be deployed easily within organizations," such as financial slack and human resource slack [44]. While slack resources are important for an organization, previous studies have shown that there are two opposing views on the effects of organizational slack.

Some scholars believe that organizational slack can alleviate enterprises' resource constraints [45], and encourage companies to increase R&D investment and engage in innovative activities with potentially high returns [46]. Furthermore, when a firm has a certain degree of redundant resources, it is likely to utilize slack resources to adapt to multiple conflicting goals, make decisions quickly, and take actions to seize uncertain opportunities in the external environment [47].Therefore, compared with enterprises with low organizational slack, firms with high organizational slack can not only adapt to the fierce market competition brought about by marketization, but also have stronger incentives and abilities to participate in green innovation.

However, some studies show that organizational slack has a negative impact on enterprises [48]. This is because organizational slack, as a kind of excess resource, not only requires enterprises to bear additional management costs, but also means that enterprises cannot achieve effective use of resources [49], whereas enterprises need to have sufficient resource allocation ability to compete with other enterprises in a fast-changing environment. Moreover, based on agency theory, scholars believe that managers use slack resources to meet personal interests, such as establishing personal power empires and obtaining personal reputation, which causes agency problems and has a negative impact on the development of enterprises [28].

In addition, organizational slack may also make managers overly optimistic and overconfident [50], and consequently misestimate the sustainability and variability of the external environment. This prejudice makes it easy for enterprises to meet the status quo of operation [51], ignoring the problems and risks existing in the enterprise, thereby reducing the ability of the enterprise to adapt to the external environment [52]. Sensitivity to environmental changes is an important

reason for enterprises to increase their willingness to engage in green innovation. Therefore, compared with companies with low slack resources, companies with more organizational slack may reduce their investment in green innovation, and thus, ultimately affect green innovation. Based on the above analysis, we propose the following competing hypotheses:

Hypothesis 3a: Organizational slack positively moderates the impact of the marketization process on green innovation.

Hypothesis 3b: Organizational Slack Negatively Moderates the Impact of the Marketization Process on Green on green innovation.

Methodology

Sample and Data

Our research sample comprises Chinese A-share listed firms for the period from 2007 to 2019. The data are obtained from three sources. The marketization process data are obtained from the "China Marketization Process Index Report" developed by Wang et al. (2019) [53], which has been widely used in empirical studies [22, 54]. The data on financial information is collected from the China Stock Market & Accounting Research database (CSMAR), and the data on green patents are from the Chinese Research Data Services Platform database (CNRDS). These two databases are the most commonly used financial databases for Chinese listed companies. To ensure data quality, we further screen the initial sample following prior literature. First, we exclude financial and insurance firms because they are subject to different accounting rules and regulations, which may lead to outliers in the results. Second, to guarantee the stability and validity of the sample, ST and *ST companies are deleted because their financial data may deviate from normal values, which may bias the regression results. Third, companies with incomplete or missing data are excluded. Fourth, to control for outliers, all continuous variables are winsorized at the 1% level in both tails. After these steps, our final sample consists of 14, 046 firm-year observations.

Variables

Dependent Variable

The dependent variable in this study is green innovation (*GI*). Given that patents that have passed the substantive examination of the patent office can more objectively reflect the innovation ability of enterprises [55], we use the number of green patent authorizations to measure enterprises' green innovation. To ensure the reliability of the research conclusions and avoid errors caused by the selection of dependent variable indicators, a robustness test is carried out with the number of enterprise green patent applications to measure green innovation [56].

Independent Variable

The independent variable is the marketization process (*Market*). The Marketization Index of China's Provinces developed by Wang et al. (2019) [53] is used to measure the regional marketization process. This index consists of five aspects: the relationship between the government and the market, the development of a non-state-owned economy, the development of the product market, the development of the factor market, the market intermediary organization, and the legal system environment.

