

Research on the Impact Mechanism of Environmental Regulation on Environmental Performance

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Abstract:

With the rapid economic growth, various environmental problems have become increasingly prominent in the process of industrialization. The public's demand for high-quality environmental quality has been continuously improved, and environmental issues have gradually become the focus of widespread attention by the country and the people, and have become the top priority in the sustainable development of the economy and society. Based on China's A-share listed companies, the paper selects data from 2012 to 2019 as samples, and discusses the relationship between command-controlled environmental regulations market-incentive environmental regulations public participation environmental regulations and environmental performance based on legality theory, stakeholder theory, environmental public trust theory, and upper echelons theory. The results show that the implementation of three environmental regulatory tools, command-and-control environmental regulations, market-incentive environmental regulations, and public participation environmental regulations, are all conducive to improving the environmental performance of enterprises.

Key words: *Environmental regulation; Environmental performance; Local identity*

1 Introduction

After more than 40 years of reform and opening up, China has continuously improved its economic level and has now become one of the most important and dynamic economies in the world. On the road of promoting the development of industrialization, with the rapid growth of the national economy, various environmental problems brought about by the process of industrialization have become increasingly prominent, the public's demand for high-quality environmental quality is increasing, and environmental problems have gradually become a national and the focus of public concern. How to improve environmental problems has become the top priority in sustainable economic and social development, and ecological environmental protection has gradually risen to the national level, becoming a national will. With the continuous deepening of the concept of "green development, circular development, and low-carbon development", and the incorporation of ecological civilization into the fundamental law of the country, my country's ecological and environmental protection has undergone historic, overall, and significant changes. In recent years, in order to encourage environmental governance, my country has focused on building and improving a civilized system for ecological construction, deepening the concept of green development, and meeting the public's needs for environmental protection. Relevant departments have promulgated and implemented environmental protection policies, issued laws and regulations, etc. Environmental responsibility, governments at all levels are also gradually increasing the subsidies and subsidies for environmental protection of enterprises, strengthening the management of the ecological environment, promoting the reform of the ecological protection system, and increasing the intensity of environmental regulation.

As an important policy tool to correct market failure, environmental regulation can improve environmental quality to a certain extent, promote the green transformation of enterprises, and realize the upgrading of industrial structure. Its existence has certain rationality and necessity. Because the problem of environmental pollution has a "negative externality", its property rights are not clear, and the cost of environmental governance is high, which can easily lead to market failure. The fundamental reason for this phenomenon is that environmental resources are an extremely important and irreplaceable scarce public

good, and the cost of private use of environmental resources is not equal to the price borne by society. Secondly, as a rational economic person, the primary goal of an enterprise is to maximize profits. If there is no environmental regulation, the enterprise will not pay the cost to actively control the environmental pollution and resource destruction caused by the environmental pollution behavior. This means that the pollution and damage to the ecological environment cannot be solved by the market itself, and only the use of market mechanisms cannot eliminate the externality of environmental problems. In response to such problems, the active intervention of relevant government departments is especially required. The government can deal with the failure of the market mechanism by implementing strong and effective control measures, such as formulating mandatory rules and regulations for environmental pollution to solve the problem of market failure.

Under the intervention of government environmental regulation, enterprises have to take environmental management measures to improve environmental performance to meet the legal requirements of enterprises. Environmental performance to a certain extent represents the willingness and ability of enterprises to undertake environmental responsibility and implement clean technologies, including efficient use of resources, reduction of waste and energy consumption, and reduction of environmental risks (Aragon-Correa et al., 2008). The behavior of corporate environmental management is inseparable from the effective application of environmental management measures. Porter pointed out that designing scientific and rational environmental regulation policies can force companies to implement technological innovation, while the compensation effect of corporate innovation and the rational use of environmental management tools can partially or even completely offset them. costs of environmental regulation, thereby maintaining environmental sustainability, driving economic growth and improving environmental performance (Porter and Van, 1995).

Compared with the existing literature, the contributions and innovations of this paper are mainly reflected in the following parts. First, domestic and foreign scholars' research on environmental performance mostly focuses on formal institutions, and explores the relationship between environmental regulation and the level of corporate environmental performance. The causal relationship between them is also inconclusive, showing the inhibitory effect, the promotion effect, the promotion first and the inhibition effect and the insignificant effect. This paper will re-examine the impact of environmental regulation on environmental performance, thereby enriching the existing literature on environmental regulation on environmental performance; secondly, considering the heterogeneity of environmental regulation forms, environmental regulation is subdivided, that is, command-and-control environmental regulation, market incentive-based environmental regulation and public participation-based environmental regulation, and discuss different types of environmental regulation and related research on environmental performance. In the current research, the main research content is still based on command-and-control environmental regulation. The market-incentive environmental regulation is gradually increasing, and the public participation-based environmental regulation is relatively rare. From the perspective of heterogeneity of environmental regulation types, this paper discusses the influence degree and path of different regulatory tools, and provides supporting evidence for the guiding role of different types of environmental regulation.

