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Environmental Regulation and High-Quality Development in China

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Abstract: This paper uses the data of 30 provincial regions in mainland China except Tibet from 2006 to 2018 to weighted measure the intensity of environmental regulation through the weight determined by the ranking of pollutant emission intensity year by year; Based on the three subsystems of economy, society and environment, this paper constructs a high-quality development measurement index system, and determines the weight year by year by entropy method, as well as measures the high-quality development level by weight; From the perspective of enterprise production decision, the influence of environmental regulation on high-quality development is theoretically deduced. Through the empirical test of two threshold models with environmental regulation intensity and per capita GDP as the threshold, it confirms each other, and empirically analyzes the impact of environmental regulation intensity on high-quality development level. The research results show that: The impact of environmental regulation intensity on high-quality development level, with the change of enterprises' decision-making to deal with environmental regulation, has an obvious threshold effect. Before reaching the threshold, the increase of environmental regulation intensity has a negative impact on high-quality development; After reaching the threshold, the impact of the increase of environmental regulation intensity on high-quality development may have a short uncertain stage, followed by a positive impact. Government environmental regulation should be combined with the local stage to avoid the misunderstanding of blindly improving the intensity of environmental regulation; Government environmental regulation should focus on reducing the cost of cleaner production and technological innovation, and accelerate the formation of "forced" innovation mechanism of environmental regulation, so as to give full play to the positive role of environmental regulation in promoting high-quality and high-development.

Keywords: Environmental regulation; High quality development; Threshold effect

1. Introduction

The existing research on the relationship between environmental regulation and high-quality development can be roughly summarized as "win-win theory," "disadvantage theory" and "synthesis theory." Based on Porter's hypothesis, the "win-win theory" holds that strict and reasonable environmental regulation is conducive to stimulate technological innovation of enterprises, improve productivity, and finally play a positive role in economic development [1-3]. On the contrary, the "disadvantage theory" holds that environmental regulation will internalize the cost of dealing with pollution, directly increase the operating cost of enterprises, compress the profit space, and have a "crowding out effect" on investment, which will reduce the production efficiency of enterprises and have a negative impact on the economy. "Synthesis theory" holds that the impact of environmental regulation on economy is very uncertain, and the specific

results are not only interfered by many external characteristics, but also have a great relationship with the behavior of economic subjects. Any subjective and objective factors may make the effect of environmental regulation deviate from the original path [4-5].

Hus paper studies the impact of environmental regulation on quality development from the perspective of enterprise production decision-making. On the basis of measuring the intensity and high-quality development level of environmental regulation in China's provincial regions and theoretically deriving the nonlinear impact characteristics of environmental regulation on high-quality development, this paper empirically analyzes the impact effect of environmental regulation intensity on high-quality development level through threshold model, and puts forward relevant countermeasures and suggestions.

2. Index measurement and model construction
2.1. Index measure
2.1.1. Intensity of environmental regulation
The actual effect of environmental regulation depends on the regulation willingness, development level and pollution status of local governments. Even if different regions implement the same environmental regulation policies, there may be great differences in the actual effects. If the traditional fixed weight is used to weight each pollutant regulation intensity index to obtain the environmental regulation intensity, it is obviously lack of pertinence. Therefore, this paper will characterize the regulation intensity of each pollutant by the completed investment in the treatment of unit industrial "three wastes," determine the weight of each pollutant regulation intensity index year by year according to the ascending ranking of industrial "three wastes" emission intensity, and weighted calculate the environmental regulation intensity of each provincial region. The details are as follows:

$$ERS_{ij} = \alpha ERS_{ij}^{w} + \beta ERS_{ij}^{a} + \gamma ERS_{ij}^{s}$$

ERS_{ij} represents the intensity of environmental regulation in the period j of the i th provincial region; ERS_{ij}^{w}, ERS_{ij}^{a} and ERS_{ij}^{s} represent the dimensionless treatment results of the regulatory intensity of industrial waste water, waste gas and solid waste in the period j of provincial region i respectively. α, β and γ represent the weights of regulatory intensity indexes for industrial waste water, waste gas and solid waste respectively.

$$\alpha = \frac{rw}{rw + ra + rs}$$

$$\beta = \frac{ra}{rw + ra + rs}$$

$$\gamma = \frac{rs}{rw + ra + rs}$$

rw, ra and ra respectively represent the ascending ranking of the discharge intensity of industrial wastewater, waste gas and solid waste in each provincial region in period j.

