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Study on the pilot emission right trading on the transformation and upgrading path selection of manufacturing enterprises

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Abstract. This paper takes A-share manufacturing listed companies from 2002 to 2020 as the research sample, proposes the service optimization effect of emissions trading on enterprises extending downstream and the innovation incentive effect of upward climb, and uses DID method to study the impact of emissions policy on the choice of manufacturing industry transformation and upgrading path. Through empirical studies, it was found that the emissions trading policy improves the embedded service level of manufacturing enterprises, strips off the blended services; however, it fails to significantly improve the green innovation level of manufacturing enterprises, and its innovation incentive effect fails to appear.The findings provide a theoretical basis for improving the emission right allocation mechanism, establishing a sound environmental regulatory system, and promoting the development of the economy in the direction of green and sustainable development.

Keywords: emissions trading, manufacturing companies, service optimization, innovation incentives

1. Introduction

In 2007, the emissions trading policy was piloted and experimented in eleven provinces. In terms of its environmental performance , the existing literature mainly centers on the regulatory role of pollution reduction of enterprises. One part of the scholars, such as Si [1] ,believe that emissions trading can reduce the uncontrolled pollution of enterprises. Another group of scholars, such as Shin [2] ,believes that the emissions trading system has limited emission reduction effects.

The existing literature about its economic performances mainly focuses on the indirect impacts on labor employment demand, enterprise green innovation and foreign direct investment. In terms of labor employment demand, Ren [4] argues that emissions trading expand production scale, thus increasing labor demand. In terms of enterprise green innovation, there are three views - promotion theory, inhibition theory and uncertainty theory, proposed by Lin [5] , Jiang Ke [6] ,Li [7] respectively. In terms of OFDI, QI [8] believes that the stricter the environmental legislation , the more obvious the promotion effect of emissions trading on OFDI of Chinese enterprises.

There is no mature research on its impact on the transformation and upgrading path choice of micro manufacturing firms. This paper explores this issue from both theoretical and empirical perspectives,

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and its contributions are: first, it innovatively puts forward the hypothesis that manufacturing enterprises will preferentially choose to upgrade their services downstream of the value chain while conditionally choosing to move upstream of the value chain to incentivize innovation; second, it finds that most manufacturing enterprises tend to choose end-of-pipe pollution control in the face of such environmental regulations as emission rights, and that green innovation research and development has a threshold effect, which provides directional guidance for the transformation and upgrading of manufacturing enterprises.

2. Model Construction

2.1. Research hypothesis

In this study, the following two research hypotheses were derived from a review of national and international literature:

Hypothesis 1: The emissions trading system facilitates manufacturing firms to create embedded services that extend the value chain and divest themselves of blended services that are not related to the core value chain, thus providing their service optimization effects.

Hypothesis 2: Conditions exist for the green innovation incentive effect of the emissions trading system to work, and the shift from end-of-pipe to green R&D and innovation will occur only when manufacturing firms have a stronger technological base and stronger core competencies.

2.2. Model setup

Pilot emissions trading is a good "quasi-natural experiment" of market-based environmental regulation policy formally implemented in 11 provinces[1] since 2007. In this paper, we use a double difference model to analyze the effect of environmental governance and the transformation and upgrading of manufacturing enterprises, and the basic model is as follows:

$$Y_{it} = \alpha_0 + \alpha_1(Treat_{it} \times Post_{it}) + \beta Control_{it} + \gamma_t + \theta_i + \varepsilon_{it} \quad (1)$$

Where Y_{it} are the explanatory variables, service integration level and green innovation level of manufacturing firm i in year t. Treat is the policy grouping variable, Post is the time grouping variable, Control is the set of control variables, γ is the time fixed effect, and θ is the firm fixed effect, and ε is the random error term.

In this paper, the initial sample of Chinese A-share listed manufacturing companies in Shanghai and Shenzhen from 2002 to 2020 is used to construct the balanced panel data of the sample of listed manufacturing companies, excluding ST companies and companies with missing core variables. The data used in this paper mainly involves four databases: China Industrial Enterprises Pollution Database, CSMAR database, Vantage Financial Terminal and Listed Company Patent Database.