2 Literature review

2.1 Research on the Economic Consequences of Environmental Regulation

The "Porter Hypothesis" is widely used in the research of environmental regulation at the enterprise level. Innovative activities can compensate for the costs of environmental regulation and can have an impact on the market competitiveness of firms (Porter and Van, 1995). Although environmental regulation has brought additional cost pressure, technological innovation by enterprises can make up for the additional cost, thus producing the effect of promoting environmental innovation of enterprises. The Porter Hypothesis is actually a manifestation of "market failure". Environmental regulation reminds enterprises to pay attention

to resource utilization efficiency, pay attention to green technology processes, and increase their enthusiasm for investment in green technology. Furthermore, environmental regulation can reduce the uncertainty of green innovation. Even if green innovation does not bring economic benefits, it will enable enterprises to meet the legality of environmental protection, thereby stimulating enterprises to improve their environmental management strategies in terms of motivation and pressure. Most scholars support the "Porter Hypothesis", which believes that environmental regulation can have an important impact on innovation and competitiveness. Appropriate environmental regulation can effectively increase investment in green innovation. Although high-intensity environmental regulation increases costs, under the effect of innovation compensation costs, innovation activities can compensate for the costs of environmental regulation, forcing enterprises to innovate products and services, and improve enterprises. Number of environmental patents. For example, Pickman (1998) used the number of environmental patents of American industrial enterprises to measure the environmental innovation of enterprises, and found that with the strengthening of environmental regulation, the number of environmental patents of enterprises will increase accordingly. Brunnermeier and Cohen (2003) used the data of US manufacturing enterprises to show that environmental patents and environmental protection expenditures have a positive impact, but they have little correlation with the frequency of government regulation, and export-oriented enterprises are more likely to innovate green. Popp (2005) used the patent data of the United States, Japan, and Germany from 1967 to 2001, and found that the relevant environmental regulatory policies issued by the administrative authorities would lead to an increase in the patents of local companies, but had no effect on the patents of foreign companies.

Contrary to the "Porter Hypothesis", "Constraint Theory" believes that environmental regulations cause enterprises to bear additional burdens, and this additional cost produces the effect of crowding out enterprise resources and hinders enterprises' innovation investment. The main mechanism is that environmental regulation increases the potential cost of enterprises. When the cost of environmental pollution is higher than the profit, the enterprise will restrict the behavior of polluting the environment. Since it takes time for the enterprise to update and transform production equipment, the current situation of the enterprise will be in pollution control. More overhead, which diverts research and development funds, leads to a decline in technological innovation, reduces production efficiency and weakens competitiveness. Some studies also empirically support this point of view, such as Portney and Gardiner (1994) research showing that environmental regulation can impose a large economic burden on enterprises, and environmental investment will inevitably squeeze production funds or other investments of enterprises, especially those with scarce funds. Small and medium-sized enterprises, the squeeze effect is more obvious. Environmental regulation is too strong, and there is a crowding out effect on corporate innovation. For this reason, companies have to reduce R&D investment, resulting in a decline in technological innovation. Vaske and Kobrin (2001) pointed out that strict regulatory measures will indeed promote R&D and improve business performance, but the innovation brought by environmental regulation cannot make up for the cost of environmental regulation.

"Uncertainty Hypothesis" combines the viewpoints of "Porter Hypothesis" and "Constraint Theory", pointing out that environmental regulation cannot be regarded as a single promoting and inhibiting effect on enterprise competitiveness and technological innovation. Lanoie et al. (2011) divided the intensity of environmental policies into three categories: weak, general, and particularly strong. The study shows that such policies that are particularly strong will have a significant promoting effect, while weak policies will have a significant inhibitory effect on performance. . Weithman's (1974) study also supports this research point of view, and empirical evidence confirms that the use of market-incentive-type environmental regulation has a more significant incentive effect on green innovation than simply using the command-and-control type. Scholars use different environmental regulation tools, and their empirical results are also different. Requate and Unold (2003) compared different environmental regulation tools, and found that environmental tax and emission standards, two environmental regulation tools, were significantly more effective than permits, and auctions and environmental permits produced the same incentive effect. Coria et

al. (2012) believe that market incentive tools have a dynamic incentive effect and can effectively motivate enterprises to invest in pollution abatement technologies.

2.2 Research on Influencing Factors of Environmental Performance

From the perspective of the environment in which the enterprise is located, some scholars have discussed the relationship between market competition and enterprise environmental performance, but there are disputes. One party believes that: in a highly competitive industry, the profitability of enterprises is often low, and enterprises are less effective in environmental protection. Investment may lack slack resources. In this case, companies pay more attention to reducing costs than social responsibility (Meng, 2016). The other party believes that market competition improves corporate environmental performance. It is more likely to pursue a differentiation strategy to gain a competitive advantage, and one potential path of differentiation is the integration of green technologies in product design and production. Therefore, these scholars believe that under the fierce market competition, enterprises are more inclined to invest in green technologies to differentiate products, obtain profits, increase environmental protection investment and improve environmental performance (Dai et al., 2015). Based on the perspective of industrial structure, some scholars believe that the improvement and adjustment of industrial structure improves the environmental performance of enterprises. Compared with the tertiary industry, the energy-intensive and highly polluting secondary industry tends to have an adverse impact on environmental performance (Luan et al. al., 2021). Changes in industrial structure can lead to changes in environmental performance, and different industries have different energy needs, so fiscal decentralization also plays a role in improving environmental performance (Zhu et al., 2019). In addition, fiscal decentralization may also be beneficial to stimulate environmental protection awareness of local governments, increase environmental investment expenditures, and then increase corporate renewable energy consumption and reduce fossil fuel consumption. However, the effect of fiscal decentralization on environmental performance will be affected differently. Regional impact (Kuai et al., 2019; Ahmad et al., 2021; Su et al., 2021). The public and the media can also have an impact on environmental performance. Based on the perspective of external public opinion, media attention can increase the motivation of enterprises to improve environmental performance, and the public pressure it generates can supervise enterprises to improve the quality of environmental disclosure, regulate enterprises' violations of environmental management, and accelerate the process of enterprises to improve environmental awareness (Solikhah, 2009). 2020). Due to the differences in the environmental importance of different stakeholders, compared with internal stakeholders, external stakeholders can significantly improve corporate environmental performance, and their importance will be affected by unemployment.

