

Article

Research on Enterprises' Intention to Adopt Green Technology Imposed by Environmental Regulations with Perspective of State Ownership

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Abstract: Environmental regulations (ER) affect enterprise behaviors. Nevertheless, whether the state ownership influences the relationship between environmental regulations and enterprises' green intentions and behaviors need to be explored further. In this paper, the effects of environmental regulations on enterprises' intentions to adopt green technologies, especially the moderating role of state ownership between environmental regulations and green technologic adoption intentions (GTAI), are proposed. An empirical study is carried out with the questionnaire data collected from 207 Chinese managers and executives in order to explore the influence of environmental regulations. With the perspective of ownership, the results confirm that the three kinds of environmental regulations (command-and-control (CAC), market-based incentives (MBI) and voluntary environmental (VER) regulations) have positive effects on enterprise green technology adoption intention. Furthermore, the state ownership of enterprise plays a positive moderating role in the relationship between command-and-control environmental regulations and green technology adoption intentions, but plays a negative moderating role in the relationship between voluntary environmental regulations and green technology adoption intentions. It generates no significant moderate effect on the relationship between market-based incentives environmental regulations and green technology adoption intentions. The work verifies that the differences of ownership would lead to varying effects on the intentions of enterprise green technology adoption imposed by regulations. Managerial implications, as well as the limitation of the work, are concluded at the end of this paper.



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1. Introduction

The pollution resulted from traditional operation of enterprises, raises serious challenges for human health and environment. With the increasingly urgent environmental problems, how to reduce air and water pollution caused by business activities of enterprises has triggered intensive attention from consumers to governments [1,2]. As a fundamental tactic for sustainable development, green technology adoption (GTA) has become an important means for enterprises to cope with the environmental pressures and improve their economic and environmental performance, which triggers the interest of practitioners as well as researchers [3,4]. In the traditional research on green technology adoption (GTA), many researchers focus on the green technology itself with its connotation, process, goals, and so on [5–7]. They prefer to pay attention to the impact of factors regarding the driver factors of GTA in macro and micro level. For instance, Hottenrott et al. [8] indicates that organizational innovations can be more efficient in adopting new green technologies that lead to improved productivity. Xia et al. [9] shows significant relationships between green technology selection and certain task-oriented circumstances and macro-circumstances.

From the perspective of technology innovations. Weng and Lin [10] identify the factors that driver GTA consist of technological, organizational, and environmental dimensions. Horbach [11] finds that technological capabilities development by the highly qualified employees encourages the adoption intention of green technology. Pujari [12] and Triguero et al. [13] also observed that market is an important factor to promote enterprises' GTAI when they providing environmental product. However, there is little systematic analysis of the effects of the environmental regulation on enterprise with the perspective of ownership feature regarding the green technology adoption intention (GTAI). The state ownership makes the owner–manager relation more complicated because the chain of principals and agents is expanded [14]. Theoretically, this gap hinders the understanding of the intention and propensity for green technology adoption, and effective design of environmental regulation to boost GTAI [15–17]. The examination of ownership influence can help better understand the enterprise green decision-making, especially in China, where there are considerable state-owned companies [18]. The work expounds the role of state ownership in the response mechanism of enterprises to external environment, will also be helpful to further supplement the theory of stakeholder. Therefore, the various operational influences of the specific environmental regulation (ER), resulting from differences of ownership right, on enterprises' green technology adoption intention (GTAI) need to be explored further.

According to the institutional theory, regulatory intervention is a necessary supplement of the pricing mechanism to shape enterprise behavior in the market. In the late 1970s, command-and-control environmental regulations (CAC) became one of the main policy to regulate the corporate environmental behaviors in many countries [19]. The government motivates the corporate behaviors through laws and regulations. However, Pollution Haven Hypothesis argued that high environmental regulations may cause unemployment and disinvestment because of the additional cost incurred by environmental regulations [20]. Practical investment of GTA as well as additional operational cost always leads to lower productivity while enterprises follow CAC [8]. With the negative effects resulting from the action of CAC, many enterprises even lose the competitive margin and interesting innovation investment on GAT. Frankly, the green technology adoption is always delayed because of extensive externalities of effects, that is the full social benefits produced by green technology cannot be completely reflected by the financial statements [21]. As the awesome implementation cost, low flexibility and other shortcomings of CAC, more flexible market-based incentive environmental regulations (MBI) and voluntary environmental regulations (VER) arise and are necessary. As Porter hypothesis claims that properly designed environmental regulations can catalyze innovations, which to some extent offset the compliance costs [22,23]. Enterprises maybe actively reduce the compliance costs of environmental regulation through specific technical adoption according to their operational feature. Consequently, three kinds of environmental regulations have different functional influences on enterprises' GTA behaviors because of the characteristics such as operational goals, measures, flexibility, etc. Previous literature and researches explore GTA with eyes on environmental regulation and the external conditions in order to explain their difference in enterprise operation [24,25]. Some literatures focus on discussing the environmental regulation on green technology adoption from the regional and industrial levels [26–28], which cannot directly display and explain the green technology intention of enterprises under the pressure of environmental regulations. Very few literatures focus on the enterprise level [29,30], with empirical research in the context of China. As the state-owned enterprises play a considerable role in Chinese and many other emerging economies, whether state ownership has influence on companies' GTA is a valuable research question. Here, with the perspective of corporate ownership, the work attempts to explore the operational relationship between ER and GTAI as well as the influence mechanism.

