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Does Environmental Policy Stringency Affect the Productivity of the Industrial Sector in China? An Empirical Analysis of the Porter Hypothesis

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Abstract. This paper focuses on the effects of environmental policy stringency (EPS) on the total factor productivity (TFP) growth of firms, which is an extension of the Porter Hypothesis (PH). PH states that strict environmental regulations can promote enterprise innovation and improve enterprise productivity. To test this, the paper uses the word frequency of the keyword in the government report of China from 2010-2020 to test the EPS and chooses the TFP of firms from 2010-2020 as the indicator of the change in productivity of enterprises. The paper also uses panel data methods and ordinary least squares to test the relationship between EPS and TFP. In terms of policies, the national government should consider the economic gap between different regions and the different pollution levels between different companies.

Keywords: Environmental regulations, TFP, EPS, Porter Hypothesis

1. Introduction

Along with the rapid development of the global economy, each industry's environmental damage has become larger. To achieve profit maximization, firms ignore the environmental damage they do for profit. With the increasing concern for the environment, the government of the People's Republic of China has proposed and promoted many different related policies toward the behavior of companies, such as the low carbon city pilot policy, to protect the environment while maintaining the economy as stable. For many circumstances, policy instruments increase the opportunity costs of pollution and environmental damage for firms, and they take the form of command-and-control policies that enforce environmental standards. It was once widely believed that additional costs would lead to lower productivity in an industry or company, but this is not true.

This paper focuses on the effects of environmental policy stringency (EPS) on the total factor productivity (TFP) growth of firms. Usually, people believe the more stringent the policy, the more it will increase the cost to the enterprises. This research question relates directly to the well-known Porter Hypothesis [1,2]. PH states that to decrease the opportunity cost, enterprises might strengthen innovation and develop new technologies to reduce pollution levels, resulting in lower costs and higher productivity in the long term. Porter's Hypothesis also points out that environmental policy may improve both the environment and competitiveness, creating a win-win situation. The

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implementation of several regulations could lead to corporate combinations, market incentives, foreign investment, international trade, and changes in human resources. All of these indicate the connection between environmental policies, productivity, and the economy.

The paper is structured in the following way. Section 2 provides an overview of the relevant literature on the effects of environmental policies on productivity growth. Section 3 introduces the conceptual framework of this paper. Section 4 presents the related data used in the analysis while providing some descriptive statistics. Section 5 explains the empirical strategy and details about the data used. Section 6 contains the analysis of heterogeneity. Section 7 is the robustness check. The final section is the conclusion.

2. Literature review

2.1. Recent studies

For researchers inside China, studies are generally based on provincial or city-level data. Since there is no index, Chinese studies prefer to calculate the intensity of environmental regulations through different indicators, such as regional pollution control degree and calculation of the environmental cases handled by the provincial government [3].

For the industry- and firm-level, many empirical analysis papers focus on highly polluted industries like the manufacturing industry. When testing firm-level productivity, researchers use multi-factor productivity (MFP) or total-factor productivity (TFP) as the indicator [4-7]. In China, previous papers usually choose A-share listed companies as test objectives [8].

Learning from the existing empirical papers, especially those focused on China, this paper finds that there is a lack of studies using updated methods of calculation of EPS, and there are few studies focused on some specific industries. This paper adapts the method including the use of TFP and EPS to further test the PH.

3. Mechanism analysis

This paper considers the market incentives of enterprise competition and enterprise innovation as the main mechanisms and comes out with two hypotheses.

With the enactment of different environmental policies, smaller companies may be more likely to exit the market due to the additional high cost. This is because smaller companies are often unable to recover the costs in a short period, leading to bankruptcy or a takeover situation. When a large number of companies leave the market, the remaining companies will begin to make profits until new companies enter and bring the market back to equilibrium. At the same time, strong local market competition makes remaining companies more likely to increase foreign trade to increase their revenue and position in the market. The remaining companies are likely to increase their productivity in response to the huge market demand. H1: Strict environmental regulations can lead to intense competition in the market, leading to increased productivity.

In addition, strict environmental regulations and enterprise competition may lead to an increase in innovation. To reduce the cost of pollution, companies will choose to develop new production tools to reduce expenses, which can help them to better survive in the market competition. Successful innovation leads to lower production costs for companies, which leads to an increase in productivity (and therefore supply). Through financing and investment by other capitals, companies can better develop new patents and possibly help expand the market. H2: Strict environmental policies will promote enterprise innovation, thus improving enterprise productivity.

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4. Data

This paper organizes all the integrated data, including EPS, TFP, and various financial indicators, and presents them through descriptive statistics (table 1). For the main regression model (which is TFP_OLS), the number of samples is 17,930, the mean of it is 10.4667, and the standard difference (SD) is 1.192. All the data are normal.