From an internal company perspective, executive characteristics, board characteristics, and corporate governance all have an impact on environmental performance. Slater and Dixon (2010) found that executives with high education level often consider the environmental performance of the company when choosing a job. Executives with high education level have higher environmental expectations. Therefore, there is a relationship between executive education level and corporate environmental performance. positive effect. Forte (2004) research believes that as the age of executives increases, executives have richer practical experience, the level of moral awareness increases, and they pay more attention to the performance of social responsibilities. There is no unified opinion on the relationship between executive compensation and environmental performance. Berrone and Gomez-Mejia (2009) research believes that executive incentives reduce exhaust emissions and improve corporate environmental performance. However, Walls et al. (2012) put forward a different view, they believe that the increase of executive compensation reduces environmental performance and brings a series of environmental problems to enterprises. Cong and Freedman (2011) believe that the relationship between executive compensation level and environmental performance is not significant, and increasing executive compensation does not have an impact on the level of corporate environmental pollution. From the perspective of board characteristics, Villiers et al. (2011) found that

independent directors who exercise supervisory functions and board members with legal background will actively promote the improvement of corporate environmental performance, and with the increase of board size and the proportion of external directors, members of the board of directors can provide guidance for the enterprise, obtain resources such as knowledge, and the environmental performance of the enterprise will increase accordingly. However, some scholars believe that with the increase of the board size and the proportion of outside directors (Post et al., 2011), it has a negative effect on environmental performance. Starting from the theory of corporate behavior, when studying the relationship between expected surplus and environmental performance, institutional shareholding can have a positive moderating effect. Earnhart and Lizal (2006) believe that ownership structure can also have an effect on environmental performance. The increase of state-owned equity and the improvement of the concentration of the largest single shareholder promote the improvement of environmental performance.

2.3 Related research on environmental regulation and environmental performance

Existing literatures have inconsistent research conclusions on environmental regulation and environmental quality. One party believes that environmental regulation will promote environmental performance. This type of research is mainly based on the "Porter Hypothesis", which believes that under appropriate environmental regulation, enterprises will be stimulated to innovate in environmental protection technology, improve green production efficiency, and produce "innovative". "Compensation" for environmental effects, and this part of "innovative compensation" can offset the cost of environmental protection activities and reduce the emission of pollutants from enterprises. The other party believes that environmental regulation has a negative impact on environmental performance, and there is a phenomenon of "green paradox". This part of the study believes that under a series of environmental protection policies issued by the government, enterprises are expected to be subject to higher environmental supervision in the future, and may seek higher operating income by increasing production to make up for the environmental costs brought by the new policies. In order to effectively deal with the adverse effects of environmental regulations, enterprises may take the initiative to take measures to avoid the adverse effects of environmental regulations, forming a situation of "policies above and countermeasures below" (Sinn, 2008; Blackman and Kildegaard, 2010). Some scholars believe that the impact of environmental regulation on environmental performance is not significant. Due to the phenomenon of "incomplete implementation" of environmental regulation by enterprises, enterprises will not complete pollution reduction and emission reduction in accordance with the ideal policy goals, and strategically avoid environmental policies. Adverse economic consequences, which will lead to insignificant effects of environmental regulation on environmental performance (Wang and Jin, 2007). Da Motta (2006) used data from the Brazilian manufacturing industry and found that government sanctions and requirements have an important impact on corporate environmental management.

Environmental regulation can improve environmental performance, mainly based on Porter's theory of competition. Strengthening environmental regulations will have an "innovation compensation" effect, which will stimulate companies to increase R&D expenditures and change production processes, thereby promoting environmental innovation. As environmental innovation improves, environmental pollutants will also be reduced. Environmental regulation can promote innovation and improve the competitiveness of enterprises. Although environmental regulation creates additional cost burdens for enterprises, innovation can make up for the extra costs, thereby further promoting the competitiveness of enterprises. With the implementation of environmental regulations, enterprises will carry out a series of environmental management activities, such as increasing investment in research and development, adopting some pollution prevention technologies, or carrying out green product design and implementing clean technologies, and the number of environmental patents will also increase. Kesidou and Demirel (2012) used the data of 1566 companies in the UK, and their empirical results show that environmental regulation

has different effects on different companies, but the results also support the Porter hypothesis. In addition, some scholars measure a company's environmental innovation by investigating whether companies have adopted certain pollution prevention technologies, or whether they have carried out green product design, and whether they have implemented clean technologies. Wagner (2008) used the EBEB survey carried out by nine European countries in 2001, and found that the more active the process innovation behavior of the enterprise, the more perfect the enterprise's environmental management system. Khanna et al. (2009) used the 1994-1996 U.S. S&P 500 list to report toxic emissions inventories and the data of enterprises under investigation, and the study found that the main motivation of enterprises' continuous cleaner production behavior is the expected effect of environmental regulations, or the existence of "Complementary Assets".