Stakeholder theory and corporate governance theory indicate that enterprise environmental operations have been influenced not only by government and customers but also by a plenty of stakeholders such as NGO, competitors, shareholders, and employees [31,32]. The three types of environmental regulations represent the appeals of different

stakeholder groups, while enterprises with different ownership are faced with different incentives and constraints [33]. The different attributes may affect the sensitivity of enterprises in GTAI originating from environment regulations [34,35]. Ownership is an important perspective to study the operational decision-making behavior of enterprises in green campaign, including green innovation [36,37]. Different ownership profile means difference rights arrangement in decision-making process during technology investment for Chinese enterprises [38,39]. As a key stakeholder, government has strong and intensive influence and intervention on state-owned enterprises. Stakeholder theory clarifies that the increasing proportion of state-owned ownership would lead to corporate governance power's decentralization [40]. At the same time, the sharing and decentralization also makes the state-owned enterprises more accessible to authority resources [41]. As far as environmental regulation is concerned, the corresponding compulsory and different types of regulation instruments are built into the arrangement and allocation of corporate governance power. Currently literature shows that different profiles of ownership have an influence on enterprise's response to environmental regulations [42], but it is still not clear what moderate effect is between specific environmental regulation instruments and green technology adoption. Therefore, this work explores the relationship between ER and GTAI, and analyzes how the relationship between them is affected by features of ownership. It would provide a new perspective to explain the enterprises' intentions and behaviors of green technology adoption. The work may benefit the designer of enterprises' greening plan and environmental regulations, motivating enterprises' green behaviors. The research hypotheses are raised with theoretical basis in Section 2, while the empirical study is carried out to collect the data from filed in Section 3. Meanwhile result analysis is also followed to verify the research purposes. To explore details about the relations among factors, measurement items are designed for ER and GTAI and specific industries are selected as the sample for data collection. Therefore, result analysis is carried out with factor correlation analysis as well as hypothesis test in Section 3. Then the discussion and conclusion is drawn in the end of the work including managerial implications, contribution and limitation.

2. Theoretical Basis and Research Hypothesis

2.1. Environmental Regulations (ER) and Enterprises' GTA

Environmental regulation consisted of tangible and intangible components, imposing influence on the individuals and organizations, leading to environmental friendly behaviors. There are many studies that divide ER into formal regulation and informal regulations [43,44]. Formal regulations come from all kinds of mechanisms implemented by the public authorities for regulating pollution emissions. Based on the stylistic difference in policies, formal regulation is more specifically classified into CAC and MBI [45]. CAC is a type of direct regulation, such as environmental licenses, emission standards. MBI characterized by economic incentives, is an embodiment of the practical application of Pigouvian tax theory, including pollution taxes, tradable permits and subsidies. Informal ER corresponds to all types of actions taken by the citizens, NGO, industrial guild aiming at modifying the behavior of pollution. Moreover, some studies divide ER into mandatory regulation and voluntary regulations [46,47]. The former is consistent with the CAC, the latter gives enterprises voluntarily choice in participation in environmental protection programs or agreements, which calls VER in the work.

Institutional theory indicates that the enterprise management decisions are strongly influenced by three kinds of pressure: compulsion, imitation, and standardization [48,49]. The green technology adoption behavior of enterprises is shaped by regulation pressure and the value system complied by a certain community. Sethi develops a framework that classifies corporate behavior into three stages, including social obligation, social responsibility, and social responsiveness [50]. Thus, it inspires our thought about a firm's green behavior. When the behavior of enterprises deviates from the regulations requirement and social value orientation, the legitimacy of enterprises is threatened and weakened [51].

Siegel and Johnson [52] believe that environmental regulation would facilitate the adoption of environmental technology of enterprises to improve economic and environmental performance. Appropriate environmental regulations can also guide and push industry to develop green technology in operation [53]. Therefore legitimacy requirement for enterprises resulting from environmental regulation is a main driving force of environmental management behavior.

Many studies explore the concept and nature of green technology with different dimensions. Braun and Wield [54] consider that green technology is a series of measurements for environmental protection. It refers to the technology for reduction, reuse, and recycling of raw materials, natural resources, and energy to contribute to the performance of economy, environment, and society [55–58]. Green technology innovation and adoption is a responsive behavior and choice under specific circumstance, also a result of interaction among internal and external factors of enterprise operation system [59]. The adoption of green technology is influenced by the intensity of environmental supervision, capability of enterprises' green technology innovation, expectation of environmental stakeholders, which involves complex decision of GTA [60]. It is a complex dynamic system while studies show environmental regulation promote the progress of green technology in industrial sectors [61].

There are different explorations and viewpoints on the relationship between environmental regulations and enterprise green innovations. Many scholars' work shows that environmental regulation leads to the recession of corporate green innovation performance, and conclude that environmental regulation may prevent corporate green technology innovation [62]. The relationship between environmental regulations and green technology innovations may also be uncertain [63,64]. Some scholars indicate that the ER makes difference in enterprise's operations due to different types of environmental regulations [19]. Wang's empirical study [65] with data from high-end manufacturing enterprises confirms that CAC and MBI can significantly stimulate green operation. Company's awareness of R&D may be enhanced further with strengthening environmental regulations [66]. Due to the asymmetric information quality of the environment, the "lemon market" effect of green technology adoption may also occur [67]. But voluntary environmental regulation measures, such as green environmental label, may enhance the competitive advantage of products, boost reputation and market share of enterprise [33]. Similarly, some research explain that it is possible for enterprises to get positive effect from green operation. GTA may facilitate enterprises to cope with environmental regulations pressure, remove green trade barriers, and catch market opportunities, shape a good reputation [68]. Consequently, there are obvious differences and gaps regarding the opinions about the relationship between environmental regulations and green technology innovations.