Moderating Variables

Two moderating variables are used in this study. The measurement of environmental uncertainty (*EU*) refers to the method used by Ghosh & Olsen (2009) [57]. In the existing literature, organizational slack is divided into three main types: available, recoverable, and potential slack [58]. Compared with other types, available slack is the most fluid resource and plays an important role in enterprise development; this study mainly focuses on the role of available slack (*Slack*) [59]. We draw on the method of Tabesh et al. (2019) [60] using the current ratio (current assets/current liabilities) to measure available slack. A higher current ratio indicates that the company has more slackness.

Control Variables

We control the variables that affect green innovation at the firm level. (1) Enterprise size (*Size*) measured using the natural logarithm of main business income. (2) Enterprise performance (*ROA*), measured as the ratio of net profit to total assets. (3) State-owned enterprise (*SOE*): if the actual controller of the enterprise is state-owned, the value is 1; otherwise, it is 0. (4) Enterprise maturity (*Age*), measured by the logarithm of enterprise age. (5) Enterprise risk (*Risk*), measured as the product of the enterprise's financial leverage and operating leverage. (6) Enterprise debt (*Debt*), measured as the ratio of the total liabilities of the enterprise to total assets. (7) Independent directors (*INDEP*), measured as the ratio of independent directors to board members. (8) Ownership concentration (*Top1*), measured as the ratio of the number of shares held by the largest shareholder to the total number of shares. (9) Tobin's Q (*Tobinq*), measured as year-end market value divided by replacement cost. Table 1 further summarizes the variables and their measurements.

Empirical Model

Refer to Becker (2011) [61] (Reviewer 1, Comment 1, 2). We construct the following regression model

Table 1. Variables used in this research.

Variables	Symbols	Measuring methods
Green Innovation	GI	The number of green patent authorizations
Marketization process	Market	Marketization Index
Environmental uncertainty	EU	Standard deviation of abnormal sales revenue over the past five years, excluding industry influences
Organizational slack	Slack	The current ratio
Firm size	Size	The natural logarithm of business income
Enterprise performance	ROA	The ratio of net profit to total assets
Firm ownership	SOE	Dummy, 1 if the firm was state-owned firm
Enterprise risk	Risk	The product of the enterprise's financial leverage and operating leverage
Enterprise debt	Debt	The ratio of the total liabilities of the enterprise to total assets
Tobin's Q	Tobinq	Year-end market value divided by replacement cost
Independent directors	INDEP	The ratio of independent directors
Enterprise maturity	Age	The logarithm of enterprise age
Ownership concentration	Top1	The ratio of the number of shares held by the largest shareholder

to analyze the impact of the marketization process on enterprise green innovation:

$$GI_{it} = \alpha_0 + \alpha_1 Market_{it} + \alpha_2 Controls + Year + Industry + \varepsilon_{it} \quad (1)$$

In Model (1), GI_{it} is the natural logarithm of the number of green patents granted by firm i in year t. Since a large number of companies have zero patents, this study adds 1 to the number of patents; $Market_{it}$ is the marketization index of the province where enterprise i is located; *Controls* are control variables, including enterprise size (*Size*), enterprise performance (*ROA*), state-owned enterprise (*SOE*), enterprise maturity (*Age*), enterprise debt (*Debt*), independent directors (*INDEP*), ownership concentration (*Top1*), and Tobin's Q (*Tobinq*); *Year* and *Industry* represent time fixed effect and industry fixed effect, respectively; ε_{it} represents the disturbance term. Based on Model (1), we constructed Models (2) and (3) to test the hypothesis of the moderating effect. In model (2), $Market_{it}$, the production $Market_{it}$ and EU_{it} are added to the model. In model (3), $Market_{it}$, the production of $Market_{it}$ and $Slack_{it}$ are added to the model.

$$GI_{it} = \alpha_0 + \alpha_1 Market_{it} + \alpha_2 EU_{it} + \alpha_3 Market_{it} * EU_{it} + \alpha_4 Controls + Year + Industry + \varepsilon_{it} \quad (2)$$

$$GI_{it} = \alpha_0 + \alpha_1 Market_{it} + \alpha_2 Slack_{it} + \alpha_3 Market_{it} * Slack_{it} + \alpha_4 Controls + Year + Industry + \varepsilon_{it} \quad (3)$$