2.4 Research Review

By sorting out relevant literature, it is found that the research on the economic consequences of environmental regulation and the influencing factors of environmental performance has achieved relatively fruitful academic results. Because scholars choose different research objects and environmental regulation tools from different research angles, and use different measurement indicators, etc., the existing literature on environmental regulation and environmental performance The research conclusions are not unified, and the relationship between the two is not uniform. There is no conclusion, showing the relationship between inhibition effect, promotion effect, first promotion and then inhibition effect and insignificant relationship, but most studies support a positive effect. Therefore, the role of environmental regulation is not yet clear, and the impact of environmental regulation on corporate environmental performance needs to be continued. Explore. Considering that the comprehensive indicators of environmental regulation are generally relatively general and cannot reflect the specific utility of various types of tools for environmental regulation, this paper divides environmental regulation into three levels, namely command-and-control, market-incentivized, and public-participation. The impact of environmental regulatory tools on environmental performance.

3 Theoretical analysis and research assumptions

Environmental resources are an extremely important and irreplaceable scarce public good. The urgency and importance of environmental problems are self-evident. Scholars continue to discuss the factors affecting environmental performance and find that environmental regulation is an important means to solve environmental problems. . The problems of unclear property rights and high governance costs brought about by environmental pollution make environmental problems "negative externalities". Enterprises are reluctant to invest more environmental protection funds to implement environmental management activities, which means that market mechanisms cannot eliminate the externalities of environmental problems, which can easily lead to market failures and inefficient allocation of environmental resources. Since the pollution and damage of the ecological environment cannot be solved by the market itself, the government needs to play an important role in market regulation at this time. Environmental regulation is an important external environmental governance method, and an external environmental regulation and constraint is formed through the active intervention of relevant government departments. As a policy tool to correct market failures, environmental regulation can improve the quality of the environment to a certain extent, promote the green transformation of enterprises, and realize the upgrading of the industrial structure. Under the intervention of government control measures, environmental regulation can urge enterprises to strictly abide by social norms and environmental protection legal standards, and form a legal deterrent effect on enterprises' environmental management behavior.

"Legitimacy Theory" believes that if an enterprise wants to achieve sustainable development, it needs to continuously abide by social legal norms and environmental protection standards, and be consistent with social values. compliance and reasonableness of behavioral outcomes. "Legitimacy theory" can provide theoretical support for the relationship between environmental regulation and environmental performance.

Under the influence of environmental regulation, enterprises have to take environmental management measures to improve their environmental performance to meet the legal requirements of enterprises. Environmental performance represents the level of effort that an enterprise undertakes to control and discharge pollutants, including the effective use of resources, the reduction of waste and energy consumption, and the reduction of environmental pollution risks, and to a certain extent reflects the enterprise's response to environmental regulations. The environmental management behaviors implemented by enterprises can interact with stakeholders such as the government and the public, and convey to them a signal that the company complies with social norms and standards, so as to obtain the recognition of stakeholders, which is an important way for enterprises to obtain legitimacy.

Based on the research of previous scholars, there are different types of environmental regulation due to different means of action and participants, namely command-and-control, market-incentivized, and public-participation-type environmental regulation. Therefore, this paper believes that it is necessary to explore the impact of command and control environmental regulation, market incentive environmental regulation and public participation environmental regulation on environmental performance respectively, so as to expand the selection and application space of environmental protection strategies of government departments.

3.1 Command-and-control environmental regulation and corporate environmental performance

Command-and-control environmental regulation establishes a demand orientation for sustainable development of environmental protection and triggers the adjustment of corporate innovation strategies to respond to changes in market demand. The "market failure theory" believes that environmental resources have the characteristics of public goods and "externalities", incomplete environmental information can easily lead to information asymmetry, and enterprises as economic subjects have bounded rationality, which will destroy the normal operation of the market mechanism. . If there is no government intervention and only complete competition through the market mechanism, enterprises will cause behavioral consequences that damage the environment in order to maximize their own interests. At this time, the phenomenon of "market failure" caused by environmental problems needs to be corrected by the government, and the means of correction are mainly command-and-control environmental regulations such as direct regulation and other coercive means. The "environmental authoritarianism theory" also provides theoretical support for the command-and-control environmental regulation tool. This theory advocates relying on the authority of the government to govern the environment by means of coercive intervention, setting standards, and implementing regulations. To control environmental problems locally, urge enterprises to increase investment in green research and development, and urge enterprises to reduce production behaviors with substandard pollutant emissions.

Under the influence of different environmental regulations, the strictness of pollution discharge management faced by enterprises will change. As a rational broker, enterprises can identify different environmental protection investment strategies to cope with changes in potential benefits and potential costs. Under the circumstance that the regulatory authorities limit the amount of pollution emissions, in order to meet legal compliance requirements, enterprises have to take a series of environmental response measures to reduce pollution and reduce emissions, so as to avoid the risk of environmental violations. At this time, enterprises may take a series of measures to meet the command-and-control policy, such as increasing pollution reduction and emission reduction equipment, implementing technological innovation decisions, researching and developing green technologies, establishing environmental management departments, and implementing environmental management activities such as organizational environmental management strategies. When companies weigh the potential benefits of organizational legitimacy against the potential costs of policy compliance, they find that the cost of increasing environmental input is far lower than the hefty fines facing environmental penalties. Based on the principle of weighing cost-effectiveness, companies

are more likely to choose to take active measures to improve their environmental performance, increase investment in environmental protection and green R&D, and promote corporate innovation, which also confirms the innovation compensation effect of Porter's hypothesis to a certain extent. Based on the above analysis, the following assumptions are put forward:

H1a: Command-and-control environmental regulation improves corporate environmental performance.