Table 1. Descriptive statistics of all the integrated data

VarName	Obs	Mean	SD	Min	Median	Max
TFP_OLS	17930	10.4667	1.192	5.827	10.37	14.41
ER	17930	0.0034	.001309	.0002944	.003333	.01239
liqRt	17930	0.5748	.1701	.01668	.5831	1
roa	179 30	0.0280	.458	-48.32	.03617	10.4
size	17930	22.0117	1.197	17.05	21.87	27.55
OperateCosts	17930	21.0249	1.518	9.316	20.93	27.37

4.1. Measuring Environmental Policy Stringency (EPS)

This paper chooses a method to measure EPS that has not been used by many before, which is measuring the EPS by using the word frequency of keywords related to environmental policy in the work report of prefecture-level city government. These keywords are collected manually and not from a database, and the data is obtained through word segmentation processing of the government work report by Python software. The keywords here include the following: environmental protection, pollution, energy consumption, emission reduction, pollutant discharge, ecology, green, low-carbon, air, chemical oxygen demand, sulfur dioxide (SO_2), carbon dioxide (CO_2), PM10, and PM2.5.

This paper selects several cities in 31 provinces in China as the test target. The paper selects prefecture-level city government reports from 2010 to 2020. By dividing the keywords by the total number of words in the report, this paper can obtain a specific ratio that represents the degree of environmental regulation in each selected city. Then, the paper combines these ratios with the annual productivity of listed companies that belong to the industrial sector to conclude whether the strictness of environmental regulations will affect productivity.

4.2. Measuring the productivity

For this analysis, to measure the change in productivity of firms and industries, the paper chooses TFP of A-share listed companies in the industrial sector in China from 2010 to 2020 as the indicator of productivity. TFP is a key indicator of measuring the productivity and technological progress of listed companies. It reflects the productivity fluctuations brought about by technological progress and innovation in addition to labor and capital input in the production process.

The data source of this paper is based on the previous literature on calculating the TFP of A-share listed companies in the Chinese market [9]. This data calculates the combined productivity of several factors of the company, and it has five calculation methods, including ordinary least square (OLS), fixed effect (FE), linear programming (LP), ordinary product (OP), and generalized method of moments (GMM).

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4.3. Control variables

To ensure the rigor of the empirical analysis, this paper selects some control variables to constrain the results. This paper consults the financial reports of A-share listed companies from 2010 to 2020 through the CSMAR database and selects some financial indicators as control variables, such as total assets, return on assets, current assets ratio, and more. These control variables can help enhance the validity of the study and help limit research bias. At the same time, these control variables can show the internal situation of the research objects (designated listed companies), helping this empirical study get better empirical results.

5. Empirical strategies

5.1. Method and economic model

This empirical analysis is based on the use of the panel dataset and TFP_OLS to test the relationship of EPS and TFP.

For the multiple regression model, the following is the formula:

$$TFPit = \alpha + \beta ERit + \beta 1 Sizeit + \beta 2 OperateCostsit + \beta 3 Roait +$$

$$\beta 4 LiqRtit + \beta 5 Ast2Liait + Year + Industry + \epsilon it$$

Where TFP_{it} represents the TFP of company i in year t, ER_{it} is the environmental regulation that company i is subject to in year t (which represents the EPS as well), $Size_{it}$ represents the scale (or total asset) of the company, $OperateCosts_{it}$ represents the operating cost, Roa_{it} represents the return on assets, $LiqRt_{it}$ represents the ratio of current assets, and $Ast2Lia_{it}$ stands for asset-liability ratio. Year and Industry indicate the fixed effect of year and industry, respectively, while ϵ_{it} stands for the random error term.

6. Results

For the main multiple regression analysis (table 2), the paper uses TFP_OLS to analyze the impact of ER under several control variables toward TFP of A-share listed companies in China. The c1 in the regression model demonstrates the impact of ER without considering all the control variables, the c2 represents the impact of ER under the consideration of companies' ratio of current assets and return on assets, and the c3 indicates the impact of ER under the consideration of all the control variables. All the coefficients show positive and significant results, standing for the direct relationship between ER and TFP. In order to further verify this analysis, this paper also considers the endogenous aspect, and then makes a heterogeneity analysis and robust analysis.

Table 2. The impact of ER under control variables toward TFP of A-listed companies

	(1)	(2)	(3)
	c1	c2	c3
ER	19.7847***	19.2764***	2.8207**
	(2.915)	(2.847)	(2.011)
liqRt		0.2997***	0.5235***

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Table 2. (continued)

		(5.600)	(45.778)
roa		0.1442***	0.0224***
		(7.949)	(5.961)
size			0.1439***
			(44.779)
OperateCosts			0.6802***
			(257.378)
alr			0.0033***
			(7.661)
_cons	10.4971***	10.3398***	-7.3422***
	(149.172)	(137.354)	(-191.625)
N	17931	17930	17930
R^2	0.135	0.140	0.963
Adj. R^2	0.133	0.138	0.963
F	71.509	70.814	10615.176

7. Heterogeneity analysis of policies

This paper identifies the location of the company as the heterogeneity variable in this empirical study. Companies from different regions may react differently to the same environmental policies. Due to the large gap in economic level between different regions, for example, southern China is richer, companies in different regions will have different rates of recovery to environmental regulations. Poorer regions are less likely to recover quickly from stringent environmental regulations, while richer ones are in the opposite way. This phenomenon exists because richer regions will have more opportunities for commercial trade.

