Promoting or Inhibiting? The Impact of Enterprise Environmental Performance on Economic Performance: Evidence From China's Large Iron and Steel Enterprises

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Promoting or Inhibiting? The impact of enterprise environmental performance on economic performance: Evidence from China's large iron and steel enterprises

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Abstract: In recent years, people have realized the importance of corporate environmental responsibility. In this study, we combine the Slack-based Measurement (SBM) model with the "Super-efficiency" model to construct the environmental performance evaluation based on Data Envelopment Analysis (DEA) to measure the environmental performance of China's large iron and steel enterprises from 2009 to 2017. Then, it studies the impact of environmental performance on enterprise economic performance through regression analysis. The results show that the impact of environmental performance of China's large iron and steel enterprises on economic performance shows an inverted U-shaped relationship. The conclusion is helpful to encourage enterprises to actively carry out environmental management, so as to maintain and enhance the competitiveness of enterprises. Therefore, this paper suggests that iron and steel enterprises should balance the relationship between environmental responsibility and economic performance in order to maximize enterprise performance. The main purpose of this paper is to let enterprises solve the negative externalities in production through internalization, and encourage enterprises to adopt environmental protection behavior for production and operation.

Keyword: Environmental performance; Economic performance; Iron and steel enterprises

1. Introduction

Green development is currently a hot issue that countries all over the world are paying attention to. Under the background of the dual pressures of economic growth and pollution control, it is vital to achieve a win-win situation of "reducing pollution" and "increasing efficiency" at the same time. Socio-economic development requires enterprises to undertake environmental responsibilities while obtaining economic benefits, so as to meet the environmental protection demands of stakeholders. How to strike a balance between ecological environmental protection and economic development has become an important issue for all sectors of society.

Industry is very important to China's economic structure. However, due to the lack of environmental protection facilities of industrial enterprises, backward technology, lax emission standards, and lack of supporting supervision, industry has become China's largest source of pollution, and industrial enterprises have a long way to go in environmental protection. At present, due to the huge scale of China's industrial economy, the environmental pollution caused by the unreasonable production structure cannot achieve the clean production encouraged by the government. Therefore, improving the environmental and economic performance of industrial enterprises has become an important goal of national environmental governance (Liang and Liu, 2017).

As the main undertaker of economic development, enterprises are not only responsible for market demand, but also for resources and environmental protection. In recent years, governments and environmental organizations in various countries have paid more and more attention to environmental protection, and enterprises are facing increasing pressure on environmental protection (Chuang and

Huang, 2018; Deng and Li, 2020; Hart, 1995). At present, China's share in world steel production and use has increased from less than 20% to more than 50%. The steel industry has become a major contributor to China's economic growth. However, this rapid development is driven by an energy-intensive model, which has caused a series of environmental problems. Many Chinese iron and steel enterprises have a negative impact on the environment in the process of production and operation (Chuang and Huang, 2018; Deng and Li, 2020; Hart, 1995). Facing the increasingly serious environmental problems and the pressure of the government, the public and other stakeholders, enterprises need to proactively assume environmental responsibilities and conduct environmental management. However, as a rational economic man, creating economic performance is almost the decision-making goal of all senior managers. Whether environmental management can bring economic performance is one of the most concerned problems of enterprises. The impact of environmental responsibility on financial performance determines the production and management decisions of enterprises. Therefore, in order to enable enterprises to actively fulfill their environmental responsibilities, this paper links corporate environmental responsibilities with corporate economic goals, discusses the impact of corporate environmental performance on corporate economic performance, and provides new ideas for improving corporate environmental management. Based on this background, this paper uses the data of China's large iron and steel enterprises from 2009 to 2017 to explore the impact of enterprise environmental performance on economic performance. We hope that the research results can provide some theoretical and practical reference for iron and steel enterprises to achieve performance optimization.

The structure of the paper is as follows. Section 2 presents an overview of related literature and formulates research hypotheses. Section 3 describes the data, sample selection, variables and our estimation approach. Sections 4 present the empirical results. Section 5 discusses the robustness test. Finally, Section 6 is the conclusions and recommendations as well as the outlook for future research.

2. Literature review and research hypotheses

Generally, enterprises will inevitably have an impact on the environment in the process of operation. The incorporation of environmental factors into enterprise management has stimulated the significant growth of research on Enterprise Environmental Management in the past decades. Research on environmental management has established a number of branches and carried out a large number of studies, proving that this issue is increasingly important (Jiménez-Parra et al., 2018).

Environmental management has external effects, so enterprises usually regard environmental investment as a cost with no obvious benefits. If investment will only bring additional costs, companies will not take the initiative to achieve long-term environmental protection. If you don’t expect entrepreneurs’ natural ethics, it is nothing more than economic performance incentives to encourage companies to fulfill their corporate environmental responsibilities. Therefore, if environmental protection can bring economic benefits, indicating that environmental protection and economic benefits are harmonious, then enterprises will voluntarily take actions to assume environmental responsibility.

2.1. Research on Corporate Environmental Responsibility

In fact, corporate environmental responsibility is playing an increasingly important role in environmental management. In recent years, the research results on corporate environmental responsibility have been abundant, mainly focusing on the following three aspects: First, the research on the interaction between corporate environmental responsibility (CER) and economic and social results, such as the impact of CER on enterprise risk (Cai et al., 2016), operating income (Wong et al., 2018)and export performance (Xu et al., 2018), the impact of CER investment on enterprise income distribution (Ee et al., 2018), the impact of government scale and government supervision on CER (Graafland, 2019), etc. Secondly, research on the relationship between corporate environmental responsibility and corporate organizational structure and behavior, such as the social relationship of the board of directors (Zou et al., 2019), female directors (Wei et al., 2017), and employees' organizational identity (Petridou, 2017). Finally, research on the driving factors of corporate environmental responsibility, including information disclosure of corporate environmental responsibility (Ali et al., 2017), Environmental NGO certification (Zhao and Du, 2017) and corporate culture (Peng et al., 2018), etc.

More and more literature have studied the reasons for enterprises to participate in environmental responsibility and its impact on economic performance. Although there are many empirical evidences on the impact of corporate environmental responsibility on economic performance, there is consistency in the conclusion that corporate environmental responsibility becomes the source of competitive advantage, promotes innovation and increases the value of stakeholders (Chuang and Huang, 2018; Xu et al., 2018). However, we know little about the impact of environmental performance on the economic performance of industrial enterprises when they perform environmental responsibility activities.