3.2 Market Incentive Environmental Regulation and Enterprise Environmental Performance

The representative theory of market-incentivized environmental regulation is the "polluter pays principle". The government collects pollution discharge fees to correct externalities, and provides various forms of government subsidies such as cash payments to enterprises that generate positive external effects, so as to achieve internal external costs. market-based means. Market-incentivized environmental regulation creates a flexible and free market operation space for enterprises by using market-oriented means. By implementing market-oriented means of regulating the nature of prices, enterprises have more flexibility in independent choice, realizing the flexibility and control of environmental resources. initiative. In the case of full market competition, market-incentive environmental regulation has static cost efficiency. The company weighs production costs and expected benefits according to its own actual situation, and seeks learning effects and green innovation compensation effects through green strategic choices to ensure corporate finance. At the same time of performance, reduce the cost of pollution payment.

Therefore, the implementation of market-based environmental policies uses the "visible hand" of the government to revise the market mechanism, stimulate enterprises' environmental protection investment and improve production methods to a certain extent, and solve the problem of market failure. Under the incentive of the government's specific market economy, enterprises choose the means most suitable for their own development, and handle the relationship between pollution control investment and production and operation. The government can provide financial support and incentives for enterprises through various forms of financial subsidies such as cash payment, interest rate concessions and tax incentives, bring direct cash inflows to enterprises, make up for the high pollution control costs of enterprises, and encourage enterprises to actively reduce pollution and reduce emissions. Compensate the cost of environmental protection input lost by enterprises to improve environmental performance. At this time, enterprises have the motivation to take a series of pollution reduction and emission reduction environmental protection measures, pay more attention to green production management, and deal with external environmental problems. At the same time, enterprises send positive signals to the market about their potential for green technology innovation, green environmental protection, etc., break information asymmetry, gain more market opportunities, and improve environmental performance while bringing value to the enterprise. Based on the above analysis, the following assumptions are put forward:

H1b: Market-incentivized environmental regulation improves corporate environmental performance.

3.3 Public participation in environmental regulation and corporate environmental performance

Public participation is the conscious expression of self-rights of citizens. For the country and society, public participation symbolizes political democratization. Public participation in environmental regulation mainly involves the public (such as the surrounding communities, media and other stakeholders) participating in public affairs and public affairs through environmental petitions, violation reports, environmental lawsuits, advocacy meetings, hearings, voting and other means and channels. Among the policies, it is an important form of government environmental regulation and is regarded as a useful supplement to the government's environmental governance measures. As an important way for citizens to express their interests and demands, public environmental participation can help solve the problem of information asymmetry in environmental governance, make the utility of command-and-control tools more comprehensive and accurate, and make the role of market-incentive tools more open and reasonable. The

public's proactive behavior of participating in environmental management through legal channels can accurately supervise the pollution behavior of enterprises. This bottom-up approach to feedback environmental interests to the government can urge the government's environmental protection departments and law enforcement departments to conduct administrative law enforcement and supervision. , which has an important impact on public policy. The public participates in the formulation of various environmental plans and the environmental management activities of environmental departments, timely corrects government decision-making mistakes, and makes up for "government failures" and "market failures", thereby improving corporate environmental performance. Based on the above analysis, the following assumptions are put forward:

H1c: Public participation in environmental regulation improves corporate environmental performance.

4 Study Design

4.1 Data sources and sample selection

The research interval selected in this paper is 2012-2019, and the annual data of China's Shanghai and Shenzhen A-share listed companies is used as the initial sample for research, and the initial sample is screened and preprocessed: (1) Remove financial insurance, ST and *ST (2) Eliminate the samples with missing key variables; (3) Eliminate listed companies with an asset-liability ratio greater than or equal to 1; (4) Perform 1% Winsorize treatment on all continuous variables.

After the above screening and preprocessing, the remaining eligible companies obtained a total of 1251 observations from 380 companies. The main data sources of this paper are: environmental performance data, market-incentivized environmental regulation data and financial data are mainly from Guotai'an database; command-controlled environmental regulation and public participation environmental regulation data are taken from the 2013-2020 China Environmental Yearbook and "China Statistical Yearbook".

4.2 Variable selection

4.2.1 Explanatory variables

Command and Control Environmental Regulation (*CER*). The existing literature mainly includes the following quantification methods. One is to measure the number of environmental regulation laws, regulations and administrative rules promulgated or currently effective by local governments in that year. The second is to measure the intensity of environmental regulation by selecting the amount of investment in environmental pollution control in each region or its proportion to GDP. The third is to measure the number of regional administrative penalty cases by using the number of government inspections of pollution emissions from enterprises. This paper comprehensively considers the representativeness, continuity, persistence and availability of the data in the disclosure period, and selects the logarithm of the number of environmental administrative penalty cases accepted in the current year in the location of the company's headquarters in the environmental legal work of each region in the "China Environmental Yearbook" to measure. .

Market Incentive Environmental Regulation (*MER*). The first quantitative method is to use the proportion of regional sewage charges in GDP. The second is to measure the ratio of environmental subsidies to operating income and whether enterprises receive environmental subsidies. In this paper, the ratio of environmental subsidies to operating income is measured by the logarithm. Market-incentive environmental regulation, the data comes from the details of "government subsidies" of listed companies in the Cathay Pacific database, and the government environmental subsidies are obtained by manually screening environmental subsidies, and the sum of the sums is taken logarithm to measure the market-incentive type. environmental regulation.