Data Analysis and Hypothesis Testing

Results of Descriptive Statistics and Correlation Analysis

Table 2 reports the means, standard deviations, and correlation matrices of the main research variables. The mean value of green innovation (*GI*) is 0.486, and the standard deviation reaches 0.847, indicating that green innovation is not balanced and that there are large differences. The average value of the marketization process (*Market*) is 8.079 and the standard deviation is 1.908, meaning that the marketization process varies greatly among provinces. On average, the environmental uncertainty (*EU*) and organizational slack (*slack*) of each listed company are 1.307 and 1.984, respectively. The standard deviation of the two variables indicates that the environmental uncertainty and organizational slack in the sample are quite different. In terms of the control variables, the standard deviation of each variable is large, suggesting that there are large differences between enterprises. Table 3 shows the correlation coefficient matrix between these variables. The relationship between the marketization process (*Market*) and green innovation (*GI*) is positive and significant (r = 0.132, p<0.01), which preliminarily supports Hypothesis 1. In addition, the variance inflation factor (VIF) of the regression equations is less than five, indicating that multicollinearity is not serious for this research.

Table 2. Descriptive statistics.

Symbols	Mean	Std. Dev.	Min	Max
GI	0.486	0.847	0	3.738
Market	8.079	1.908	3.130	11.04
EU	1.307	1.190	0.123	7.086
Slack	0.486	0.847	0.257	11.31
Size	8.079	1.908	19.83	26.07
ROA	1.307	1.190	-0.197	0.192
SOE	1.984	1.768	0	1
Risk	-0.104	1.171	0.889	19.88
Debt	22.230	1.198	0.0495	0.872
Tobinq	0.034	0.056	0.886	7.687
INDEP	0.500	0.500	0.313	0.571
Age	2.701	3.120	4	26
Top1	0.458	0.201	8.860	74.96

Regression Analysis

Marketization Process and Green Innovation

Table 4 reports the results of regression analysis. As shown in column (1), the marketization process has a significant positive impact on green innovation at the 1% level (β = 0.042, p<0.01), indicating that the marketization process increases green innovation, which supports hypothesis H1.

Moderating Effect Test

Columns (2) and (3) of Table 4 show the regression results of the moderating effects of environmental uncertainty and organizational slack, respectively. In Column (2), the coefficient of the interaction term (Market*EU) is positive and statistically significant (β = 0.006, p<0.05), indicating that environmental uncertainty has a significant positive moderating effect on the marketization process and enterprise green innovation, thus supporting Hypothesis 2. In Column (3), the interaction term (Market*Slack) has a negative coefficient and is statistically significant (β = -0.013, p<0.001), implying that organizational slack (*Slack*) can weaken the positive effect of marketization on enterprise green innovation; hence, Hypothesis 3b is supported.

Robustness Test

Lag Analysis

Because the impact of the marketization process on green innovation may have a time lag, we further use the number of green patent authorizations that lag one period. The regression results are reported in Column (1) of Table 5. After excluding the influence of the time lag, the coefficient of the marketization process remains positive and statistically significant (β = 0.156, p<0.001).

Alternative Measure of Dependent Variables

To enhance the robustness of the research conclusions, we change the method used to measure green innovation. Although the number of authorized green patents of enterprises can better reflect their actual innovation ability, some studies have pointed out that patents are likely to have an impact on enterprise performance during the application process. To mitigate the problem caused by variable measurement, this study further uses the number of patent applications to measure green innovation. As shown in Column (2) of Table 5, the results are consistent with previous findings.

Change the Regression Model Using Tobit Test

To enhance the robustness of the research conclusions, this study uses different regression models to test these hypotheses. As the number of patents of listed companies has a large number of zero values and is characterized by censored data, this study uses the Tobit regression model to further test the influence of the marketization process on enterprise green innovation. Columns (3)-(5) of Table 5 present the regression results of the Tobit model. After changing the regression method, the marketization process still has a significant positive effect on green innovation, proving the reliability of the previous benchmark regression results.

Table 3. Results of correlation analysis.