2.2 Research on the relationship between environmental performance and economic performance

In 1989, the British economist David Pierce first proposed the term "Green Economy" in the "Green Economy Blue Book", arguing that the economy and the environment influence each other, and the integration of the environment into capital and investment can help resolve the relationship between economic growth and the environment. Contradiction. Since the 21st century, in the theoretical and empirical literature, the relationship between environmental performance and economic performance has aroused great interest. In practice, including in developing countries, this is also one of the key issues that determines whether enterprises can incorporate environmental protection into their core operations and strategic management systems.

Traditional economic theory believes that there is a negative correlation between environmental protection and economic performance. They believe that, while complying with relevant environmental laws and regulations, the investment of limited resources in non-productive anti-pollution equipment and the reduction in investment in production equipment will reduce productivity (Haveman and Christainsen, 1981). The transaction theory shows that the environmental protection activities of enterprises will consume the financial resources of the enterprise, thereby reducing the economic performance of the enterprise, and the benefits of environmental protection activities cannot offset the costs involved, thereby reducing the economic performance of the enterprise (Waddock and Graves, 1997). In addition, the environmental activities of enterprises are in conflict with the main objective of maximizing shareholders' short-term wealth. Voluntary environmental management related activities are regarded as charitable organizations, which contradict the principle of profit maximization (Zhi and Tang, 2012) and increase the risk of enterprises (Cai et al., 2016). Filbeck and Gorman found that there is a negative correlation between the environmental performance of companies and the value of stocks (Filbeck and Gorman, 2004). This view challenges those who believe that there is a win-win situation between enterprise interests and environmental protection (Porter and Claas, 1995).

At present, many opinions believe that good corporate environmental performance can effectively reduce energy use and waste generation, and enable companies to save costs (Porter and Claas, 1995). Studies have shown that although compliance with environmental regulations will incur additional costs, it can also cut costs in other areas (such as waste treatment technology). Some studies have also explored the factors that promote enterprises' participation in environmental responsibility and their impact on enterprise performance (Ee et al., 2018; Hart, 1995; Xu et al., 2018). Hart et al. proposed that the relevant efforts of enterprises to improve environmental performance can create more valuable resources and become a source of competitive advantage (Hart, 1995). Porter and Van der Linde put forward the “Porter hypothesis”. They believe that under the traditional economic model in the past, the development of enterprises has not been constrained by the shortage of existing resources, and enterprises aim at maximizing profits, and their environmental performance and environmental responsibility have been ignored. In the absence of traditional corporate responsibility, enterprises can gain an advantage in market competition at low prices with low resources and at the expense of the environment. However, world demand is shifting to products with low pollution and high energy efficiency. Many enterprises have opened up new market spaces by producing "green" products. Those enterprises that adopted higher environmental standards earlier have the first mover advantage, gaining product premiums and more market share (Porter and Claas, 1995). Miles and Covin pointed out that good environmental initiatives can create new opportunities for gaining a higher ecological reputation and benefit from premium pricing and increased sales (Porter and Claas, 1995).

By adopting an environmentally responsible approach, enterprises can meet the needs of stakeholders who provide resources for enterprises, such as customers, shareholders, governments, consumers and community residents, so as to obtain the resources needed for enterprise development, and achieve social legitimacy and avoid the regulatory risk of the government (Xu et al., 2018). Hang Song et al examined the relationship between environmental management and financial performance of listed companies in China from 2007 to 2011. The results show that environmental management is significantly positively correlated with the next year's financial performance, indicating that environmental management can significantly improve future profitability (Song et al., 2017). Malik Shahzad Shabbir and Okere Wisdom studied the relationship between corporate social responsibility, environmental investment and financial performance of Nigerian manufacturing enterprises. The results show that enterprises with high environmental investment have higher profitability than environmentally unconscious enterprises (Shabbir and Wisdom, 2020). Yun Liu et al. studied the impact of environmental performance on China’s financial performance based on the information of Chinese listed companies disclosed in 2008-2017. The results show that fulfilling environmental responsibility can significantly improve corporate financial performance (Liu et al., 2020).

Regarding empirical research on the relationship between environmental performance and economic performance, some research results are uncertain (Torugsa et al., 2013), highlighting the complex relationship between environmental performance and economic performance (Corbett and Klassen, 2006; Tang and Tang, 2018). According to Telle's research, the positive impact of environmental performance on economic performance obtained by hybrid regression has become insignificant in panel econometric research that controls data heterogeneity (Telle, 2006). Li et al. used a sample of 475 listed Chinese companies from 2013 to 2014 to analyze the relationship between environmental performance, environmental information disclosure and financial performance of Chinese companies. The results found that there is a U-shaped nonlinear relationship between corporate environmental performance and environmental disclosure, and the relationship between environmental performance and financial performance is insignificant (Li et al., 2016).

Based on the above analysis, we believe that environmental performance and economic performance are not a simple linear relationship between positive and negative. With the increasing of environmental performance, the impact on economic performance may show a nonlinear relationship. This paper believes that when companies begin to actively fulfill their environmental responsibilities, they will improve their environmental performance, which will have a positive impact on their economic performance. However, with the continuous increase of environmental investment, although the environmental performance of the enterprise has been further improved, under the condition that the resources of the enterprise are limited, it will inevitably cause the loss of production and financial resources of the enterprise, and the benefits generated by environmental performance cannot make up for the loss. The cost of consumption, thereby reducing the economic performance of the enterprise. Therefore, we propose the following hypothesis:

Hypothesis H: The impact of environmental performance on economic performance presents an inverted U-shaped relationship.

3. Data and measurement of environmental performance

3.1. Data and sample selection

Enterprises from different industries operate under different degrees of environmental pressure and government supervision, which makes it difficult to accurately compare the environmental performance of enterprises in various industries. As an important high pollution, high energy consumption and high emission industry in China, iron and steel enterprises have been required to reduce pollution emissions and improve efficiency for a long time. Taking a single industry as the research object can effectively eliminate the noise interference of different industries (Tang and Tang, 2018). Therefore, this paper chooses the iron and steel industry as the research object. In the selection of research samples, because the production and manufacturing of iron and steel industry has a greater impact on environmental pollution, stakeholders pay more attention to the impact of their environmental performance on economic performance. This paper takes iron and steel enterprises as research samples, which makes the research more realistic and targeted.