For the result of the regression model (table 3), the ER, which also stands for EPS, is positive and significant for companies' TFP in eastern China, while the one for companies in western China shows negative but significant results. The paper believes that the major reason for the negative result is that Western China lacks infrastructure, human resources, technology, and capital, so the companies cannot recover soon after the imposition of ER. For the central region of China, the result is insignificant, which means the EPS has no influence on TFP in the central region of China. There are many possibilities for this situation, and this paper is unable to determine the specific reason.

Table 3. The impact of ER in different areas of China

	(1)	(2)	(3)
	East	Mid	West
ER	5.7436***	3.5944	-9.4541**
	(3.502)	(1.067)	(-2.160)
liqRt	0.5248***	0.3401***	0.6298***
	(40.744)	(11.220)	(18.823)
roa	0.0239***	0.5010***	0.0082
	(4.035)	(13.610)	(1.453)

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Table 3. (continued)

size	0.1347***	0.1502***	0.1965***
	(35.937)	(19.061)	(21.123)
OperateCosts	0.6845***	0.6594***	0.6605***
	(218.287)	(104.393)	(88.647)
alr	0.0029***	0.0013	0.0019
	(6.374)	(0.869)	(1.269)
_cons	-7.2453***	-6.8575***	-8.2054***
	(-166.873)	(-70.512)	(-70.600)
N	12254	3160	2516
R^2	0.967	0.963	0.960
Adj. R^2	0.967	0.963	0.960
F	8048.825	1941.151	1459.353

8. Robustness check

This paper is aware that only one method for empirical analysis may lead to bias and inaccuracy in empirical results. Therefore, this paper also adopts other methods to support this analysis. In this part, the paper uses the level of informal environmental regulation (focusing on income level, education level, and population density in a region), TFP_OP, TFP_LP, TFP_FE, and TFP_GMM to enhance the degree of accuracy (table 4). The rest of the data source and empirical strategies are the same. All the results except for ER's impact under the use of TFP_FE are positive and significant. Therefore, the validity of this empirical analysis is verified.

Table 4. The testing of the impact of ER under the use of different models

	(1)	(2)	(3)	(4)	(5)
	ER_nonOffi	OP	LP	FE	GMM
ER_nonOffi	0.1390***				
	(11.729)				
ER		10.4966***	5.2492***	1.6669	11.1367***
		(4.893)	(3.077)	(1.209)	(4.914)
liqRt	0.5201***	0.9526***	1.0482***	0.4230***	1.2756***
	(45.630)	(54.464)	(75.358)	(37.638)	(69.039)
roa	0.0224***	0.0252***	0.0211***	0.0222***	0.0238***
	(5.968)	(4.384)	(4.596)	(6.009)	(3.911)
size	0.1441***	-0.0652***	0.0027	0.1823***	-0.1381***
	(45.006)	(-13.274)	(0.699)	(57.722)	(-26.592)
OperateCosts	0.6793***	0.5130***	0.6256***	0.7055***	0.4978***
	(257.818)	(126.914)	(194.594)	(271.649)	(116.572)
alr	0.0031***	0.0065***	0.0035***	0.0029***	0.0062***
	(7.186)	(9.868)	(6.680)	(6.837)	(8.863)
_cons	-7.3349***	-3.4875***	-5.6634***	-7.9642***	-2.8269***

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Table 4. (continued)

	(-193.021)	(-59.513)	(-121.522)	(-211.516)	(-45.667)
N	17928	17930	17930	17930	17930
R2	0.963	0.809	0.919	0.969	0.750
Adj. R2	0.963	0.809	0.919	0.969	0.749
F	10696.734	1726.359	4635.623	12533.928	1217.714

9. Conclusion

In general, this paper demonstrates the impact of EPS on the productivity of China's industrial sector through panel data analysis and the OLS regression model. Though EPS may not have a positive impact on enterprise productivity in the short term, it may promote TFP in a certain period. Under the test by the regression model, the coefficients show positive and significant results, which lead to the conclusion that EPS may increase the TFP for companies. This paper shows that EPS may promote innovation in some enterprises in the rich area of China and thus promote company productivity in some cases during the test period. However, in most cases, EPS can not improve the overall productivity of the industry due to the imbalance of different local economies and resources for companies in different regions.

Due to the lack of technology and data, the empirical results may still be biased. At the same time, because there are many influencing factors, this paper cannot consider and analyze all of them at once. In terms of policy planning, this paper suggests that the government should consider the differences between regions and the pollution levels of different companies to enact policies with greater fairness. It is hoped that more complex economic models can be used in the future to further verify the relationship between EPS and productivity.

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