The influence of environmental regulation on green total factor productivity——based on the Yangtze River panel data empirical research

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Abstract. At present, the environmental problem is increasingly serious, how to achieve the sustainable development has become very important recently. This paper used the data of 106 prefecture-level cities of the Yangtze River Economic Belt to study the effect of environmental regulation on green total factor productivity. The results show that environmental regulation can significantly improve the GTFP. There is significant heterogeneity. Also found that the level of economic development has a threshold effect.

1 Introduction

As environmental pollution and resource depletion becomes more serious, how to realize the sustainable development becomes important in recent years. Since the reform and opening up, China's economy has developed rapidly, GDP grows from 367.8 billion yuan in 1987 to more than 114 trillion yuan in 2021, has made a remarkable achievement. 2017 the report to 19 also explicitly proposed to "promote economic development of high quality, efficiency, power, to improve total factor productivity". Therefore, how to achieve the growth of total factor productivity (GTFP) has become important for the sustainable development of green economy. So having a further study of the present situation of our GTFP and influence factors, is of great significance for our country economy.

2 The research hypothesis

Generally, environmental regulation can ease pollution. On the premise of environmental regulation, it can reduce emissions of pollutants and energy consumption. In environmental regulation becomes severe cases, the product will be more clean, also can motivate enterprises to carry out technical innovation, change the original mode of production, so improve GTFP. In the long run it can lead to the profound changes of the enterprise, change production structure, which was beneficial to GTFP. So, put forward the hypothesis 1:

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Hypothesis 1: The environmental regulation is conducive to the improvement of China's Yangtze River Economic Belt's GTFP.

The Yangtze River Economic Belt has three big areas, are important for economic development, but they are diffenent. Downstream communities are one of the areas with higher economic contribution rate, have obvious advantages. The upper and middle reaches' development is relatively backward, forming the a manufacturing industrial cluster, the process will produce much pollutants. So it will lead to different effect of environmental regulation. Therefore, put forward the hypothesis 2:

Hypothesis 2: The influence of environmental regulation of the Yangtze river economic belt GTFP has a significant regional heterogeneity.

Under the environmental regulation, the higher the degree of economic development, the more rational economic structure, the more positive influence will produce on GTFP. Different regions have different features, so has different requirements on environment, the ability of environmental optimization varies. When economic levelopment level is low, influenced by GDP championship, they will focus more on GDP, lacking the environmental regulation, which is not conducive to GTFP. When areas with higher level of development, in the pursuit of better environment, environmental regulation will encourage firms to develop green technology to reduce emissions Therefore, put forward the hypothesis 3:

Hypothesis 3: The level of economic development of the relation between "environmental regulation - GTFP" function is non-linear.

3 Model, variables and data

3.1 Model building

In order to investigate the effects of environmental regulation on GTFP, based on existing research, this paper constructs the following empirical model:

$$\ln GTFP_{it} = \alpha_0 + \alpha_1 \ln ER_{it} + \Sigma \alpha_j control_{it} + \varepsilon_{it} \quad (1)$$

GTFP representative Green total factor productivity, ER represents the environmental regulation, i represents prefecture-level cities along the Yangtze river Economic Belt, t represents time, control represents the other control variables, ε_{it} represents random disturbance, accord with normal distribution with zero mean and variance.

According to above analysis, use the nonlinear panel Hansen's threshold model to test the level of economic development of the relation between "environmental regulation - GTFP" effect, thus build the model as follows:

$$\begin{aligned} \ln GTFP_{it} = {} & \alpha_0 + \beta_1 \ln ER_{it} \times (\ln ECO \le \gamma_1) + \\ & \beta_2 \ln ER_{it} \times (\ln ECO \le \gamma_2) + \ldots\ldots + \beta_n \ln ER_{it} \times (\ln ECO \le \gamma_n) + \\ & \beta_n \ln ER_{it} \times (\ln ECO > \gamma_{n+1}) + \Sigma \alpha_j control_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

3.2 Variables

3.2.1 Explained variable

Green total factor productivity (GTFP). The paper base on the GTFP of 106 cities in Yangtze River Economic Belt, using SBM ML index method and MAXDEA to calculate.

Input indicators include labor input, the energy input and capital input. Labor put is employed by the total employmenyt at the end of the year (ten thousand); Energy input in employed by the whole society power consumption (million kilowatt hour); Capital in employed by the capital stock. The general practice is to use the capital stock represented by capital investment, but due to the capital stock is difficult to estimate on the level of prefecture level, therefore. So draw lessons from liu Binglian scholar's practice, used fixed assets investment amount to describe capital input.