Database and estimation methods are the key factors of empirical research. Environmental data used in early research is usually based on ratings or binary data. For example, in order to evaluate the enterprise environment score, some scholars use the KLD database which only provides binary numbers. These databases only use the methods of questionnaire survey and expert evaluation to calculate. The data set used by Ismail Sila and Kemal Cek relies on the information disclosed in corporate social responsibility reports. This information may sometimes be biased. Enterprises exaggerate the level of their social responsibility practices and create a more positive corporate image for stakeholders (Sila and Cek, 2017). Due to the over reporting of participants and the uncontrollable heterogeneity of enterprises, these studies are often biased. Therefore, based on the statistical data of China Iron and Steel Industry Association, this paper collects and constructs the unique environmental panel data set of 54 large-scale enterprises in China's iron and steel industry from 2009 to 2017, and this data set provides financial data of large-scale iron and steel enterprises in China, which can more accurately study the impact of enterprise environmental performance on economic performance. These sample enterprises account for more than 50% of China's crude steel output

3.2. Measuring enterprise environmental performance

3.2.1. Measurement methods

Studying the relationship between environmental performance and economic performance, and accurately evaluating environmental performance plays an important role. As far as the research on quantifying environmental performance is concerned, the difficulty in studying the relationship between environmental performance and economic performance lies in the lack of a standard measurement of environmental performance. Most existing studies use subjective content analysis (Ali et al., 2017) and questionnaire survey methods (Dey et al., 2018; Peng et al., 2018). Incorporating resources and environmental factors into productivity accounting for environmental performance evaluation has always been the focus of academic circles. DEA method is an effective analysis tool of measurement, which is widely used (Chen et al., 2017; Chen and Jia, 2017; Wang et al., 2019). Wu et al. used Two-stage DEA model to study China's energy issues and environmental performance evaluation (Wu et al., 2017). When conducting enterprise-level environmental efficiency evaluation research, the DEA method is better than the parameterized method. This is because the production conditions of enterprises in various countries or regions vary greatly. In this case, fitting the parameter relationship between the input and output of different enterprises may encounter deviations in practice. Therefore, the DEA method is more popular in enterprise-level research (Wang et al., 2020). In order to further improve the research mechanism of quantifying environmental performance, this paper uses DEA method to measure enterprise environmental performance, which will help establish objective evaluation standards and is of great significance for fully understanding the relationship between environmental performance and economic performance.

The original DEA model measures the efficiency score of the decision-making unit (DMU) based on inputs and desired outputs (such as income, profitability, and production). When it comes to pollution such as greenhouse gas emissions, wastewater, and poorly produced solid waste, the traditional method of only considering the expected output is no longer applicable. In order to overcome the limitations of the original data envelopment analysis method, some scholars have proposed a data envelopment analysis method that includes undesired output. Due to the disadvantages and complexity of the traditional DEA model configuration, Slack-based measurement (SBM) has become the mainstream of current research (Wang et al., 2019). The maximum efficiency value obtained by the standard DEA model is 1, and the effective DMU efficiency value is the same, and the efficiency of these effective DMUs cannot be further distinguished. In order to solve this problem, Andersen and Petersen proposed a method to further distinguish the effective degree of effective DMU. This method is called the "Super-efficiency" model (Andersen and Petersen, 1993). For the need of further research, we combine the SBM model with undesired output and the "Super-efficiency" model to form an SBM Super-efficiency model with undesired output. The planning formula of the model is as follows:

$$\min \rho = \frac{1+\frac{1}{m}\sum_{i=1}^{m} A_i^- / x_{ik}}{1-\frac{1}{q_1+q_2}\left(\sum_{r=1}^{q_1} A_r^+ / y_{rk} + \sum_{t=1}^{q_2} A_t^{b-} / b_{tk}\right)} \tag{1}$$

S. t. $$\sum_{j=1, j\neq k}^{n} x_{ij}\lambda_j - A_i^- \leq x_{ik}$$

$$\sum_{j=1, j\neq k}^{n} y_{ij}\lambda_j - A_r^+ \geq y_{rk}$$

$$\sum_{j=1, j\neq k}^{n} b_{tj}\lambda_j - A_t^{b-} \leq b_{tk}$$

$$1-\frac{1}{q_1+q_2}\left(\sum_{r=1}^{q_1} A_r^{+} / y_{rk}+\sum_{t=1}^{q_2} A_t^{b^-} / b_{tk}\right)>0$$

$$\lambda_j, \mathrm{A}_i^-, \mathrm{A}_r^+ \geq 0$$

$$i=1,2,\cdots,m; r=1,2,\cdots,q; j=1,2,\cdots,n(j \neq k).$$

In model (1), it is assumed that there are n decision-making units, and each decision-making unit has an input vector, an expected output vector and an undesired output vector. Assuming that there are m types of inputs and q types of outputs, including q_1 expected outputs and q_2 undesired outputs, the input vector is $x \in R^m$, the expected output vector is $y \in R^{q1}$, and the undesired output vector is $b \in R^{q2}$. Where S represents the slack of input and output, A^- represents the input redundancy, A^+ represents the expected output shortage, A^{b-} represents the undesired output excess, λ is the weight vector, and ρ represents the efficiency score.

3.2.2. Description of measurement variables

According to the research purpose and the situation of China's iron and steel industry, this paper selects the following indicators, as shown in Table 1.

Table 1 Variable selection and interpretation

Variable		Interpretation
Inputs	New water consumption	=total water consumption * (1 - water resource reuse rate)
	Fixed assets	=the original value of the fixed assets - the accumulated depreciation - the provision for impairment of fixed assets
	Number of employees	Average number of employees per year
	Energy consumption	A unified conversion of various energy consumption into standard coal consumption
	Environmental protection investment	Amount of investment for environmental protection
Undesirable outputs	Waste residue	Total amount of waste residue produced by enterprises
	Waste gas	Total amount of waste gas produced by enterprises
	Waste water	Total amount of waste water produced by enterprises
	Pollutant discharge fees	Fees paid to the government according to the type, quantity and concentration of pollutants discharged
Expected output	Output value of three wastes utilization	Refers to the value of products produced using the "three wastes" (waste water, waste gas, and waste residue) as the main raw materials

Table 1 is a description of the input and output variables of iron and steel enterprises, in which the new water consumption, fixed assets, number of employees, energy consumption and environmental protection investment are input variables, the output value of three wastes utilization is desirable output variable, and the waste residue, waste gas, waste water and pollutant discharge fees are undesirable output variables.