	GI	Market	EU	Slack	Size	ROA	SOE	Risk	Debt	Tobinq	INDEP	Age	Top1	VIF
Green Innovation	1													
Market	0.132***	1												1.150
EU	-0.035***	-0.057***	1											1.030
Slack	-0.089***	0.105***	0.011	1										1.800
Size	-0.005	0.240***	0.014*	0.201***	1									1.710
ROA	0.293***	0.026***	-0.026***	-0.282***	-0.211***	1								1.610
SOE	-0.026***	0.034***	-0.074***	0.207***	0.008	0.051***	1							1.550
Risk	-0.002	-0.258***	-0.059***	-0.219***	-0.440***	0.222***	-0.068***	1						1.510
Debt	0.015	-0.131***	0.002	-0.215***	-0.087***	0.050***	-0.429***	0.113***	1					1.270
Tobinq	0.107***	-0.139***	0.042***	-0.659***	-0.232***	0.423***	-0.335***	0.266***	0.263***	1				1.510
INDEP	-0.109***	0.031***	0.030***	0.298***	0.158***	-0.480***	0.183***	-0.175***	-0.142***	-0.343***	1			1.880
Age	0.017**	0.032***	0.022***	0.030***	0.626***	0.000	-0.031***	-0.074***	-0.005	-0.030***	0.056***	1		1.260
Top1	0.005	-0.052***	0.072***	-0.147***	-0.250***	0.244***	-0.054***	0.3695***	0.042***	0.216***	-0.104***	-0.036***	1	1.160

Note: *** means $p<0.001$, ** means $p<0.05$, * means $p<0.01$

Table 4. Results for the relationship between green innovation, marketization process, environmental uncertainty and organizational slack.

	(1)	(2)	(3)
VARIABLES	GI	GI	GI
Market	0.042***	0.027***	0.060***
	(10.73)	(5.24)	(11.41)
EU		-0.051***	
		(-2.62)	
Market*EU		0.006**	
		(2.24)	
Slack			0.091***
			(6.59)
Market*Slack			-0.013***
			(-8.15)
Size	0.246***	0.243***	0.244***
	(27.22)	(27.47)	(27.81)
ROA	-1.079***	-0.452**	-0.486**
	(-5.33)	(-2.26)	(-2.43)
SOE	0.095***	0.084***	0.088***
	(5.85)	(5.27)	(5.57)
Risk	-0.012***	-0.008***	-0.007***
	(-4.81)	(-3.29)	(-3.13)
Debt	0.293***	0.216***	0.132**
	(6.56)	(4.94)	(2.51)
Tobinq	0.034***	0.032***	0.034***
	(5.14)	(5.04)	(5.39)
INDEP	-0.133	-0.065	-0.087
	(-0.99)	(-0.50)	(-0.66)
Age	-0.009***	-0.006***	-0.006***
	(-6.87)	(-4.35)	(-4.80)
Top1	-0.001***	-0.001***	-0.001***
	(-2.78)	(-2.77)	(-2.90)
Constant	-5.684***	-5.523***	-5.763***
	(-27.92)	(-27.82)	(-28.95)
Observations	14,046	14,046	14,046
R-squared	0.228	0.263	0.266
IndustryFE	YES	YES	YES
Year FE	YES	YES	YES