Exploration and measurement of behavior related to enterprises' GTA is also an important issue. Theory of planned behavior (TPB) [69] indicates requirement of green technology adoption is that companies, especially senior managers, are willing to change and innovate, which may be interpreted and predicted by intention, attitude, subjective norms, and behavior control. Intention is the antecedent of behavior action, and helps in better understanding the process mechanism of enterprise response. GTA behavior acts in varieties of ways, also effect by factors like resource and capability, is harder to evaluate than intention. Zhang et al.'s study [70] explains the intention of enterprises in green campaign with senior managers' attitude to the application of green technology and social pressure to develop green technology for sustainable operation. "Intention" may be looked at as a predictor of an enterprise behavior of green tech adoption. Therefore, the study of the relationship between environmental regulation and GTAI rather than GAT behavior in our work can provide more proactive feedback on managers' intentions and decision-making, and reference for regulators, so as to timely adjust regulation strategies, and finally to trigger green technology adoption behavior.

2.2. State Ownership, Environmental Regulation and Enterprises' GTA

Social norms, cognition and attitude about sustainability, as well as attributes of technology, may affect the enterprises' adoption of green technology [71]. However, these dimensions are not the whole story about factors involving GTA. When it comes to enterprise attribute factors, especially the ownership attribute, whether and how the ownership plays a role in environmental regulation and enterprises' intention of green technology adoption, the answer is still kept open.

Previous study and experience indicates that, for Chinese enterprises, the attribute of state ownership profile is a significant factor which influences the operation [72]. Regarding the profile of the internal and external stakeholders, participation paradigms, there are obvious differences between the state-owned enterprises and non-state-owned enterprises regarding the environmental pressure, motivation, and capability.

Some scholars believe that the ownership of state-owned enterprises is substantial in the charge of local and central government, therefore, the operational management is influenced by the government in some degree with eyes on Chinese economic, society condition [73]. With intensive pressure from the authorities, state-owned enterprises (or those with a high proportion of state-owned enterprises) may be more sensitive to compulsory environmental code. After comparative study about the behavior of GTA among state-owned, foreign capital owned, and private enterprises, Zhang and Zhao [74] found that the increasing intensity of environmental regulation will promote the technical progress of state-owned enterprises, but generate no significant impact on the foreign capital enterprises' operation as well as negative impact to the private enterprises. Empirical study [70] confirms that the investment behavior of the company about the environmental protection is characterized by profile of ownership, while state-owned companies invested a huge money in environmental protection instead of private companies.

In contrary, some scholars hold that private enterprises are more sensitive to environmental regulations because of less tolerance to pressure from outsiders [72]. Cambini and Rondi's study [75] shows that non-state-owned enterprises' environmental investment is more sensitive to environmental regulations than state-owned enterprises. In order to obtain preferential policies from the government and more financial opportunities, as well as establishing a good corporate image, private enterprises may proactively implement the government environmental protection policies, thus invest more in environmental protection.

Regarding the interesting viewpoint at GTA of previous studies, the influences imposed by command-and-control, market-based incentive, and voluntary environmental regulations on enterprise's green technology adoption intention need to be explored further. It is significant to examine the nature of state ownership's moderating effects on the relationship between each environmental regulation and GTAI, which is shown in Figure 1.

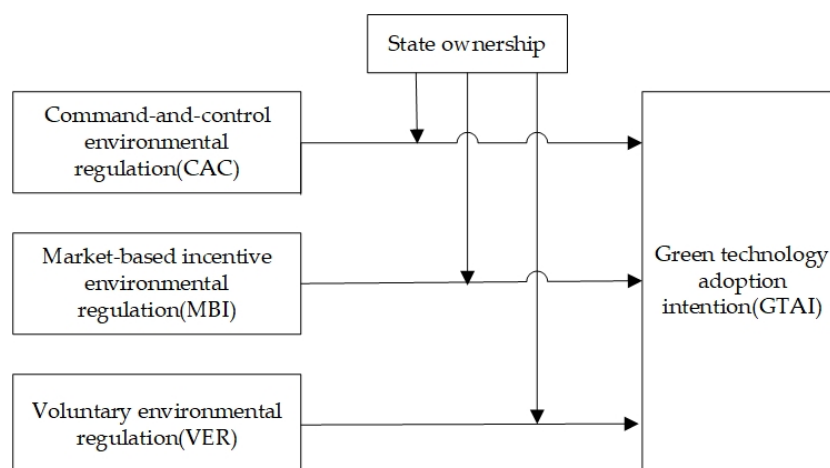


Figure 1. Research framework of moderating role of state ownership in the relationship between environmental regulations (ER) and green technologic adoption intentions (GTAI).

2.2.1. Command-and-Control Environmental Regulation (CAC) and Green Technology Adoption Intention (GTAI)

Regarding the influence of command-and-control environmental regulation on corporate behavior in operation, it is generated through the compulsion and obligation, which requires enterprises to comply with environmental code and technical standards of CAC [6,19,65]. The US was an early adopter of stringent SO₂ standards, which leads to a significant increase of patents. Similar trends are also observed in Japan and Germany following the implementation of stringent NO_x regulations. It shows these CAC measures promote green technology development and adoption [8,76]. Jennings and Zandbergen [48] point out that compelling force is the main driver of sustainable operation and practice. Some institution sectors including environmental agents have sufficient power to impose structural forms or practices on organizational units [77]. State-owned enterprises are subject to more significant interventions and influences by authority and policy systems than non-state-owned ones. One of the main function of state-owned enterprises is to accomplish public policy objective [78]. Consequently, state-owned enterprises may bear more environmental and social responsibility from the policy-maker and biggest-share-holder and have to adopt green technology in advance [79]. Meanwhile, the enterprises also have more access to various resources as well as credits from financial institutions because they are state owned [80]. Therefore, state-owned enterprises are more likely to follow the voice and corresponding regulations from government. Under certain context of the environmental protection system, difference of internal factors (organization size, operational technology types, ownership profile, and financial information disclosure) of enterprises may have influence on their sensitivity to CAC, affecting the enterprise's environmental protection behaviors. The state-owned enterprises' legitimate sensitivity may be stronger than non-state-owned enterprises. As a result, state-owned enterprises are more likely to invest more in GTA for environmental protection. Therefore, here are the following proposes:

Hypothesis 1a (H1a). *CAC has a significant positive impact on the enterprise's GTAI.*

Hypothesis 1b (H1b). *The state ownership moderate the influence of CAC on the enterprise's GTAI: CAC has a more significant positive impact on GTAI of state-owned enterprises than non-state-owned ones.*

2.2.2. Market-Based Incentive Environmental Regulation (MBI) and Green Technology Adoption Intention (GTAI)

Regarding the influence of market-based incentive environmental regulations on enterprises, the green behavior may be cultivated by the market means such as pollution taxes, trading license, and environmental subsidies etc. Compared with other type of regulations, MBI has obvious advantages in the cost effectiveness to boost innovation and diffusion of green technology [81,82]. Zhou et al. suggests that government subsidies may alleviate the negative impact of compliance costs on firms, and enable the latter to adopt expensive green technology such as pollution abatement technologies [83]. Krass et al. [25] and Bertarelli and Lodi [84] report that green policies such as taxes and charges provide more effective incentive for enterprises to introduce green technologies than other kinds of policy. Some researches of scholars indicate that sensitivity of enterprises in tax burden may be different because of their operational attributes. Compared with private enterprises, incentive effect of tax on state-owned enterprises is very low, and is even less on central government-owned enterprises [85]. Meanwhile, subsidies lead to higher possibility to convince the private enterprises than state-owned ones to believe that it is the government's recognition of GTA, which would cultivate their willingness to adopt green technology further [86,87]. Therefore, the differences in resource access channels may also lead to differences in the sensitivity of enterprises to subsidies. Generally, state-owned enterprises still have comparative advantages over private enterprises in business [88], while the latter are expecting MBI's subsidies to boost their green campaign. For competitive advantage in market, enterprises have to get more support through green operation [89]. Appropriate

green innovations and GTA would also help companies to reduce production cost, improve economic and environmental performances [90,91], while state-owned enterprises may be short of willingness to green innovation input, innovation efficiency, and production efficiency regarding the MBI [92]. Therefore, it is proposed that:

Hypothesis 2a (H2a). *MBI has a significant positive impact on the enterprise's GTAI.*

Hypothesis 2b (H2b). *The state ownership moderates the influence of MBI on the enterprise's GTAI: MBI has a more significant positive impact on GTAI of non-state-owned enterprises than state-owned ones.*

2.2.3. Voluntary Environmental Regulation (VER) and Green Technology Adoption intention (GTAI)

The implementation of voluntary environmental regulation consisted of environmental certification, voluntary agreements, etc., is mainly monitored informally by public. It encourages enterprises to be self-disciplined in voluntary environmental protection, to promote environmental behavior with more reasonable technologies, in order to obtain first-mover advantage [93–95]. Motivation to follow-up voluntary environmental regulation with GTA may be generated by cost saving, efficiency improvement, brand reputation, or external market pressure [96]. Normative pressure from industry associations can also prompt positive environmental behaviors in moral. Camisón [97] and Bu et al. [47] point out that compared with other types of environmental policies, voluntary regulations can trigger innovative activity. Woerter [98] indicates that voluntary agreements are one of the most important drivers for the adoption intention of green energy technologies. Jiang et al. [99] also confirms the positive effect of voluntary environmental information disclosure and environmental management system certification on enterprise innovation. Studies indicate that enterprises with various profile of ownership have differences in access to resource that leads to varying consciousness and sensitivity to VER [100]. In terms of corporate citizenship and fulfillment of social responsibilities, state-owned enterprises are traditionally trusted in the consciousness of Chinese people, and non-state-owned enterprises may have to take more effects to cultivate the circumstance for their business. According to the mimetic isomorphism mechanism in the new institution theory [101], when faced with uncertain factors in the business, enterprises would follow partners as the template to learn and regulate their behaviors [102]. For enterprises, green technology adoption behavior always have a positive demonstration effect in market, and the diffusion of positive information will further influence the decision-makers of other enterprises, ultimately boosting green campaign [103]. When the shareholder possess higher percentage of stock, they have more external control on managers and result in more voluntary CSR disclosure, thus fully reflected in private firms [104]. Additionally, other studies find that government support produces a negative moderating effect on the relationship between voluntary environmental regulations and economic benefits, social benefits of technological innovation [105]. The reason of this effect maybe resulted from the difference of ownership profile and resource access between state-owned enterprises and non-state-owned enterprises. Then ownership may be a moderator between voluntary environmental regulation and green technology adoption intention. This paper proposes:

Hypothesis 3a (H3a). *VER has a significant positive impact on the enterprise's GTAI.*

Hypothesis 3b (H3b). *The state ownership moderates the influence of VER on the enterprise's GTAI: VER has a more significant positive impact on non-state-owned enterprises enterprise's GTAI than state-owned ones.*

3. Methodology

3.1. Sample and Data Collection

Regarding the environmental influence from business operation, industries such as manufacturing and civil engineering, which involve intensive consumption of resources

and energy, cause a great deal of pollution. They are faced with the increasingly serious pressures from environmental regulations. Therefore, these energy-intensive industries may be the reasonable sample to explore the relationship between the green technology adoption intentions and environmental regulations. With the perspective of ownership, the sample structure should be extended, therefore to be consistent with the industrial context, other industries were not excluded from the survey to prevent missing some potential relationship. The questionnaire for data collection is mainly distributed through online and offline simultaneously. (1) Part-time MBA students of Wuhan University of Technology from different industries are selected to respond to the questionnaire offline; (2) With Yellow Page and social networking in related industries, other questionnaires are filled in by the enterprise managers and engineers through email. Finally, 250 questionnaires are collected, 207 of which were valid, with an effective recovery rate of 82.8%. More details about the data are shown in Table 1.