Indicator selection basis: Input variables include new water consumption, fixed assets, number of employees, energy consumption and environmental protection investment. Assets and labor are traditional input variables for research efficiency. On this basis, this paper focuses on the environmental performance of iron and steel enterprises, so new water consumption, energy consumption and environmental protection investment variables are added to make the investment indicators more comprehensive. Undesirable output variables include waste residue, waste gas, wastewater, and pollutant discharge fees. Waste residue, waste gas and wastewater are the main pollutants discharged by enterprises; pollutant discharge fees indicate the degree to which the enterprise is regulated by the government and highlight the government's supervisory role in the environmental management of the enterprise. The desirable output variable selects the output value of the three wastes, which indicates the degree of utilization of pollutants by the enterprise, and fully reflects the degree of importance the enterprise attaches to environmental management. The descriptive statistics of variables are shown in Table 2.

Table 2 Descriptive statistics of input and output variables for iron and steel enterprises (2009—2017)

Variable	Units	Mean	Std. dev.	Min	Max
New water consumption	Ten thousand m3	2729.62	2198.23	228.56	11495.04
Fixed assets	Billion Yuan	208.11	204.07	7.93	1177.92
Number of employees	Thousand people	20.49	19.20	1.90	140.00
Energy consumption	Ten thousand tons	438.11	344.00	24.51	2062.20
Environmental protection investment	Ten thousand Yuan	18685.37	33853.49	25.00	268939.00
Waste residue	Ten thousand tons	462.65	450.14	1.64	2682.52
Waste gas	Hundred million m3	1585.38	1423.30	0.06	7976.02
Waste water	Million m3	517.65	569.41	1.20	3760.80
Pollutant discharge fees	Ten thousand Yuan	2504.16	2443.92	179.08	14690.21
Output value of three wastes utilization	Ten thousand Yuan	58957.63	84670.18	275.00	595652.00

3.2.3. Measurement result

According to the existing research and through careful analysis of the actual environmental management situation of the enterprises included in the sample, this paper takes the waste residue, waste gas, waste water and pollutant discharge fees as the environmental undesirable output of iron and steel enterprises. Among them, the emission of three wastes is the main output variable affecting the environmental performance of enterprises. In addition, pollutant discharge fees are levied by regulators, which are also the variables most concerned by regulators; pollutant discharge fees are also output variables that affect the environmental performance of enterprises.

This paper calculates the input and output data of iron and steel enterprises in the environment through the SBM super-efficiency model including the undesirable outputs, and uses the EP to express the results. It provides objective and effective data for examining the relationship between the environmental performance and the economic performance of enterprises. Due to space limitation, figure 1 only shows the calculation results in 2009. EP1-3 input variables are the same, but output variables are different. Among them: EP1 indicates that the undesired output variables include the three wastes (waste residue, waste gas, and waste water) and pollutant discharge fees; EP2 indicates that the undesired output variables only include the three wastes; EP3 indicates that the undesired output variables include only the pollutant discharge fees.

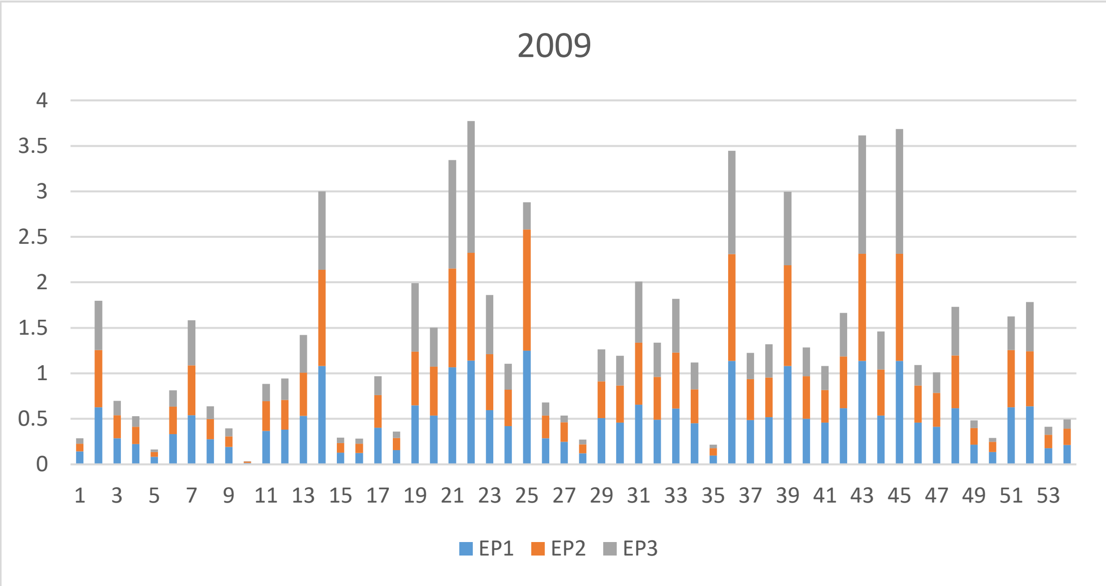

Fig. 1 Measurement results in 2009

As can be seen from Figure 1, the results of EP1, EP2 and EP3 in 2009 are significantly different. We have calculated that 2010-2017 also has this characteristic. Therefore, it is reasonable for this paper to separate the three wastes and pollutant discharge fees to measure the environmental performance of iron and steel enterprises. It is possible to explore the mechanism of environmental performance on economic performance in more detail, which is also one of the main contributions of this paper.