3. The Empirical Findings

3.1. Benchmark regression

Columns (1) and (2) of Table 1 show the results of service integration in manufacturing industry, and the results show that the pilot emissions trading policy significantly enhances the level of embedded service integration of manufacturing firms but significantly reduces the level of integration of their blended services. Columns (3) and (4) show the results for green innovation in manufacturing, which indicate that the pilot emissions trading policy has no significant effect on the level of green innovation in manufacturing firms, probably due to insufficient incentives, technological constraints, and lagged effects.

[1] The 11 provinces specifically include: Zhejiang, Jiangsu, Hunan, Hubei, Tianjin, Hebei, Shanxi, Chongqing, Shaanxi, Inner Mongolia and Henan.

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Table 1. Benchmark regression results

VARIABLES	(1) Embedded Services	(2) Blended services	(3) Green Inventive Patents	(4) Green Utility Patent
treat_post	0.022***	-0.017***	-0.015	-0.001
	(0.003)	(0.004)	(0.019)	(0.017)
Constant	-0.203***	0.135***	-2.087***	-1.592***
	(0.027)	(0.032)	(0.150)	(0.138)
R-squared	0.033	0.066	0.090	0.063
Number of id	1,093	1,093	1,091	1,091
Control	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses,*** p<0.01,** p<0.05,* p<0.1

3.2. Robustness discussion

In terms of service blending, the paper replaces the original variables using the firm's revenue from each service as a share of total assets, as shown in columns (1) and (2) of Table 2. The results show that emissions trading significantly increases the level of embedded services and significantly reduces the level of blended services in manufacturing firms, indicating that the original estimation results are robust. In terms of green innovation, since patents need a lag of one to two years from application to grant, this paper uses the number of patents granted in the lagged period to replace the original variables, as shown in columns (3) and (4) . The results show that emissions trading has no significant effect on the green innovation level of manufacturing enterprises, indicating that the original estimation is robust.

Table 2. Replacement of explanatory variable results

VARIABLES	(1) Embedded Services rate	(2) Blended services rate	(3) Green Inventive Patents granted	(4) Green Utility Patent granted
treat_post	0.014***	-0.015***	0.007	0.004
	(0.003)	(0.003)	(0.013)	(0.017)
Constant	-0.056**	0.167***	-1.074***	-1.635***
	(0.027)	(0.027)	(0.106)	(0.137)
R-squared	0.013	0.047	0.070	0.070
Number of id	1,093	1,093	1,091	1,091
Control	Yes	Yes	Yes	Yes

4. Analysis Of The Mechanism

4.1. Mediating effects of service and innovation transformation and upgrading

4.1.1. Service optimization mechanisms. In order to study the mechanism path of embedded service optimization effect, this paper chooses customer concentration and fixed asset ratio as its mediating variables, as shown in columns (1) and (2) of Table 3. And in order to study the mechanism of the optimization effect of blended services, this paper chooses the current asset ratio and marketing intensity as the mediating variables of blended services, as shown in columns (3) and (4). The results

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show that manufacturing firms will achieve service optimization and upgrading through increased customer concentration and fixed asset investment, reduced current assets and marketing intensity.

Table 3. Mechanistic Tests of Service Optimization Effects

VARIABLES	(1) Customer Concentration	(2) fixed assets	(3) current asset	(4) marketing intensity
treat_post	2.109***	0.014***	-0.003*	-0.005***
	(0.531)	(0.004)	(0.001)	(0.002)
Constant	98.383***	0.485***	0.206***	0.929***
	(4.306)	(0.032)	(0.011)	(0.015)
R-squared	0.029	0.072	0.039	0.316
Number of id	1,090	1,093	1,093	1,093
Control	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses,*** p<0.01,** p<0.05,* p<0.1

4.1.2. Innovative incentives. According to Liu [9] , this paper chooses the number of enterprise desulfurization facilities to indicate the level of pollution treatment investment, the desulfurization capacity of desulfurization facilities to measure the pollution treatment level of the enterprise, and the R&D investment intensity of the enterprise as a measure of green innovation investment, and the regression results are shown in Table 4. The test results indicate that the coefficients of the number of desulphurization facilities and desulphurization capacity are both significantly positive, and the coefficient of R&D investment is positive but not significant, which indicates that the emissions trading system will increase the level of end-of-pipe treatment of enterprises and install more end-of-pipe emission reduction equipment, whereas under the limited resource constraints, the investment in pollution treatment crowds out the input of innovation factors.