Table 1. Distribution of samples in terms of industries, ownership, and size.

Feature	Range	N	Percentage
Industry (Ind.)	Agriculture, forestry, animal husbandry and fishery	4	1.93%
	Mining industry	13	6.28%
	Manufacturing	65	31.4%
	Electricity, heat, gas and water production and supply	18	8.7%
	Civil engineering industry	31	14.98%
	Transportation, warehousing and postal services	15	7.25%
	Accommodation and catering industry	5	2.42%
	Others	56	27.05%
Ownership (owns)	State-owned enterprise	90	43.48%
	Non-state-owned enterprise	117	56.52%
Number of employee (Size)	<300	64	30.92%
	<2000	49	23.67%
	>2000	94	45.41%
No. of years establishment (Firm Age)	≤2	37	17.87%
	3–5	29	14.01%
	6–10	31	14.98%
	>10	110	53.14%

Notes: in our work state-owned enterprise means state-owned assets investment or holding are more than 50% of the share, otherwise non-state-owned enterprise.

Our respondents include 90 executives, 102 managers, and the rest are mostly senior engineers. The focus enterprises are mainly from Hubei, Guangdong, and Shanghai of China. According to the statistical data, most of the participated enterprises are manufacturing enterprises (31.4%). Nearly half of the enterprises are state-owned (43.48%), whereas 56.52% are non-state-owned enterprise. Most of the enterprises have over 2000 employees (45.41%), and 30.92% of them are small-size with employees less than 300. 23.67% of them are medium-size with the employee number between 301 and 2000. The majority of the enterprises are in operation over ten years (53.14%). More details are shown in Table 1.

3.2. Variable and Items

All measures and items are derived from existing scales in previous research. Items are set up according to the characteristics of the three environmental regulations to measure, based on the regulatory theory [106]. There are 5 items for CAC, 5 items for MBI, and 5 items for VER. All of the items are derived from maturity scales [65,107,108]. Five-point scales for responses from 1 = completely disagree to 5 = completely agree. All items on three types of environmental regulations are shown in Table 2.

Table 2. Variable measurement items.

Variable	Measurement Items
Command-and-control environmental regulations (CAC)	Enterprise's production follows strict technical standards from policy; The products produced by the company meet the relevant environmental standards from regulatory department; Enterprise control the concentration and total amount of waste according to emission performance standards; Some production licenses of enterprise are determined by the regulatory department; Enterprise violating the relevant regulations of environmental regulations will be severely punished.
Market-based incentive environmental regulations (MBI)	Enterprise have to bear the corresponding taxes and fees when discharge pollutants; Enterprise must pay a certain pollution deposit; Enterprise can get financial subsidies for environmental pollution control; Enterprise can get tax benefits for environmental pollution control; Enterprise can get a certain deposit refund for recycling product waste.
Voluntary environmental regulations (VER)	Enterprise publishes the business environment information in time and accurately; Enterprise environmental management is ISO 14000 certified; We will actively solicit opinions from relevant units, experts and the public on the enterprise's environmental impact assessment report; Companies are actively committed to achieving higher environmental performance than regulatory policies; Enterprise implements clean production and whole process control.
Green technology adoption intention (GTAI)	Knowledge-awareness stage The employees of my company can know the existence of green technology in related business areas; Corporate employees will actively consider the applicability of a certain green technology to the enterprise; Corporate employees will actively participate in conference discussions about green technology adoption; Evaluation-choice stage Enterprise is willing to formally put forward strategic plans for green technology adoption practices; Our company is willing to conduct technical and economic evaluations for the proposed green technology adoption ideas; Our company is willing to evaluate the compatibility of alternative green technologies with the strategic requirements; Adoption-implementation stage Company is willing to adopt green technologies and try them out; Company is willing to adopt green technologies and use them often; Company is willing to continue to adopt this green technology in the next similar production activities; Company is willing to adopt green technology and continue to expand, improve and innovate.

Resource: ER's classify and items derived from [106]: Gunningham N., Grabosky P., Sinclair D. Smart regulation [J]. Regulatory Theory, 1998, 133. GTAI's from [109]: Meyer A D, Goes J B. Organizational assimilation of innovations: A multilevel contextual analysis [J]. Academy of management journal, 1988, 31 (4): 897–923.

Technology adoption is the process in which organizations as well as relevant individuals recognize and implement new technologies. Here the green technology adoption intention means that enterprise is willing to budget for technology adoption, take the initiative to adopt green technology, and support the implement of policies, codes, and treaties on green technology introduced by the government, market, and relevant institutions. Therefore, organization's behavioral intention in the whole process is measured and taken into account from the initial knowledge-awareness of green technology to consider the investment decision and the acceptance of green technology. Based on Meyer and Goes's achievements in green technology adoption, the process of GTAI is divided into three stages [109]. There are 10 items for GTAI, including 3 items of knowledge in awareness stage, 3 items of evaluation in choice stage, and 4 items of adoption in implementation

stage (details shown in Table 2). The five-point measurement scale is applied for measuring GTAI from 1 (completely disagree) to 5 (completely agree).