4. Empirical analysis

4.1. Model building

This paper focuses on the impact of environmental performance on economic performance. In order to make an empirical analysis of the above hypothesis, this paper uses the environmental panel data of 54 large-scale enterprises in China's iron and steel industry from 2009 to 2017, constructed the index of environmental performance (EP) to measure corporate environmental responsibility, and on this basis, makes an empirical test on the relationship between environmental performance and economic performance. This paper draws on the research of Cai et al. (2016), Liang et al. (2017), and Xu et al. (2018) (Cai et al., 2016; Liang and Liu, 2017; Xu et al., 2018), combined with the research hypothesis proposed in this paper, and proposes the following econometric equation model:

$$ROA_{i,t} = a_0 + a_1 EP1_{i,t\text{-}1} + a_2 (EP1_{i,t\text{-}1})^2 + a_3 \ln Scale_{i,t} + a_4 Fes_{i,t} + a_5 \ln TC_{i,t} + a_6 \ln MBI_{i,t} + a_7 Leverage_{i,t} + m_{i,t} \quad (1)$$

$$ROA_{i,t} = b_0 + b_1 EP2_{i,t\text{-}1} + b_2 (EP2_{i,t\text{-}1})^2 + b_3 \ln Scale_{i,t} + b_4 Fes_{i,t} + b_5 \ln TC_{i,t} + b_6 \ln MBI_{i,t} + b_7 Leverage_{i,t} + q_{i,t} \quad (2)$$

$$ROA_{i,t} = d_0 + d_1 EP3_{i,t\text{-}1} + d_2 (EP3_{i,t\text{-}1})^2 + d_3 \ln Scale_{i,t} + d_4 Fes_{i,t} + d_5 \ln TC_{i,t} + d_6 \ln MBI_{i,t} + d_7 Leverage_{i,t} + h_{i,t} \quad (3)$$

In the above model, **i** represents the enterprise and **t** represents the time (2009-2017).$\boldsymbol{\alpha_0 \sim \alpha_7}$, $\boldsymbol{\beta_0 \sim \beta_7}$ and $\boldsymbol{\delta_0 \sim \delta_7}$ are parameters to be estimated. $\boldsymbol{\theta_{i,t}}$, $\boldsymbol{\eta_{i,t}}$ and $\boldsymbol{\mu_{i,t}}$ are the random disturbance term. Scale, Fes, TC, MBI and Leverage are a set of control variables.

4.2. Variable description

Explained variable: return on assets (ROA). Return on assets is considered as the best measure of enterprise economic performance, and is widely used (Ali et al., 2017; Zou et al., 2019).

Core explanatory variable: environmental performance (EP). In this paper, the SBM super-efficiency model including undesired output is used to evaluate the state of environmental input and output of iron and steel enterprises, and the evaluation results are expressed by environmental performance. Among them, EP1 indicates that the undesired output variables include the measurement results of three wastes (waste residue, waste gas and waste water) and pollutant discharge fees, EP2 indicates that the undesired output variables only include the measurement results of three wastes, and EP3 indicates that the undesired output variables only include the measurement results of pollutant discharge fees. Since the impact of corporate environmental behavior on corporate economic performance often has a lag effect; therefore, we will conduct an empirical test based on the lag phase of environmental performance (EP).

Control variable: Scale of the enterprise (Scale) is measured by the natural logarithm of total assets at the end of the year. The factor endowment structure (Fes) is expressed by the ratio of the enterprise's net fixed assets to the enterprise's annual average number of employees. The higher the factor endowment structure of the enterprise, the more capital-intensive the enterprise is, and the capital-intensive enterprise is more conducive to the improvement of production technology and the economic performance of the enterprise. Total operating cost (TC) refers to the total cost of goods sold or services provided by an enterprise. This variable is added to control the impact of the total investment of the enterprise on the economic performance of the enterprise. Main business income (MBI) refers to the operating income obtained by the enterprise from the production and operation activities of the industry. This paper also considers the impact of financial leverage on the enterprise, using the enterprise's year-end asset liability ratio (leverage) to measure the financial leverage (Xu et al., 2018). Table 3 presents the summary statistics for all variables.

Table 3. Summary statistics.

Variable Name	Variable Symbol	Obs	Mean	Std. dev.	Min	Max
Return on assets	ROA	486	1.487	4.247	-23.338	11.828
Environmental performance 1	EP1	486	0.534	0.311	0.006	1.250
Environmental performance 2	EP2	486	0.514	0.331	0.005	1.333
Environmental performance 3	EP3	486	0.417	0.365	0.002	1.739
Enterprise scale	lnScale	486	15.080	0.948	11.956	17.006
Factor endowment structure	Fes	486	11.091	8.104	0.410	49.560
Total operating cost	lnTC	486	14.926	0.849	12.018	17.009
Main business income	lnMBI	486	14.853	0.870	11.902	17.022
Asset liability ratio	Leverage	486	68.735	13.562	32.200	120.660

In Table 3, the environmental performance (EP) represents the environmental performance of Chinese iron and steel enterprises. Among them, the maximum value of EP1 is 1.25 and the average value is 0.534; the maximum value of EP2 is 1.333 and the average value is 0.514; the maximum value of EP3 is 1.739, and the average value is only 0.417. This means that the environmental performance of Chinese steel companies is quite different, and the overall environmental management level is low.

4.3. Empirical result analysis

Based on the panel data used in the research of this paper, the three models of fixed effects model, random effects model and mixed model are comprehensively considered in the model selection. By comparing the regression results of the three models, the fixed effects model is finally determined as the optimal model. The regression results of the fixed effects model are shown in Table 4.