Public Participation in Environmental Regulation (*VER*). In academic circles, public participation-based environmental regulation is also called voluntary environmental regulation. It mainly

takes the following forms, which are measured by the number of petitions for environmental pollution in the region, the number of public environmental complaints, and the number of environmental supervision. Through the inductive analysis of the existing research on environmental regulation measurement indicators, combined with the specific situation in China and the maximum availability of relevant data, this paper believes that the proposals of deputies to the National People's Congress and members of the Chinese People's Political Consultative Conference on environmental protection can reflect the public's environmental protection petitions to a certain extent. Therefore, the ratio of the number of people's congress recommendations undertaken by regions involving environmental protection departments in the "China Environmental Yearbook" to the total population of the region is selected as an indicator to measure the intensity of public participation in environmental regulation.

4.2.2 Explained variables

Environmental Performance (*EP*). The data at the micro-enterprise level is difficult to obtain directly, and there is no uniform standard for the measurement of corporate environmental performance. my country's environmental performance evaluation system is not perfect, there is no environmental performance scoring index, and there has not been established a ranking of excellent environmental performance. Emissions related databases. Some scholars have used the analytic hierarchy process to construct the enterprise environmental performance evaluation index system, but the data sources of the environmental indicators used are not uniform, the reliability is not high, and there is no objective standard for the assignment method. Some scholars use the penalties imposed by government departments for corporate pollution violations and discharge fees to measure environmental performance. However, because violation penalties, pollution fees and environmental protection taxes themselves reflect some means of environmental regulation intensity, this paper uses corporate violations. Penalties and sewage charges are illogical to measure environmental performance. In addition, violation penalties only represent the environmental performance results of high-polluting enterprises to a certain extent, and there will be a certain degree of sample bias.

Enterprise environmental performance is the result of the implementation of environmental strategy and is an active behavior of enterprises. Enterprise environmental capital expenditure is a relatively accurate and objective indicator of environmental performance (Patten, 2005). In the process of transforming from an extensive economy to an environment-friendly economy, the existing basic production conditions and production and operation processes of Chinese enterprises have not reached the mode of circular economy and clean production. At this time, the solution of environmental problems cannot be separated from the reform of the existing production mode. , the change of green production model is rooted in the degree of effort made by enterprises for the environment, whether it is to implement cleaner production, carbon emission reduction or circular economy, it is inseparable from environmental capital expenditure. Therefore, this paper uses the logarithm of the ratio of environmental capital expenditure to operating income to measure corporate environmental performance.

4.2.3 Control variables

Drawing on the research of Patten (2005), Kesidou and Demirel (2012), this paper controls for firm size (*SIZE*), financial leverage (*LEV*), return on total assets (*ROA*), cash holdings (*CASH*), and institutional investor stockholdings. (*INST*), executive compensation (*SALARY*), two jobs in one (*DUAL*).

Table 4.1 Variable Definition Table

variable category	variable name	variable description
Explained variable	$LN(EP)$	The ratio of environmental capital expenditure to operating income is measured by the logarithm

	<i>LN(CER)</i>	Select the logarithm of the number of environmental administrative penalty cases accepted by each region in the current year in the environmental legal work of each region in the "China Environmental Yearbook" to measure
Explanatory variables	<i>LN(MER)</i>	The ratio of environmental subsidy to operating income is measured by logarithm
	<i>LN(VER)</i>	Take the logarithm of the ratio of the number of people's congress recommendations undertaken by the regions involving environmental protection departments in the "China Environmental Yearbook" and the total population of the region (10,000 people)
	<i>SIZE</i>	Natural logarithm of total assets at the end of the period
	<i>LEV</i>	The ratio of total liabilities to total assets
	<i>ROA</i>	The ratio of net profit to average total assets
	<i>CASH</i>	The ratio of net cash flow from operating activities to total assets
Control variable	<i>INST</i>	Institutional investor shareholding
	<i>SALARY</i>	The natural logarithm of the total compensation of the top three executives
	<i>DUAL</i>	The value is 1 when the chairman and the general manager are the same person, otherwise 0
	<i>Year</i>	annual dummy variable
	<i>Industry</i>	Industry dummy variable

4.3 Model Design

Model 1 is constructed to verify the impact of H1a command-and-control environmental regulation on environmental performance, as shown in Equation (4.1). Model 2 is constructed to verify the impact of H1b market incentive environmental regulation on environmental performance, as shown in Equation (4.2). Model 3 is constructed to verify the impact of H1c public participation in environmental regulation on environmental performance, as shown in Equation (4.3). Model 4 is constructed to verify the combined results of the hypothesis H1a-H1c, as shown in Equation (4.4).

$$LN(EP) = a_0 + \beta_1 LN(CER) + \beta_2 SIZE + \beta_3 LEV + \beta_4 ROA + \beta_5 CASH + \beta_6 INST + \beta_7 SALARY + \beta_8 DUAL + \sum YEAR + \sum INDUSTRY + \varepsilon_i \quad (4.1)$$

$$LN(EP) = a_0 + \beta_1 LN(MER) + \beta_2 SIZE + \beta_3 LEV + \beta_4 ROA + \beta_5 CASH + \beta_6 INST + \beta_7 SALARY + \beta_8 DUAL + \sum YEAR + \sum INDUSTRY + \varepsilon_i \quad (4.2)$$

$$LN(EP) = a_0 + \beta_1 LN(VER) + \beta_2 SIZE + \beta_3 LEV + \beta_4 ROA + \beta_5 CASH + \beta_6 INST + \beta_7 SALARY + \beta_8 DUAL + \sum YEAR + \sum INDUSTRY + \varepsilon_i \quad (4.3)$$

$$LN(EP) = a_0 + \beta_1 LN(CER) + \beta_2 LN(MER) + \beta_3 LN(VER) + \beta_4 SIZE + \beta_5 LEV + \beta_6 ROA + \beta_7 CASH + \beta_8 INST + \beta_9 SALARY + \beta_{10} DUAL + \sum YEAR + \sum INDUSTRY + \varepsilon_i \quad (4.4)$$