3.3. Measurement and Results Analysis

3.3.1. Validity and Reliability Analysis

In order to identify the main factors of CAC, MBI, and VER as well as GTAI, an exploratory factor analysis (CFA) is carried out with application of SPSS20.0. Principal components method with a varimax rotation is introduced to extract the theoretical dimensions as well as initial eigenvalue test (the eigenvalue > 1) for the number of extracted factors. Here one factor is extracted for CAC with explanation 80.4% of the variations. One factor extracted of MBI explains 81.27% of the variations. One factor extracted of VER explains 78.73% of the variations. The Cronbach's alpha is introduced to examine if those items grouped into particular factors are statistically reliable. The result indicates that the alpha value in this study is 0.906 for the factor of CAC, 0.859 for the factor of MBI, and 0.904 for the factor of VER. It shows a reasonable internal consistency.

The initial eigenvalue test indicates that the GTAI consists of three factors. According to the item meanings of each main factor, they may be labeled as knowledge-awareness stage, evaluation-choice stage, and adoption-implementation stage of GTAI. These three factors explain 83.59% of the inherent variations. Loading of these individual items on the three main factors is shown in Table 3. Similarly, check the reasonability of the item grouping by reliability analysis. The alpha values for the items of those three main factors indicating fundamental stages of GTAI, are 0.912, 0.900, and 0.921, which means a reasonable internal consistency. Meanwhile, the KMO value of the items scale is 0.952, Bartlett-sphericity test is significant at the 0.001 level, indicating good structural validity.

Table 3. Factor analysis of CAC, MBI, VER, and GTAI.

Variables	Item	Factor Loading	Means	Cronbach's α
CAC	CAC1	0.882	3.974	0.906
	CAC2	0.895		
	CAC3	0.904		
	CAC4	0.902		
	CAC5	0.901		
MBI	MBI1	0.866	4.131	0.859
	MBI2	0.901		
	MBI3	0.904		
	MBI4	0.927		
	MBI5	0.908		
VER	VER 1	0.709	3.898	0.904
	VER 2	0.727		
	VER 3	0.775		
	VER 4	0.760		
	VER 5	0.688		
GTAI				
Knowledge-awareness stage	GTAI1	0.814	3.834	0.912
	GTAI2	0.845		
	GTAI3	0.815		
Evaluation-choice stage	GTAI4	0.708	3.973	0.900
	GTAI5	0.770		
	GTAI6	0.652		
Adoption-implementation stage	GTAI7	0.737	3.954	0.921
	GTAI8	0.831		
	GTAI9	0.865		
	GTAI10	0.737		

3.3.2. Correlation among Variables

Correlation between major variables is analyzed with Pearson correlation coefficient test. The results are shown in the Table 4. The correlation coefficients between the three types of regulations and enterprise GTAI are 0.588, 0.659, and 0.733 respectively, all of which are significant at the significance level of 1%. It preliminarily verifies that there is a very close relationship among three types of regulations and enterprise GTAI, and all of them are positively correlated. While three types of regulations are the major categories for environmental protection, a certain correlation among them is there. According to Tsui et al. [110], the critical value of correlation level with multi-collinearity problems is generally more than 0.75, which means that there is no serious multi-collinearity problem in the sample data of this study. More details are shown in Table 4.

Table 4. Descriptive statistics and correlation matrix: dependent and explanatory variables.

No. Variable	Mean	SD	1	2	3	4	5	6	7	8
1 Ind.	4.95	2.20	1							
2 Owns	0.43	0.50	0.15 *	1						
3 Size	2.15	0.87	−0.11	−0.319 **	1					
4 Age	3.04	1.18	0.057	−0.087	0.376 **	1				
5 CAC	3.97	0.82	−0.003	0.253 **	0.023	0.048	1			
6 MBI	4.13	0.92	−0.059	−0.002	0.077	0.038	0.702 **	1		
7 VER	3.90	0.90	−0.075	−0.087	0.112	0.129	0.607 **	0.712 **	1	
8 GTAI	3.92	0.78	−0.076	−0.018	0.082	0.099	0.588 **	0.659 **	0.733 **	1

Notes: ** $p < 5\%$, * $p < 10\%$. TWO-TAILED. N = 207.

3.3.3. Results Analysis

Before hypothesis testing, independent variables and moderating variables are centrally processed to reduce the endogenous multi-collinearity. The following regression model is established and carried out with empirical data.

Model:

$$\text{GTAI} = \beta_0 + \beta_1 \text{Ind} + \beta_2 \text{Size} + \beta_3 \text{Age} + \beta_4 \text{CAC} + \beta_5 \text{MBI} + \beta_6 \text{VER} + \beta_7 \text{Owns} + \beta_8 \text{CAC} \times \text{Owns} + \beta_9 \text{MBI} \times \text{Owns} + \beta_{10} \text{VER} \times \text{Owns}$$

The hierarchical regression is applied to examine those six hypotheses about the relationship between ER and GTAI, as well as the effect of ownership. Industry (Ind.), corporate size (Size), and corporate Age (Age) may influence that relationship. Thus, the three control variables are included in the model as the first step. As shown in Table 5, the $\Delta R^2 = 0.018$ indicates that the control variable explains an additional variation of 1.18% green technology adoption intention. To examine the effect of command-and-control environment regulation (CAC), market-based incentive environmental regulation (MBI), and voluntary environmental regulation (VER); these three factors are added at the second step. The results show that three types of environmental regulations on enterprise green technology adoption intention have significant positive influence. It means Hypothesis 1a, Hypothesis 2a, and Hypothesis 3a are verified and reasonable, while the independent variables and control variables together explained 58.7% of the GTAI variation. Then, the ownership is represented by 0–1 dummy variables, 1 represents state-owned enterprise, 0 represents non-state-owned enterprise, and are taken into the regression test in the third step.

