# A INFLUÊNCIA DA REGULAÇÃO AMBIENTAL NA PRODUTIVIDADE TOTAL DOS FATORES VERDE - COM BASE NA PESQUISA EMPÍRICA DE DADOS EM PAINEL DO RIO YANGTZE.

*THE INFLUENCE OF ENVIRONMENTAL REGULATION ON GREEN TOTAL FACTOR PRODUCTIVITY—BASED ON THE YANGTZE RIVER PANEL DATA EMPIRICAL RESEARCH*

*LA INFLUENCIA DE LA REGULACIÓN AMBIENTAL EN LA PRODUCTIVIDAD TOTAL DE LOS FACTORES VERDES: BASADO EN LA INVESTIGACIÓN EMPÍRICA DE DATOS DE PANEL DEL RÍO YANGTSÉ.*

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**Resumo:**Atualmente, o problema ambiental está se tornando cada vez mais sério, e alcançar o desenvolvimento sustentável se tornou muito importante recentemente. Este artigo utilizou os dados de 106 cidades de nível de prefeitura do Cinturão Econômico do Rio Yangtze para estudar o efeito da regulação ambiental na produtividade total dos fatores verdes. Os resultados mostram que a regulação ambiental pode melhorar significativamente a PTFV. Há uma heterogeneidade significativa. Também foi encontrado que o nível de desenvolvimento econômico tem um efeito de limite.

**Palavras-chave:** desenvolvimento sustentável, desenvolvimento econômico,

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

**Keywords:**sustainable development, economic development.

**Resumen:** Enlaactualidad, el problema ambiental es cada vez más grave, y cómo lograr eldesarrollosostenible se havueltomuy importante recientemente. Este artículo utilizalosdatos de 106 ciudades de nivel de prefectura de la Franja Económica del Río Yangtsé para estudiarelefecto de laregulación ambiental enlaproductividad total de losfactores verdes. Los resultados muestran que laregulación ambiental puedemejorar significativamente la GTFP (Productividad Total de losFactores Verdes, por sus siglas eninglés). Se encontró una heterogeneidad significativa y también se descubrió que elnivel de desarrollo económico tieneunefecto umbral.

**Palabras clave:** desarrollosostenible, desarrollo económico.

## Introduction

As environmental pollution and resource depletion becomes more serious, how torealize the sustainable development becomes important in recent years. Since the reformand opening up, China's economy has developed rapidly, GDP grows from 367.8 billionyuan 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 highquality, efficiency, power, to improve total factor productivity". Therefore, how to achievethe growth of total factor productivity (GTFP) has become important for the sustainabledevelopment of green economy. So having a further study of the present situation of ourGTFP and influence factors, is of great significance for our country economy.

The research hypothesis:

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

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

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

Hypothesis 2: The influence of environmental regulation of the Yangtze river economicbelt 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, theability of environmental optimization varies. When economic levelopment level is low,influenced by GDP championship, they will focus more on GDP, lacking the environmentalregulation, which is not conducive to GTFP. When areas with higher level of development,in the pursuit of better environment, environmental regulation will encourage firms todevelop 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.

**Material e methods**

1 Model building

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

$$\ln GTFP_{it} = \alpha_0 + \alpha_1 \ln ER_{it} + \Sigma \alpha_j \text{control}_{it} + \varepsilon_{it} \tag{1}$$

GTFP representative Green total factor productivity, ER represents the environmentalregulation, i represents prefecture-level cities along the Yangtze river Economic Belt, trepresents time, control represents the other control variables, ε it represents randomdisturbance, accord with normal distribution with zero mean and variance.

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

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

2 Variables

2.1 Explained variable

Green total factor productivity (GTFP). The paper base on the GTFP of 106 cities inYangtze 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 isemployed by the total employmenyt at the end of the year (ten thousand); Energy input inemployed by the whole society power consumption (million kilowatt hour); Capital inemployed by the capital stock. The general practice is to use the capital stock representedby capital investment, but due to the capital stock is difficult to estimate on the level ofprefecture level, therefore. So draw lessons from liuBinglian scholar's practice, used fixedassets investment amount to describe capital input.

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

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### 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 andindustrial soot.