5 Empirical Analysis

5.1 Descriptive statistical analysis

It can be seen from Table 5.1 that the mean value of the explained variable environmental performance is -7.054, that is, the proportion of environmental capital expenditure in operating income is about 0.09%, indicating that the proportion of environmental protection capital expenditure of enterprises is relatively small, and the degree of emphasis on environmental performance needs to be improved. The maximum and minimum values are -3.352 and -14.155 respectively, which means that the proportion of environmental capital expenditure in the sample to operating income is quite different, and the environmental performance level is uneven. Some enterprises may pay more attention to environmental performance and assume more social responsibilities. The average value of the explanatory variable command-and-control environmental regulation is 8.344, that is, the number of environmental administrative penalty cases accepted by each region in that year is about 4,205. The average value of market incentive-based environmental regulation is

-7.993, that is, the ratio of government environmental subsidies to corporate operating income is about 0.03%. The average value of public participation in environmental regulation is -0.619, the maximum and minimum values are 2.449 and -2.762, respectively. The ratio of the number of NPC recommendations undertaken by the corresponding environmental protection department to the total population of the region is 0.54 per million population. The number of NPC recommendations undertaken per million population is 11.58, and the number of NPC recommendations undertaken per million population is 0.06, indicating that the number of NPC recommendations undertaken by different regions is different, and the intensity of public participation in environmental regulation varies in different regions.

Table 5.1 Sample Statistical Description Table

variable	mean	sd	min	p50	max
<i>LN(EP)</i>	-7.054	1.438	-14.155	-6.960	-3.352
<i>LN(CER)</i>	8.344	1.106	2.708	8.419	10.718
<i>LN(MER)</i>	-7.993	1.833	-18.193	-7.958	-2.845
<i>LN(VER)</i>	-0.619	0.596	-2.762	-0.707	2.449
<i>ELR</i>	0.685	0.465	0.000	1.000	1.000
<i>SIZE</i>	22.433	1.161	19.863	22.278	26.315
<i>LEV</i>	0.453	0.198	0.015	0.445	0.983
<i>ROA</i>	0.034	0.060	-0.399	0.029	0.399
<i>CASH</i>	0.136	0.092	0.003	0.114	0.697
<i>INST</i>	0.014	0.042	0.000	0.000	0.492
<i>SALARY</i>	15.298	0.703	12.121	15.245	18.945
<i>DUAL</i>	0.203	0.402	0.000	0.000	1.000

5.2 Regression results and analysis

5.2.1 Average effect test of environmental regulation and environmental performance

Table 5.2 reports the main effect regression results of each type of environmental regulation and environmental performance. The estimated coefficient of the variable *LN(CER)* is 0.1124, which has passed the significance test at the 1% level. Since the estimated coefficient is positive, this indicates that the hypothesis H1a passed the test, indicating that there is a positive correlation between command-and-control environmental regulation and corporate environmental performance, that is, the larger the command-and-control environmental regulation, the higher the environmental performance level of the sample enterprises. Specifically, when the command-and-control environmental regulation increases by 1%, It can promote the level of corporate environmental performance to increase by 0.1124%.

Table 5.2 Average effect regression analysis

variable	(1) <i>LN(EP)</i>	(2) <i>LN(EP)</i>	(3) <i>LN(EP)</i>	(4) <i>LN(EP)</i>
<i>LN(CER)</i>	0.1124*** (2.77)			0.1028** (2.52)
<i>LN(MER)</i>		0.0723*** (3.20)		0.0804*** (3.57)
<i>LN(VER)</i>			0.2217*** (3.24)	0.2150*** (3.13)
<i>SIZE</i>	-0.1559*** (-3.20)	-0.1430*** (-2.93)	-0.1546*** (-3.18)	-0.1378*** (-2.84)
<i>LEV</i>	-0.2749 (-1.05)	-0.2996 (-1.15)	-0.2570 (-0.98)	-0.2294 (-0.88)
<i>ROA</i>	-2.0364*** (-2.65)	-1.8520** (-2.41)	-2.0299*** (-2.65)	-1.9212** (-2.52)
<i>CASH</i>	0.0125	0.0582	0.0529	0.1465

	(0.03)	(0.13)	(0.12)	(0.32)
<i>INST</i>	-1.7519	-1.7054	-1.8231	-1.7737
	(-1.57)	(-1.53)	(-1.64)	(-1.60)
<i>SALARY</i>	0.1257*	0.1438**	0.1266*	0.1317**
	(1.87)	(2.14)	(1.89)	(1.97)
<i>DUAL</i>	0.1257	0.1457	0.1356	0.1345
	(1.25)	(1.45)	(1.35)	(1.34)
<i>_cons</i>	-6.6996***	-5.7921***	-5.9047***	-6.3840***
	(-5.45)	(-4.83)	(-4.93)	(-5.23)
<i>Industry</i>	control	control	control	control
<i>Year</i>	control	control	control	control
<i>R²</i>	0.1485	0.1504	0.1505	0.1632
<i>F</i>	5.14	5.22	5.23	5.48

Note: *** means $p < 0.01$, ** means $p < 0.05$, * means $p < 0.1$

The estimated coefficient of the variable LN(MER) is 0.0723, which has passed the significance test at the 1% level. Since the estimated coefficient is positive, this indicates that the hypothesis H1b also passed the test, indicating that there is a significant positive correlation between corporate environmental performance and market-incentive environmental regulation. relationship, that is, the greater the government's environmental subsidies to sample enterprises, the higher the level of enterprise environmental performance. When the government's environmental subsidy is increased by 1%, it can promote the level of environmental performance to increase by 0.0723%.