2.1.2 High quality development level
High quality development is an economic development mode, structure and dynamic state that can better meet the growing real needs of the people [6-8]. Therefore, high quality development covers more contents than economic growth, which needs to be comprehensively evaluated by constructing an index system. Referring to relevant literature and the availability of data, this paper comprehensively considers the three subsystems of economy, society and environment to build a comprehensive evaluation index system of high-quality development level, as shown in **Table 1**.

Table 1. Comprehensive evaluation index system of high-quality development level

Evaluation criteria		Evaluating indicator	Index calculation method	Attribute
Economics	Production efficiency	Labor productivity	GDP / employed persons	Forward
	Innovation ability	Proportion of technology turnover in output value	Technology turnover / GDP	Forward
	Structural optimization	Proportion of output value of high-tech enterprises	Main business income of high-tech enterprises / GDP	Forward
Society	Regional development balance	Ratio of urban and rural Engel coefficient	Engel coefficient of urban family / Engel coefficient of rural family	Forward
	Basic happiness	Per capita medical resource level	Number of doctors per 10000 people	Forward
		Per capita educational resource level	Per capita education expenditure	Forward
	Modern life	Resident informatization level	Internet penetration	Forward
Environment	Environmental quality	Vegetation coverage level	Forest coverage	Forward
		Regional greening level	Greening rate of built-up area	Forward
	Industrial pollutant discharge	Wastewater discharge intensity	Industrial wastewater discharge / GDP	Negative
		Exhaust gas discharge intensity	Industrial exhaust gas discharge / GDP	Negative
		Solid waste discharge intensity	Industrial solid waste discharge / GDP	Negative

Carry out positive treatment on negative indicators (convert the indicator value of negative indicators into the gap between the original indicator value and the maximum value of the indicator in each provincial region), then standardize each indicator by using range method, determine the indicator weight by entropy method, calculate the evaluation value of each subsystem, and determine the weight of each subsystem by entropy method. Finally, measure the high-quality development level.

2.2. Model building

2.2.1. Theoretical model

Environmental regulation has two impacts on high-quality development by influencing enterprise decision-making. One is the impact on the economic level, namely "economic effect"; The other is the impact of non-economic aspects (society and environment), namely "non-economic effects."

In terms of "economic effect," before the threshold, due to the low production level and high cost of technological innovation and cleaner production, enterprises will bear the cost burden brought by environmental regulation and maintain the original production and operation plan. Environmental regulation only produces "cost burden" and does not produce "innovation compensation," and the "economic effect" is negative, as shown in line a of **Figure 1 (a)**; After the threshold, due to the improvement of enterprise production level and the reduction of the cost of technological innovation and cleaner production, enterprises no longer bear the cost burden brought by environmental regulation, but carry out technological innovation and cleaner production. Environmental regulation not only produces the "cost burden" of technological innovation and cleaner production investment, but also produces the corresponding "innovation compensation," and the intensity of environmental regulation increases "economic effect" depends on the comparison between "innovation compensation" and "cost burden," as shown in line B and line C of **Figure 1 (a)**. The "economic effect" of environmental regulation can be described by the following theoretical model:

$$HQD_1 = f_1(ERS, X) \cdot I(TV < \varphi) + f_2(ERS, X) \cdot I(TV \geq \varphi) + \varepsilon_1$$

Where, HQD_1 represents the high-quality development level at the economic level; $f_1(\cdot)$ and $f_2(\cdot)$ are the influence functions of environmental regulation before and after the threshold value on high-quality development level at the economic level respectively. $I(\cdot)$ is indicative function; ERS represents the intensity of environmental regulation; TV represents the control variable; φ represents the threshold variable; ε_1 represents the threshold value; I is the random perturbation term.

In terms of "non-economic effects," before the threshold, enterprises cannot carry out technological innovation, can only maintain the original production plan, endure the high cost of environmental regulation, and the pollutant emission cannot be reduced. "Non-economic effect" is 0, i.e. "regulation is invalid," as shown in line A of **Figure 1 (b)**. After the threshold, when enterprises carry out technological innovation and cleaner production, the pollutant emission will decrease, and the "non-economic effect" is positive, as shown in line B of **Figure 1 (b)**. Therefore, the "non-economic effect" of environmental regulation can be described by the following theoretical model:

$$HQD_2 = g_1(X) \cdot I(TV < \varphi) + g_2(ERS, X) \cdot I(TV \geq \varphi) + \varepsilon_2$$

Where, HQD_2 represents the high-quality level of non-economic development; $g_1(\cdot)$ and $g_2(\cdot)$ are the influence functions of environmental regulation on non-economic high-quality development level before and after the threshold variable reaches the threshold value. ε_2 is the random perturbation term.