Table 4 Regression analysis results

Models Variables	(1) ROA	(2) ROA	(3) ROA
$EP1_{t-1}$	7.68*** (2.77)		
$(EP1_{t-1})^2$	-4.43** (-2.43)		
$EP2_{t-1}$		6.65*** (2.79)	
$(EP2_{t-1})^2$		-4.31*** (-2.61)	
$EP3_{t-1}$			3.77* (1.93)
$(EP3_{t-1})^2$			-2.65* (-1.94)
lnScale	-0.05 (-0.05)	-0.09 (-0.18)	-0.05 (-0.12)
Fes	0.00 (0.05)	0.00 (0.05)	0.00 (0.15)
lnTC	-3.71*** (-4.36)	-3.63*** (-4.33)	-3.73*** (-4.25)
lnMBI	4.52*** (5.22)	4.51*** (5.18)	4.39*** (5.13)
Leverage	-0.21*** (-8.43)	-0.21*** (-8.43)	-0.21*** (-8.39)
Constant	4.11 (0.44)	4.92 (0.51)	5.48 (0.57)
N	432	432	432
R^2	0.318	0.318	0.309

Notes: t statistics in parentheses. ***, **, and * denote the statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Through the control of the fixed effects of enterprises, we essentially explore how the economic performance of enterprises in the same industry changes with changes in environmental performance. The specific regression results are shown in Table 4. The results show that: enterprise environmental performance (EP_{t-1}) has a significant positive correlation with return on assets (ROA), but the estimated coefficient of the square term of enterprise environmental performance (EP_{t-1}^2) is significantly negative. Therefore, there is a significant inverted U-shaped relationship between enterprise environmental performance and return on assets. That is, in the initial stage, the continuous improvement of environmental performance of iron and steel enterprises will improve the economic performance of enterprises, but with the further improvement of environmental performance, when the environmental performance exceeds the critical value, it will have a negative impact on economic performance.

Specifically, according to model (1), the impact coefficient of enterprise environmental performance ($EP1_{t-1}$) on return on assets (ROA) is 7.68, which is significant at the level of 1%; but the estimated coefficient of the square term of enterprise environmental performance ($EP1_{t-1}^2$) is - 4.43, which is significant at the level of 5%. It shows that there is a significant inverted U-shaped relationship between enterprise environmental performance ($EP1_{t-1}$) and return on assets with undesired output variables including three wastes (waste residue, waste gas and waste water) and pollutant discharge fees, which validates the theoretical hypothesis: the impact of corporate environmental performance on economic performance presents an inverted U-shaped relationship.

According to model (2), the impact coefficient of enterprise environmental performance ($EP2_{t-1}$) on return on assets is 6.65, which is significant at the level of 1%; however, the estimated coefficient of the square term of enterprise environmental performance ($EP2_{t-1}^2$) is -4.31, which is significant at the level of 1%; it shows that there is a significant inverted U-shaped relationship between enterprise environmental performance ($EP2_{t-1}$) and return on assets when the undesired output variable only contains three wastes. It also verifies the hypothesis of this paper: the impact of environmental performance on economic performance presents an inverted U-shaped relationship.

According to Model (3), the impact coefficient of enterprise environmental performance ($EP3_{t-1}$) on the rate of return on assets is 3.77, which is significant at the level of 10%; but the estimated coefficient of the square term of enterprise environmental performance ($EP3_{t-1}^2$) is -2.65, which is significant at the level of 10%; it shows that there is a significant inverted U-shaped relationship between enterprise environmental performance ($EP3_{t-1}$) and return on assets that indicate that the undesired output variables only include pollutant discharge fees, which also verifies the hypothesis of this paper: the impact of environmental performance on economic performance presents an inverted U-shaped relationship.

We compare $EP1_{t-1}$, $EP2_{t-1}$ and $EP3_{t-1}$, and the results show that the environmental performance of enterprises considering different environmental undesired output variables has different effects on economic performance. Among them, considering the environmental performance of three wastes (waste residue, waste gas and waste water) has a greater impact on the economic performance of enterprises than pollutant discharge fees.

The results of Model (1) - (3) show that the impact of environmental performance of Chinese iron and steel enterprises on economic performance presents an inverted U-shaped relationship. This shows that the impact of enterprise environmental performance on economic performance can be divided into two stages. First, with the continuous improvement of enterprise environmental performance, the contribution of environmental performance to economic benefits has gradually increased. This may be because the current environmental problems in China are becoming increasingly serious. Whether the government introduces incentives and penalties for enterprises to protect the environment, or the expectations and requirements of consumers, employees, media and other stakeholders for enterprises to protect the environment, all urge enterprises to strive to improve their environmental performance and improve their image of assuming environmental responsibility, thereby reducing their operating costs and risks, improving their legitimacy and reputation, creating competitive advantages(Chuang and Huang, 2018; Xu et al., 2018), and promoting the improvement of their economic performance. However, with the further improvement of enterprise environmental performance and the increase of enterprise investment in environment, more limited resources are allocated to non-productive environmental protection, which erodes the enterprise investment in productive resources and leads to the decrease of enterprise profit margin, thus resulting in the decline of enterprise economic performance. This is because the capital, resources and management capacity of enterprises are usually limited. Therefore, increasing the investment in environmental protection will inevitably reduce the investment in normal production management, thus reducing the financial performance of enterprises.

The regression results of the control variables show that there is a significant positive correlation between the total operating costs, main business income, asset-liability ratio and return on assets. However, there is a small positive correlation between the enterprise factor endowment structure and the return on assets, and the result is not significant. While there is a negative correlation between enterprise size and return on assets, but the result is not significant. It shows that the total operating cost, main business income and asset-liability ratio have a significant promotion effect on the economic performance of the enterprise, the factor endowment structure of the enterprise has no significant promotion effect on the economic performance, and the scale of the enterprise has an inhibitory effect on the economic performance but is not significant.

The above analysis shows that the performance of environmental responsibilities by enterprises has a non-linear effect on economic performance, and it also shows that the performance of environmental responsibilities by enterprises has a lagging effect. This means that environmental management is a long-term investment process, and enterprises must weigh environmental performance and economic performance at the same time, and establish long-term environmental strategies and plans.

5. Robustness checks

In order to test the robustness of the above regression results, this paper uses the dynamic system GMM model and the two-stage least square method (2SLS) for robustness test.

5.1. Dynamic system GMM test

The GMM dynamic panel model is often used as a robustness test. In order to solve the endogenous problems caused by reverse causality, simultaneity, and omitted variables, this paper refers to the method of Cai et al. for the GMM test of the dynamic panel system (Cai et al., 2016). The results are shown in Table 5.