Note: *** means p <0.001, ** means p <0.05, * means p <0.01

Table 5. Robustness analysis.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	GI_{t+1}	GI	GI	GI	GI
Market	0.035 * * *	0.042 * * *	0.156***	0.119***	0.249***
	(9.03)	(10.23)	(8.40)	(4.64)	(9.48)
Slack2					
Market*Slack2					
EU				-0.267**	
				(-2.37)	
Market*EU				0.025*	
				(1.82)	
Slack					0.330***
					(4.17)
Market*Slack					-0.048***
					(-5.28)
Size	0.226***	0.298***	0.864***	0.860***	0.870***
	(24.96)	(31.46)	(21.36)	(21.28)	(21.47)
ROA	-0.567***	-0.330	-2.372**	-2.348**	-2.564***
	(-2.72)	(-1.56)	(-2.42)	(-2.40)	(-2.62)
SOE	0.095***	0.093***	0.525***	0.503***	0.530***
	(5.97)	(5.60)	(6.99)	(6.67)	(7.06)
Risk	-0.006**	-0.008***	-0.031***	-0.032***	-0.030***
	(-2.34)	(-3.13)	(-2.99)	(-3.01)	(-2.83)
Debt	0.181***	0.169***	0.847***	0.873***	0.409
	(3.94)	(3.63)	(4.06)	(4.17)	(1.60)
Tobinq	0.034***	0.040***	0.026	0.024	0.036
	(5.27)	(5.97)	(0.78)	(0.74)	(1.07)
INDEP	-0.060	-0.065	-1.277**	-1.243**	-1.312**
	(-0.45)	(-0.47)	(-2.25)	(-2.19)	(-2.32)
Age	-0.005***	-0.006***	-0.038***	-0.037***	-0.039***
	(-3.77)	(-4.59)	(-6.37)	(-6.16)	(-6.58)
Top1	-0.001**	-0.001***	-0.008***	-0.007***	-0.007***
	(-2.41)	(-2.82)	(-3.51)	(-3.30)	(-3.42)
Constant	-5.143***	-6.824***	-24.002***	-23.578***	-24.613***
	(-25.45)	(-32.18)	(-23.64)	(-23.11)	(-23.73)
Observations	12,936	14,046	14,046	14,046	14,046
R-squared	0.247	0.287			
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Note: *** means $p<0.001$, ** means $p<0.05$, * means $p<0.01$

Conclusions and Discussions

Research Conclusions

In this study, Chinese A-share companies are used as samples to empirically test the relationship between the marketization process and corporate green innovation and further investigate the moderating effect of environmental uncertainty and organizational slack on the above relationship. Our findings reveal a positive and significant relationship between the marketization process and green innovation, suggesting that the improvement of the marketization process in the region where the enterprise is located is more likely to encourage enterprises to participate in green innovation activities. Moreover, in the process of marketization affecting green innovation, environmental uncertainty plays a positive moderating role, and organizational slack can reinforce the positive association between the marketization process and green innovation. These conclusions are also supported by robustness tests.

Discussion

The value of this study is mainly reflected in the following aspects: First, to our knowledge, very few studies have explored the direct relationship between marketization processes and green innovation. Therefore, analyzing the impact of marketization processes on green innovation can help enrich the existing literature on the determinants of green innovation. Given this finding, the Chinese government should further promote market-oriented reforms, such as reducing unnecessary government intervention in the market and creating a favorable business environment for enterprise development.

Second, environmental uncertainty is an important boundary condition that affects the relationship between the marketization process and green innovation. Whether the enterprise can cope with the threats and impacts of the external environment is not only related to green innovation but also closely related to the survival and long-term development of enterprises in a highly uncertain market environment. Therefore, it is necessary for enterprises to identify internal and external risks within an organization and formulate risk-response plans.

Third, this study explores the moderating role of organizational slack. Although some studies have suggested that organizational slack functions as a "buffer pool," this study finds that organizational slack can weaken the positive effect of the marketization process on green innovation. Thus, companies should improve operational efficiency by applying emerging technologies, such as the Internet of Things and big data, as well as adjusting organizational models and business processes.

Research Deficiencies and Future Research Directions

This study has several limitations. First, among the factors influencing green innovation, in addition to the marketization process discussed in this study and government factors that have received widespread attention, there are other potential influencing factors, such as individual executive factors that may also affect corporate green innovation. Future research can further explore the impact of executives' individual characteristics on corporate green innovation based on Upper Echelons Theory. Second, when analyzing the moderating effect of organizational slack, this study only explored available slack, and future research should analyze the impact of other types of slack resources. Third, because this study is conducted under Chinese context, research findings may not fit well with other contexts. As a result, caution should be exercised in generalizing our findings to other settings. In this regard, cross-national empirical evidence will provide important supplements to this research.

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Conflict of Interest

The authors declare no conflict of interest.

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