Finally, three kinds of interaction terms between environmental regulations and state ownership are taken into account in regression. It can be seen that the regression coefficient of $\text{CAC} \times \text{Owns}$ is 0.327, which is significant at the significance level of 0.05, it indicates that the interaction between state ownership and command-and-control environmental regulation has a significant positive effect on green technology adoption intention. Mean-

while market-based incentive environmental regulation and state ownership interactive indicators ($MBI \times Owns$) of the regression coefficient is not significant with value 0.069. It means the state ownership does not play a significant role as a moderator on the relationship. Therefore, Hypothesis 2b is rejected, but the results still have certain theoretical and practical significance. It shows that when it comes to market-based incentive environmental regulation, the sensitivity of state-owned enterprises and non-state-owned enterprises doesn't differ a lot, so they have similar behavioral intensity in adopting green technology. In addition, the regression coefficient of the interaction between voluntary environmental regulation and state ownership ($VER \times Owns$) is -0.496 , which is significant at $p = 0.001$, indicating that the state ownership and voluntary environmental regulation has a significant interaction effect on the GTAI.

Table 5. Descriptive statistics and correlation matrix: dependent and explanatory variables.

	Step1	Step 2	Step 3	Step 4
Control variables				
Ind.	−0.027	−0.010	−0.010	−0.019
Size	0.036	−0.004	−0.006	−0.018
Age	0.058	0.015	0.015	−0.015
Independent variables				
CAC		0.134 *	0.137 *	0.133 *
MBI		0.172 **	0.171 **	0.154 *
VER		0.430 ***	0.429 ***	0.466 ***
Regulated variables				
Owns			−0.012	−0.013
Interaction item				
CAC \times Owns				0.327 *
MBI \times Owns				0.069
VER \times Owns				−0.496 ***
R ²	0.018	0.586	0.587	0.627
ΔR^2	0.018	0.569	0.001	0.040
VIF	<2	<3	<3	<4
F	1.225	47.274 ***	40.325 ***	32.940 ***

Notes: *** $p < 1\%$, ** $p < 5\%$, * $p < 10\%$.

Regarding the moderating effect of state ownership on the relationship between certain regulations and GTAI, more details are shown in Figure 2. It indicates that state ownership has a significant moderating effect on the relationship between CAC and GTAI. A further examination shows that, for state-owned enterprises, command-and-control environmental regulation has a higher positive impact on enterprises GTAI than non-state-owned enterprises. Hypothesis 1b is verified and acceptable. The details in Figure 3 shows that for the state-owned enterprises, the stronger voluntary environmental regulation would lead to lower GTAI. Meanwhile with stronger the voluntary environmental regulation for non-state-owned enterprises, the higher GTAI is over there. The result explains that state ownership has significant negative moderating effects on the relationship between VER and GTAI. For non-state-owned enterprises, VER has a more significant positive impact on the intention to adopt green technology, while for state-owned enterprises, VER has a negative impact on the GTAI. It shows that Hypothesis 3b is accepted and reasonable.

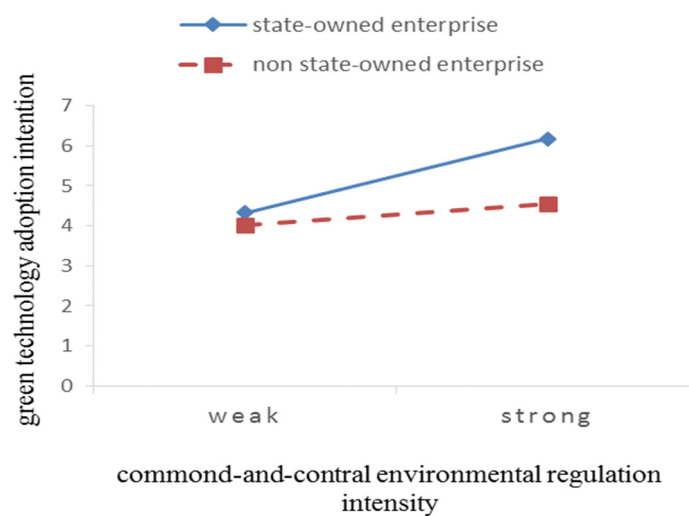


Figure 2. The moderate effect of state ownership on the relationship between CAC and GTAI.

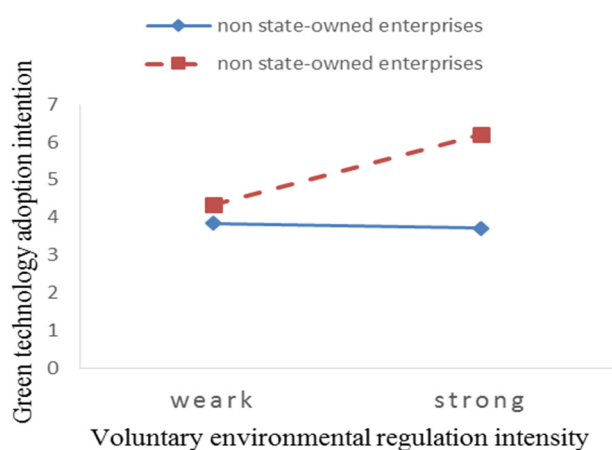


Figure 3. The moderate effect of ownership on the relationship between VER and GTAI.

Based on the above result, the framework of moderating role of ownership in the relationship between ER and GTAI is restructured, as shown in Figure 4.