Table 5 Dynamic system GMM regression results

Models **Variables**	**(4)** **ROA**	**(5)** **ROA**	**(6)** **ROA**
$EP1_{t-1}$	17.88*** (5.43)		
$(EP1_{t-1})^2$	-11.93*** (-4.28)		
$EP2_{t-1}$		16.13*** (5.63)	
$(EP2_{t-1})^2$		-10.58*** (-4.86)	
$EP3_{t-1}$			3.42* (1.72)
$(EP3_{t-1})^2$			-2.56* (-1.77)
ROA_{t-1}	0.01 (0.02)	-0.02 (-0.28)	-0.03 (-0.75)
ROA_{t-2}	-0.09*	-0.09*	-0.12**

	(-1.81)	(-1.88)	(-2.38)
ROA $_{t-3}$	0.16***	0.16***	0.08**
	(3.27)	(3.31)	(2.15)
lnScale	2.12***	2.08***	1.61**
	(3.07)	(3.17)	(2.44)
Fes	0.01	0.01	0.01
	(1.03)	(1.11)	(1.45)
lnTC	-2.36**	-2.41**	-2.77***
	(-2.02)	(-2.12)	(-2.77)
lnMBI	3.17***	3.21***	3.63***
	(2.85)	(2.93)	(3.49)
Leverage	-0.18***	-0.18***	-0.18***
	(-5.80)	(-5.95)	(-4.86)
Constant	-35.22***	-34.78***	-26.36**
	(-3.25)	(-3.22)	(-2.28)
N	324	324	324
AR(1)test(p-value)	0.0003	0.0003	0.0001
AR(2)test(p-value)	0.632	0.378	0.265
Hansen test(p-value)	0.172	0.349	0.235

Notes: t statistics in parentheses. ***, **, and * denote the statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Based on the estimation results of the GMM dynamic panel model, the P values of the AR(2) test and the over-restricted Hansen test exceed the levels of 1%, 5%, and 10%, which cannot reject the original hypothesis that there is no second-order sequence correlation and the original hypothesis that the tool is effective. This means that the inverted U-shaped relationship between environmental performance and return on assets is not driven by simultaneity bias. The results of table 5 show that corporate environmental performance ($EP1_{t-1}$, $EP2_{t-1}$ and $EP3_{t-1}$) has a positive and significant relationship with return on assets, but the square term of corporate environmental performance has a negative and significant relationship with return on assets, which confirms the inverted U-shaped relationship between environmental performance and economic performance of China's iron and steel enterprises, thus providing strong support for the hypothesis proposed in this paper.

5.2. Two-stage least squares test

Previous studies of enterprise environmental performance think that enterprise environmental performance is an endogenous variable, and the environmental performance (EP) variable is associated with disturbance term, which makes OLS estimation biased and inconsistent. In order to alleviate the endogenous worry driven by simultaneity and reverse causality, this paper uses the instrumental variable method to test the causal effect of environmental performance (EP) on economic performance. The regression results using the two-stage least squares method and the environmental performance (EP) with a lag of 2 years and a lag of 3 years as instrumental variables are shown in Table 6.

Table 6 Two-stage least squares regression results

Models	**(7)**	**(8)**	**(9)**
Variables	**ROA**	**ROA**	**ROA**
$EP1_{t-1}$	47.37*		

	(1.71)		
$(EP1_{t-1})^2$	-30.23*		
	(-1.66)		
$EP2_{t-1}$		36.12*	
		(1.79)	
$(EP2_{t-1})^2$		-22.56*	
		(-1.81)	
$EP3_{t-1}$			12.59*
			(1.67)
$(EP3_{t-1})^2$			-7.82*
			(-1.66)
lnScale	1.55	1.32	0.61
	(1.21)	(1.09)	(0.67)
Fes	0.02	0.02	0.02
	(0.92)	(0.96)	(1.09)
lnTC	-3.42**	-3.17**	-2.60**
	(-2.38)	(-2.33)	(-1.99)
lnMBI	3.12**	3.08**	3.14**
	(2.28)	(2.17)	(2.39)
Leverage	-0.27***	-0.27***	-0.24***
	(-5.36)	(-5.44)	(-4.25)
N	324	324	324
First-stage F test	0.000	0.000	0.000
Hansen test(p-value)	0.682	0.901	0.245

Notes: t statistics in parentheses. ***, **, and * denote the statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

The ideal instrumental variable should be highly correlated with environmental performance (EP_{t-1}) and not directly correlated with the return on assets (ROA) of the explained variable. By performing the first stage F test to verify the choice of instrumental variables, the test results are consistent with the hypothesis. The first stage F test results are highly significant, indicating that the selected instrumental variables meet the correlation hypothesis. Through the Hansen test, the tested P values also exceed the 1%, 5%, and 10% levels, and the null hypothesis that the tool is valid cannot be rejected. Table 6 reports the detailed test results. The results show that the impact coefficient of enterprise environmental performance ($EP1_{t-1}$, $EP2_{t-1}$ and $EP3_{t-1}$) and return on assets is positive and significant, but the influence coefficient of square term of environmental performance and return on assets is negative and significant. It is confirmed that the impact of environmental performance on economic performance of Chinese iron and steel enterprises presents an inverted U-shaped relationship, and the robustness of the results is further supported.

6. Discussion and conclusions

In the context of emerging economy, Chinese enterprises are facing various forms of constraints in environmental management. Enterprises are more and more challenged by stakeholders, which require enterprises to fulfill their environmental responsibilities and improve their environmental performance. First of all, although environmental regulation and related laws have increased in recent years, compared with western developed countries, Chinese enterprises are still in the early stage of environmental protection. The top management of Chinese enterprises did not show a positive attitude towards environmental issues (Ali et al., 2017). Secondly, among the stakeholders, there are conflicting expectations for the environmental management and sustainability of enterprises (Zou et al., 2019). They not only agree that the sustainable development of enterprises needs to invest resources in environmental protection, but also worry that the investment of environmental protection resources will affect the economic interests of enterprises. Therefore, based on the samples of large iron and steel enterprises in China from 2009 to 2017, this paper explores the impact of enterprise environmental performance on economic performance, and links enterprise environmental responsibility with enterprise strategic and financial objectives. The results show that there is an inverted U-shaped relationship between environmental performance and economic performance.