### 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 governmentcontrol (GOV) as control variable. The economic development (ECO) expressed in percapita GDP, import and export trade (OPEN) expressed in the terms of the proportion ofimport and export to GDP, level of human capital (HUM) expressed theproportion ofnumber of colleges and universities to total population, industrial structure(IND) expressedthe proportion od the added value of the second industry to GDP, R&D strength (RD) usedpatent grant, the financial development level(FIA) expressed the proportion of balance ofdeposits in financial institutions to GDP, the government control(GOV) expressed theproportion of local fiscal budget spending to GDP.

### 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 in2011, so they are not included. There are total 1166 samples. Data is mainly got in Chinesecity statistics yearbook, the urban statistical yearbook, taian database, EPS database, etc.Use the stata completion the interpolation method to complement the missing data. In orderto eliminate influence brought by the heteroscedasticity, so take the log for each variables.

## Resultedanddiscussion

### 1 All samples regression result analysis

Table 4-1 shows the regression results of the whole samples. Table 4-1 model 1-3 columnused the mixed OLS, model 4-6 used the fixed effects model, model 1, 4 not conclude thecontrol variables, model 2, 5 joined the control variables, considering the GTFP will beaffected by a period, so the model 3, 6, joined the lag issue, a lag period

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significantlypositive suggests that GTFP is cumulative and sustainable. From the results, the estimatesof environmental regulation variable coefficient is all significantly positive, which indicatesthat environmental regulation can significantly promote the growth of GTFP, and it also hasa 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

2 Regional sample regression

Because the different regions are different in the economic development, resourceendowment, industrial structure, so the overall regression may mask regional differences,so the sample is divided into the upper, middle and downstream groups to verify regionaldifferences 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 ofenvironmental regulation on GTFP are different. The influence of the downstream ispositive, but not significant. Possible reason is the downstream areas uese the cumulativecapital, technology and other factors to promote economic development, so the greentechnology is reletively advanced, environmental protection consciousness is also higher,so the coefficient of environmental regulation is positive, but is not very significant. In theupper and middle reaches, environmental protection consciousness constantly improve,with the adjustment of environmental regulation, pollution is under control. At the sametime, technical level of this areas is relatively low, the strict environmental regulation maybe reversed transmission enterprise reform, realizing green innovation, to play a significantrole in the improvement of GTFP. To verify the hypothesis 2.

**Table 2**. Regional samples 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
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

3 Robustness test

In order to prevent the occasionality, to have a robustness test. The first one is replacingGTFP with the decomposition term of EC, the second is considering the influence of

timefactor, eliminate the first and the end time of sample data, the third on is when calculatingthe 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 takinginto account the above factors, the core variable environmental regulation is significantlypositive, regression results is relatively stable, the conclusion of the reliability is higher.

**Table 3**. Regional samples 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 Further analysis: threshold regression

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

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

Threshold regression is presented in table 4-5. It can be seen from the table, wheneconomic development level is lower than 0.9397, the estimated coefficient for theenvironmental regulation 0.042, significantly positive, while the economy developmentdegree 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

positive adjustment function for the relationship between environment regulation and the GTFP, andthe marginal benefits of the nonlinear relation is increasing.

**Table 4**. Panel threshold estimation and significance test results

| Thresholdvariable | Thethreshold number | Thresholdvalue | P-Value | Lower limitofconfidence interval | Upperlimitofconfidence interval | Thenumber ofBS |
|---|---|---|---|---|---|---|
| ECO | Asingle 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

## Conclusions

This paper takes the Yangtze River Economic Belt 106 cities as the object, discusses theeffect of environmental regulation on GTFP. The results shows environmental regulationcan 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 economicdevelopment has a popsitive adjustment function for the relationship between environmentregulation 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. Thestudy found that trade openness is not conducive to the GTFP, the possible reason is duringthe foreign trade, developed countries' environmental regulation is larger, and the Yangtzearea has become a "sanctuary" of pollution intensive industries. Therefore in the process ofexpanding foreign trade, focus on the quality, attract high quality foreign direct investment.

Second, enhance investment in research and development, inncrease in infrastructureinvestment, relying on colleges and universities, research institutions, etc., to strengthen thekey technology innovation ability, promoting r&d and technological innovation, realize thetechnoligical 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 areashould abandon industrial pollution transfer. Government should vigorously support theemerging technology industry, eliminate low added value and high pollution enterprises,promote industrial structure upgrade. And try to reduce the proportion of high pollution andhigh energy consumption, so can improve environmental quality, it is beneficial for GTFP.

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