Table 4. Mechanistic Tests of Innovation Incentive Effects

VARIABLES	(1) desulfurization facility	(2) Desulfurization capacity	(3) Investment in R&D
treat_post	0.090**	0.337**	0.002
	(0.039)	(0.146)	(0.053)
Constant	-1.376**	-1.610	1.299***
	(0.567)	(2.131)	(0.176)
R-squared	0.169	0.136	0.010
Number of id	283	283	1,077
Control	Yes	Yes	Yes

4.2. Moderating effects in a heterogeneous firms perspective

4.2.1. Service optimization effects. The position of manufacturing enterprises in the production chain and the digitalization level of enterprises will bring about differences in product division of labor, thus affecting the optimization and upgrading of their services, Table 6 shows the results of the heterogeneity test of the above two moderating effects. The results illustrate that for manufacturing enterprises with location in the upstream production chain and high digitization level, emissions trading significantly contributes to the optimization and upgrading of their services.

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Table 5. Conditional tests for the occurrence of service integration effects

	Production chain location		Level of digitization	
	(1)	(2)	(3)	(4)
VARIABLES	Embedded Services	Blended services	Embedded Services	Blended services
treat_post_Var	0.013***	-0.001	0.003*	-0.003
	(0.003)	(0.002)	(0.002)	(0.002)
treat_post	-0.016	-0.018*	0.020***	-0.015***
	(0.010)	(0.010)	(0.004)	(0.004)
Constant	-0.240***	0.147***	-0.179***	0.145***
	(0.037)	(0.036)	(0.028)	(0.032)
R-squared	0.048	0.057	0.034	0.066
Number of id	613	613	1,090	1,090
Control	Yes	Yes	Yes	Yes

Note: Standard errors in parentheses,*** p<0.01,** p<0.05,* p<0.1

4.2.2. Innovation incentive effects. On the one hand, when constructing the market power indicator, this paper takes into account the differences in the transformation decisions of enterprises with different markup capabilities, so it uses the Lerner index to measure the market power of manufacturing enterprises, and the regression results are shown in columns (1) and (2) of Table 6. It can be seen that the interaction terms between the core explanatory variables and market power are all significantly negative, which indicates that emissions trading significantly inhibits the green innovation level of manufacturing firms for firms with high market power. On the other hand, considering the different technological base of different firms, this paper chooses patent stock to measure the technological base of the firm, and the results are shown in columns (3) and (4) . The data show that the interaction terms between the core explanatory variables and technology base are all significantly positive, which indicates that enterprises with strong technology base are more likely to stimulate green innovation under emissions trading.

Table 6. Conditional Tests for the Occurrence of Innovation Incentive Effects

	market power		technological base	
	(1)	(2)	(3)	(4)
VARIABLES	Green Inventive Patents	Green Utility Patent	Green Inventive Patents	Green Utility Patent
treat_post_Var	-0.271***	-0.253***	0.015**	0.016***
	(0.074)	(0.067)	(0.006)	(0.006)
treat_post	0.049**	0.059**	-0.061**	-0.052**
	(0.025)	(0.023)	(0.027)	(0.025)
Constant	-2.100***	-1.621***	-1.727***	-1.249***
	(0.151)	(0.139)	(0.153)	(0.142)
R-squared	0.091	0.064	0.143	0.127
Number of id	1,091	1,091	1,091	1,091
Control	Yes	Yes	Yes	Yes

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5. Conclusions

The emissions trading policy improves the embedded service level of manufacturing enterprises, strips off the blended services; however, it fails to significantly improve the green innovation level of manufacturing enterprises, and its innovation incentive effect fails to appear. Mechanism tests show that manufacturing firms will promote embedded service upgrading through increased customer concentration and fixed asset investment, reduce the number of blended services by lowering current assets and marketing intensity to achieve service optimization and upgrading, and will prefer end-of-pipe management to increased green innovation investment to achieve emission reduction targets.And the results of the heterogeneity analysis show that manufacturing firms located upstream of the production chain and with high levels of digitization are better able to strengthen the service optimization effect of extending downstream of the value chain, and that firms with low market power and high technological bases are more inclined to choose the green innovation strategy of climbing upstream of the value chain.

The government should establish a sound environmental regulatory system, improve the effectiveness of service supply, and promote the transformation of manufacturing industry to the direction of green, intelligent and sustainable development.

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