In this paper, the basic question of "the relationship between environmental performance and economic performance", the key lies in the analysis of the internal process between environmental performance and economic performance and the understanding of the incentive factors, so that the corresponding environmental performance evaluation can help to promote and strengthen the competitive advantage of enterprises, increase their economic performance, and improve the competitiveness of enterprises. Only in this way can it have a continuous incentive effect on the activities of enterprises to improve environmental performance. This paper aims to make a practical contribution to improve the economic value of environmental performance of Chinese iron and steel enterprises, and hopes that the empirical results can provide guidance for the future environmental management of iron and steel enterprises. Corporate environmental responsibility makes corporate behavior not only efficient economic behavior, but also efficient conservation and protection of environmental resources. Therefore, enterprises should balance the relationship between environmental performance and economic performance in order to maximize enterprise performance. Accordingly, we propose the following policy recommendations.

First, the government should be aware of the important role enterprises play in environmental governance in fulfilling their environmental responsibilities. The government should supervise and enforce compliance with environmental laws. This is an effective way to guide enterprises to carry out environmental governance. Facts have proved that environmental supervision can enhance the environmental performance of enterprises with a sense of environmental responsibility (Jiménez-Parra et al., 2018).

Second, in terms of environmental responsibility, Chinese enterprises are still in a passive state, either in concept or in practice. They are often under the pressure of the government, society and partners in the industrial chain, and ignore the benefits and competitiveness brought by environmental responsibility. Enterprises must update their ideas and take the initiative to take environmental responsibility. (1) Strengthen the concept of environmental responsibility and make it a part of corporate culture (Chuang and Huang, 2018; Peng et al., 2018). Having a proactive corporate environmental responsibility culture is rapidly becoming the source of competitive advantage for many enterprises. (2) Establish enterprise environmental information disclosure system. Consciously put the production of enterprises under the supervision of the public, so as to protect the public's right to know the environment.

From the perspective of economic benefits, this paper suggests that enterprises should establish a long-term management mechanism to encourage enterprises to fulfill their environmental responsibilities and improve their environmental performance, so as to realize the healthy and sustainable development of enterprises and society.

This study only uses data from China, and does not conduct comparative studies with companies in developed economies. Therefore, in other economies with different political and economic systems, the interpretation of the results should be cautious, and further discussion may be needed in the future. In addition, why do enterprises in the same industry have different environmental performance? In this direction, future research can explore the role of senior managers, especially their vision of environmental sustainability, and analyze the impact of management in promoting enterprises to fulfill their environmental responsibilities.

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Author Contributions

Rong Liu wrote the paper and revised the manuscript, Feng He involved in the result analysis and discussion, Jianyu Ren organized and performed the data collection. All authors read and approved the final manuscript.

Data availability

The datasets used during the current study are available from the China Iron and Steel Industry Association (http://www.chinaisa.org.cn). The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Ethics approval and consent to participate： Not applicable.

Consent for publication： Not applicable.

Conflicts of interest： The authors declare no conflict of interest.

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Figures

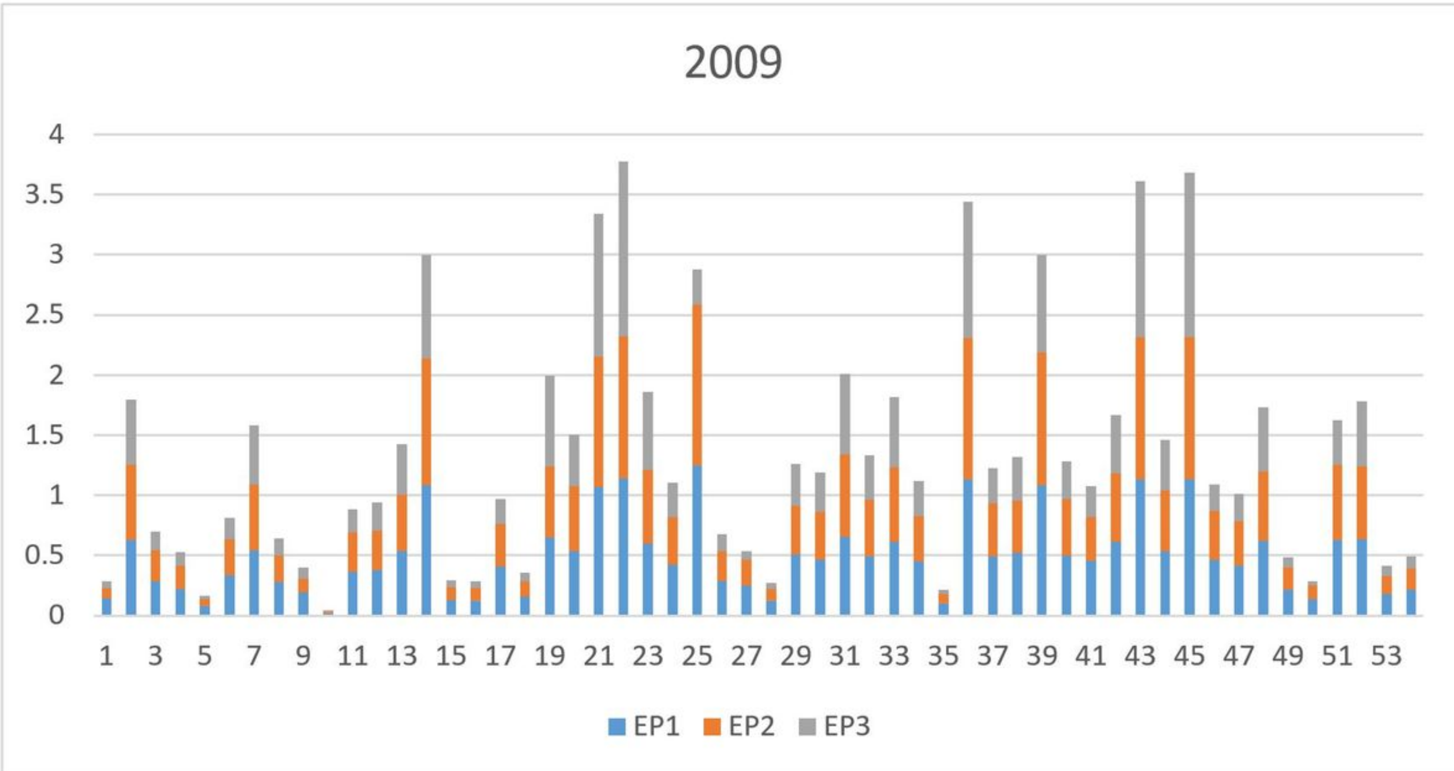

Figure 1

Measurement results in 2009