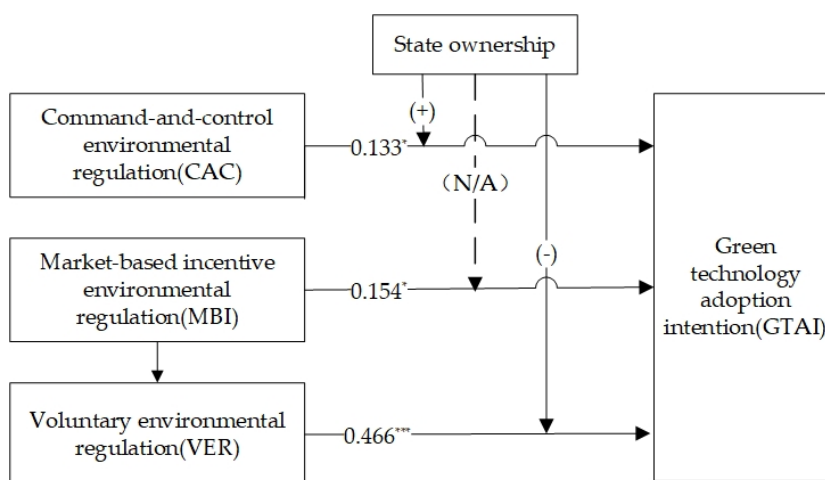


Figure 4. Results of hypotheses relationship and weights.

4. Discussion

4.1. The Effect of Environmental Regulations

Based on the regression analysis result, three type of environmental regulations including CAC, MBI, VER impose positive influence of enterprise GTAI. That is, they may promote the application of green technology in operation. First, CAC is positive related to GTAI, which means it is necessary to carry a certain intensity of mandatory norms on the enterprises' operation, government should play a good regulatory role. Second, MBI has a positive impact on GTAI; the possible reason is that enterprises are aware of the future economic benefit in the market, which can be acquired by adopting green technologies. Moreover, VER has a very strong positive effect on GTAI. The result manifests that incentives on GTAI induced by the VER measures are much more effective than CAC and MBI. It indicates that the flexible voluntary environmental regulations provide enterprises more choice to adopt green technologies. These companies are more forward-looking in environmental management, with a stronger intention to adopt green technologies.

4.2. The Moderate Effect of State Ownership

On the one hand, state ownership plays a positive moderator role in the relationship between CAC and GTAI. Specifically, CAC imposes more positive influence on state-owned enterprise than non-state-owned enterprises regarding the GTAI. This reflects under different ownership, firms have different complying intentions but same regulations. The state ownership makes firm attach more importance to CAC from government regulators. Meanwhile, state-owned enterprises encountering VER are less sensitive; state ownership produces no or negative moderate effect in the relationship between VER and GTAI. On the contrary, non-state-owned firms show more enthusiasm in GTA when facing VER. The research results indicate that non-state-owned firms think that the public image has bigger impact on the operation and performance, while state-owned firms care resources and penalties from their owner and regulator more.

On the other hand, the moderate function of enterprise ownership is not verified regarding its effect on the relationship between MBI and GTAI. It means that state ownership does not play a significant role in the production of GTAI while facing market-based incentive environmental regulations. The result indicates that there are no difference regarding MBI (such as taxes, subsidies, compensation)'s effect on state-owned and non-state-owned enterprises GTAI. In other words, there is no significant difference regarding enterprise green behavior and operation when facing similar MBI.

4.3. Managerial Implication

The work may also benefit the practitioners in green campaign. For policy-makers, the attribute of regulations should be taken into account with the enterprises features, especially ownership profile. In addition to generally improve regulation strength to promote the enterprises' green technology adoption, they should be tailored according to ownership attributes of the enterprises. That is, more CAC should be introduced into state-owned enterprises, such as stringent laws and technical standards, supplemented by MBI and VER, to promote corporate green technology adoption. Emphasis on VER for non-state-owned enterprises, may promote positive implementation of environmental management systems such as ISO14001, and guide and disclose environmental information about business operation. Thereafter a reasonable combination of three types of environmental regulations may be shaped and introduced into enterprise greening operation. For the senior managers, the conclusion may guide them to follow-up the rule of regulation mechanism, to achieve competitive advantage.

5. Conclusions

5.1. Contribution

Based on institution and stakeholder theories, the work explores the mechanism about whether and how the state ownership influences the response of enterprises to three types of environmental regulations. The work finds that state ownership poses a positively moderating effect on the influence of CAC to GTAI and negative moderating effect on the influence of VER to GTAI.

Our paper focused on the influence of state ownership on green innovation. There are already some research on the influencing factors of green innovation, which will help to find effective ways to promote green innovation and sustainability goal. The authors explored the influence of state ownership, which had not been addressed previously.

This article has discovered the different responses of state-owned and non-state-owned enterprises to environment regulations, which will help achieve a better understanding of enterprises GTA.

Different countries and regions have different market structures. In China and other emerging economies, state-owned enterprises are important market players. If the governments want to achieve sustainable goals, such as promoting green technologies, it must consider how to design effective environment regulations to achieve the desired outcome. According to the findings of this study, policy-makers should consider the state ownership. If there are more state ownership firms in certain industries, policy-makers should consider more CAC regulations. Otherwise, policy-makers should promote the publicity of VER regulations. The results of this study, along with previous studies, offer a better guide for policy-makers.

5.2. Limitations and Future Study

While we carry an innovation in the research perspective and get some novel viewpoints, the limitation should not be ignored. In terms of the research methodology, first, the data we collected are based heavily on respondents self-reporting, even though it is a popular method and acceptable widely [7,16,60], its reliability is also reminded by some researches [111]. Consequently, more reasonable measures to get data such as real field studies may be needed to be carried out in future to examine the study. Second, our samples are not all executives but also managers and senior engineers. Because many strategic thoughts and decisions of the firm are related to the management, it is better to focus on executives or leaders in the future. Regarding the environmental regulation, only three types are taken into account roughly: not covering environmental consciousness, value, and some other intangible code influencing enterprise green behavior. Ultimately, due to the limited resources and accessibility, the work only divides the ownership into state-owned and no-state-owned. As family and non-family firms play different roles in non-state-owned enterprises, family firms concerning reputation, pay more attention to sustainable operations and environmental behavior than their non-family counterparts [112,113]. That may also be taken into account and should be studied in the future.

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