Output indicators including expected output and the unexpected output. This paper used the literature general practice, using the real GDP of the various cities to measure. Unexpect output is measured in industrial SO2 emissions.

3.2.2 The core variable

Environmental regulation (ER). Based on the "three wastes" emissions as a share of GDP, to measure. The three wastes include industrial waste water, industrial sulfur dioxide and industrial soot.

3.2.3 The control variables

GTFP also influenced by other factors, this article selected the economic development level (ECO), import and export trade (OPEN), human capital level (HUM), industrial structure (IND), R&D strength (RD), the level of financial development(FIA), the government control (GOV) as control variable. The economic development (ECO) expressed in per capita GDP, import and export trade (OPEN) expressed in the terms of the proportion of import and export to GDP, level of human capital (HUM) expressed theproportion of number of colleges and universities to total population, industrial structure(IND) expressed the proportion od the added value of the second industry to GDP, R&D strength (RD) used patent grant, the financial development level(FIA) expressed the proportion of balance of deposits in financial institutions to GDP, the government control(GOV) expressed the proportion of local fiscal budget spending to GDP.

3.3 Data specification

This article selects the Yangtze River Economic Belt level panel data from 2010 to 2020. Due to the lack of data of prefecture-level cities newly established in bijie and tongren in 2011, so they are not included. There are total 1166 samples. Data is mainly got in Chinese city statistics yearbook, the urban statistical yearbook, taian database, EPS database, etc. Use the stata completion the interpolation method to complement the missing data. In order to eliminate influence brought by the heteroscedasticity, so take the log for each variables.

4 The empirical test results and analysis

4.1 All samples regression result analysis

Table 4-1 shows the regression results of the whole samples. Table 4-1 model 1-3 column used the mixed OLS, model 4-6 used the fixed effects model, model 1, 4 not conclude the control variables, model 2, 5 joined the control variables, considering the GTFP will be affected by a period, so the model 3, 6, joined the lag issue, a lag period significantly positive suggests that GTFP is cumulative and sustainable. From the results, the estimates of environmental regulation variable coefficient is all significantly positive, which indicates

that environmental regulation can significantly promote the growth of GTFP, and it also has a certain robustness. To verify the hypothesis 1.

Table 1. Full sample regression results.

Variable	Model1	Model2	Model3	Model4	Model5	Model6
lnER	0.0392***	0.0505***	0.0577***	0.161***	0.047***	0.062***
	(0.00637)	(0.00811)	(0.00600)	(0.014)	(0.010)	(0.009)
lnECO		-0.0862***	-0.150***		0.059	-0.021
		(0.0228)	(0.0179)		(0.043)	(0.039)
lnOPEN		-0.0135*	-0.0110**		-0.035***	-0.023***
		(0.00707)	(0.00532)		(0.009)	(0.009)
lnHUM		0.0770***	0.0413***		-0.022	-0.003
		(0.00892)	(0.00692)		(0.016)	(0.014)
lnIND		-0.209***	-0.191***		-0.046	-0.019
		(0.0469)	(0.0351)		(0.060)	(0.053)
lnRD		-0.0207**	-0.00798		-0.026**	-0.028***
		(0.00864)	(0.00660)		(0.012)	(0.011)
lnFIA		-0.228***	-0.211***		-0.326***	-0.305***
		(0.0258)	(0.0196)		(0.025)	(0.022)
lnGOV		-0.180***	-0.254***		-0.414***	-0.474***
		(0.0264)	(0.0214)		(0.025)	(0.025)
L.lnGTFP			0.879***			0.449***
			(0.0260)			(0.030)
Constant	0.144***	1.130***	0.901***	0.616***	-0.646***	-0.508**
	(0.0187)	(0.179)	(0.135)	(0.056)	(0.240)	(0.212)
R-squared	0.031	0.258	0.656	0.247	0.677	0.780
i.City				Yes	Yes	Yes
i.Year				Yes	Yes	Yes

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

4.2 Regional sample regression

Because the different regions are different in the economic development, resource endowment, industrial structure, so the overall regression may mask regional differences, so the sample is divided into the upper, middle and downstream groups to verify regional differences of environmental regulation on GTFP, as shown in table 4-2. Model 6, 7, 8, respectively the upstream, middle, downstream reaches. In table 4-2, the effects of environmental regulation on GTFP are different. The influence of the downstream is positive, but not significant. Possible reason is the downstream areas uese the cumulative capital, technology and other factors to promote economic development, so the green technology is reletively advanced, environmental protection consciousness is also higher, so the coefficient of environmental regulation is positive, but is not very significant. In the upper and middle reaches, environmental protection consciousness constantly improve, with the adjustment of environmental regulation, pollution is under control. At the same time, technical level of this areas is relatively low, the strict environmental regulation may be reversed transmission enterprise reform, realizing green innovation, to play a significant role in the improvement of GTFP. To verify the hypothesis 2.