The estimated coefficient of the variable LN(VER) is 0.2217, which has passed the significance test at the 1% level. Since the estimated coefficient is positive, this indicates that the hypothesis H1c has also passed the test, indicating that there is a significant positive correlation between corporate environmental performance and public participation in environmental regulation. relationship, that is, the greater the intensity of public participation in environmental regulation, the higher the level of corporate environmental performance. When public participation in environmental regulation increases by 1%, it can promote the level of environmental performance to increase by 0.2217%.

5.2.2 Robustness check

In order to verify that the above conclusions are robust and reliable, this paper conducts a robustness test. Since the bidirectional causal relationship between causal variables in this paper may exist, instrumental variables are used to overcome the endogeneity problem of variables. Considering the lag of environmental regulation indicators as an instrumental variable, the specific results are shown in Table 5.3. From the robustness test results of the relationship between environmental regulation and environmental performance in Table 5.3, it can be seen that the regression coefficient of the command-type environmental regulation and the environmental performance variable index is 0.0791, which is significant at the 10% level. The command-and-control environmental regulation significantly increases the environmental capital of enterprises Expenditure, improve the environmental performance of enterprises; the regression coefficient of market incentive environmental regulation and environmental performance variable indicators is 0.0979, which is significant at the level of 1%. Market incentive environmental regulation significantly increases corporate environmental capital expenditure and improves corporate environmental performance. The regression coefficient of public environmental regulation and environmental performance variable index is 0.2118, which is significant at the 1% level. Public participation in environmental regulation significantly increases corporate environmental capital expenditure and improves corporate environmental performance.

Table 5.3 Regression results of robustness test (lag by one period)

variable	(1) <i>LN(EP)</i>	(2) <i>LN(EP)</i>	(3) <i>LN(EP)</i>	(4) <i>LN(EP)</i>
<i>LN(CER)</i>	0.0791* (1.74)			0.1091** (2.12)
<i>LN(MER)</i>		0.0979*** (3.33)		0.1038*** (3.55)
<i>LN(VER)</i>			0.2118*** (2.74)	0.1836** (2.11)
<i>SIZE</i>	-0.2034*** (-3.67)	-0.1295** (-2.05)	-0.1953*** (-3.53)	-0.1336** (-2.12)
<i>LEV</i>	-0.1751 (-0.59)	-0.5176 (-1.58)	-0.1768 (-0.60)	-0.4444 (-1.36)
<i>ROA</i>	-2.2243** (-2.52)	-1.6645* (-1.74)	-2.3132*** (-2.62)	-1.8444* (-1.93)
<i>CASH</i>	0.0914 (0.16)	-0.0723 (-0.11)	0.1334 (0.24)	0.1192 (0.19)
<i>INST</i>	-2.0644 (-1.37)	-3.0040* (-1.82)	-1.8984 (-1.26)	-2.7212* (-1.65)
<i>SALARY</i>	0.1788** (2.29)	0.1868** (2.18)	0.1732** (2.22)	0.1763** (2.07)
<i>DUAL</i>	0.1509 (1.28)	0.1433 (1.12)	0.1688 (1.44)	0.1409 (1.10)
<i>_cons</i>	-6.3756*** (-4.49)	-6.4225*** (-4.15)	-5.8678*** (-4.21)	-6.9131*** (-4.41)
<i>Industry</i>	control	control	control	control
<i>Year</i>	control	control	control	control
<i>R²</i>	0.1703	0.1838	0.1742	0.1958
<i>F</i>	4.76	4.33	4.89	4.43

Note: *** means $p < 0.01$, ** means $p < 0.05$, * means $p < 0.1$

6 Conclusions

In recent years, in order to encourage corporate environmental governance, my country has been striving to establish and improve the ecological civilization system. Relevant departments have promulgated relevant policies, promulgated relevant laws and regulations, increased government subsidies for enterprises that produce positive external effects, and collected pollutant discharge environmental protection from enterprises. To encourage enterprises to fulfill their environmental responsibilities, strengthen the management of the ecological environment, and promote the reform of the ecological protection system. Using the sample data from 2012 to 2019, this paper takes different types of environmental regulation as the starting point, and deeply analyzes the impact of environmental regulation on the environmental performance of enterprises. actual.

The main conclusions of this paper are as follows: Environmental regulation can have a positive impact on environmental performance. Specifically, the command-and-control type of environmental regulation promotes the improvement of corporate environmental performance by mandatory means; the market-incentive type of environmental regulation promotes the improvement of enterprises' environmental performance by means of incentives; the public participates in environmental management through the use of legal means, and the public-participation type of environmental regulation Positive impact on

environmental performance. The research results show that no matter what type of environmental regulation, it can play a certain role in the environmental performance of enterprises, and the government and the public play an important role in environmental management.

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