Table 2. Regional sample regression results.

	Model6	Model7	Model8
lnER	0.027*	0.046**	0.007
	(0.016)	(0.018)	(0.016)
Controls	Yes	Yes	Yes
_cons	0.704	-1.665***	-0.908**
	(0.427)	(0.494)	(0.397)
r2	0.554	0.855	0.458
i.City	Yes	Yes	Yes
i.Year	Yes	Yes	Yes

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

4.3 Robustness test

In order to prevent the occasionality, to have a robustness test. The first one is replacing GTFP with the decomposition term of EC, the second is considering the influence of time factor, eliminate the first and the end time of sample data, the third on is when calculating the environment regulation, using the proportion of industrial SO2 emissions to GDP.

Three robustness regression is shown in table 4-3. According to the table, after taking into account the above factors, the core variable environmental regulation is significantly positive, regression results is relatively stable, the conclusion of the reliability is higher.

Table 3. Robustness test regression results.

	Model9	Model10	Model11
lnER	0.134***	0.021**	0.039***
	(0.011)	(0.009)	(0.008)
Controls	Yes	Yes	Yes
_cons	-0.365	-0.124	-0.681***
	(0.284)	(0.227)	(0.238)
r2	0.943	0.415	0.678
id	Yes	Yes	Yes
year	Yes	Yes	Yes

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

4.4 Further analysis: threshold regression

On the basis of the above regression, using the economic development as the threshold variable, considering whether there is a nonlinear relationship between the eenvironment regulation and GTFP. The results are as follows.

From table 4-4, the double threshold model failed the test, a single threshold model passes the test, it shows that the level of economic development of the relation between "environmental regulation - GTFP" function is non-linear and has significant single threshold effect, the threshold value of 0.9397.

Threshold regression is presented in table 4-5. It can be seen from the table, when economic development level is lower than 0.9397, the estimated coefficient for the environmental regulation 0.042, significantly positive, while the economy development degree is greater than 0.9397, environmental regulation of regression coefficient is positive, coefficient increases to 0.06, it shows that the level of economic development has a opsitive adjustment function for the relationship between environment regulation and the GTFP, and the marginal benefits of the nonlinear relation is increasing.

Table 4. Panel threshold estimation and significance test results.

Threshold variable	The threshold number	Threshold value	P-Value	Lower limit of confidence interval	Upper limit of confidence interval	The number of BS
ECO	A single threshold	0.9397	0.000	0.9350	0.9460	300
	Double threshold	1.7018	0.667	1.5948	1.7118	300

Table 5. Threshold regression model.

Variable	lnGTFP
lnER(lnECO≤0.9397)	0.042***
	(0.010)
LnER(lnECO＞0.9397)	0.060***
	(0.010)
Controls	Yes
_cons	-0.481*
	(0.220)
i.City	Yes
i.Year	Yes

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

5 The conclusion and suggestion

This paper takes the Yangtze River Economic Belt 106 cities as the object, discusses the effect of environmental regulation on GTFP. The results shows environmental regulation can significantly improve GTFP, and the influence of the downstream was not significant, the influence of the upper and middle reaches are significant. The level of economic development has a popsitive adjustment function for the relationship between environment regulation and the GTFP, and the marginal benefits of the nonlinear relation is increasing.

The above conclusions enlighten us:

First, improve the quality of openness to trade, strengthen regional cooperation. The study found that trade openness is not conducive to the GTFP, the possible reason is during the foreign trade, developed countries' environmental regulation is larger, and the Yangtze area has become a "sanctuary" of pollution intensive industries. Therefore in the process of expanding foreign trade, focus on the quality, attract high quality foreign direct investment.

Second, enhance investment in research and development, inncrease in infrastructure investment, relying on colleges and universities, research institutions, etc., to strengthen the key technology innovation ability, promoting r&d and technological innovation, realize the technoligical transformation, increase rearch on green-energy technology.

Third, based on local conditions, implement different environmental regulations. According to each region's conditions, formulate reasonable environmental regulation, avoid to pursue economic development instead of green, achieve coordinated development, encourage local enterprises to carry out the green technology innovation.

Fourth, optimize the industrial structure. During the process of trade openness, the area should abandon industrial pollution transfer. Government should vigorously support the emerging technology industry, eliminate low added value and high pollution enterprises, promote industrial structure upgrade. And try to reduce the proportion of high pollution and high energy consumption, so can improve environmental quality, it is beneficial for GTFP.

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