Combining the "economic effect" and "non-economic effect" of environmental regulation, before the threshold, the increase of environmental regulation intensity has a negative impact on high-quality development, as shown in line a of **Figure 1 (c)**. After the threshold, the impact of the increase of environmental regulation intensity on high-quality development may have a short uncertain stage, followed by a positive impact. As shown in line B and line C of **Figure 1 (c)**. Therefore, the impact of environmental regulation on high-quality development can be described by the following theoretical model:

$$HQD = h_1(ERS, X) \cdot I(TV < \varphi) + h_2(ERS, X) \cdot I(TV \geq \varphi) + \varepsilon$$

Where, HQD represents high quality development level; $h_1(\cdot)$ and $h_2(\cdot)$ represent the influence function of environmental regulation on the level of high-quality development before and after the threshold variable reaches the threshold value. ε is the random perturbation term.
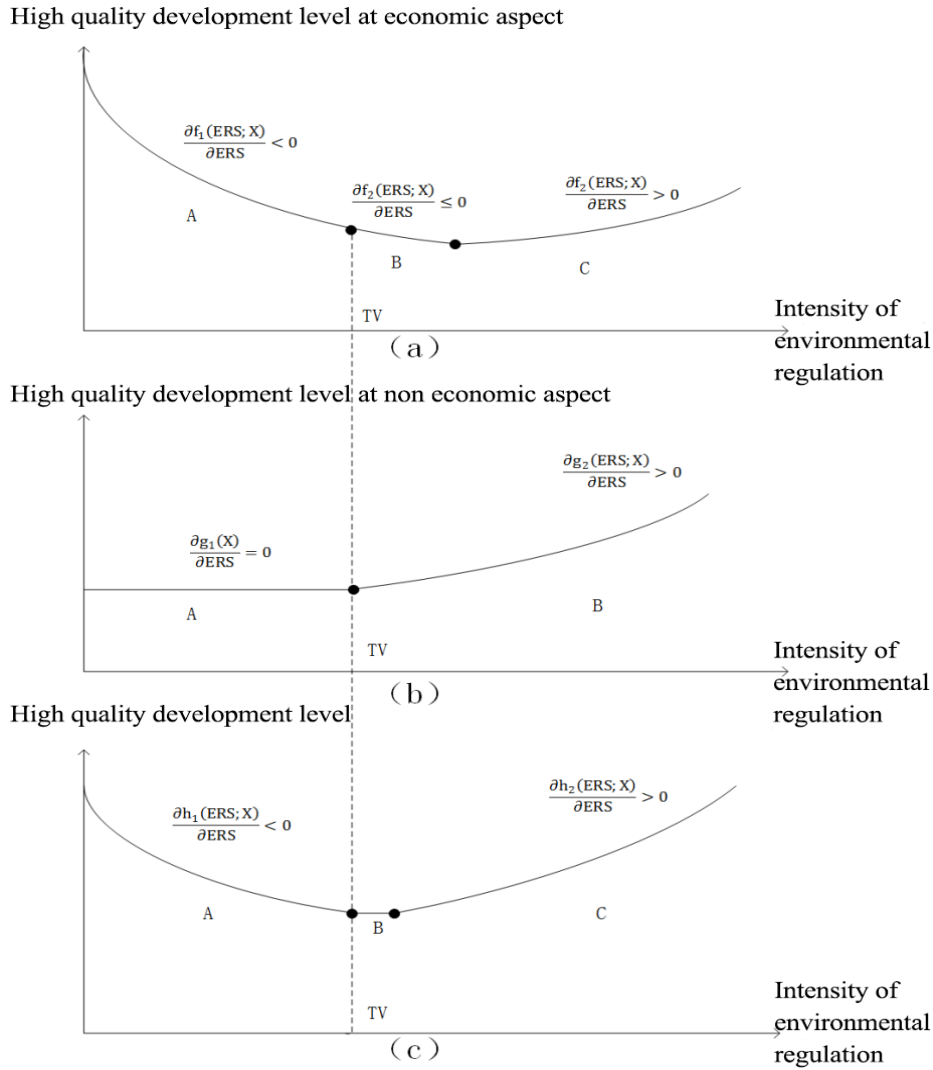
Figure 1. Impact of environmental regulation on high-quality development

2.2.2. Empirical model

This paper establishes threshold models based on the intensity of environmental regulation and per capita GDP, empirically tests the impact of environmental regulation on high-quality development, and draws a conclusion through the mutual confirmation of different models. The construction model is as follows:

$$\text{HQD}_{it} = c + \beta_1 \text{ERS}_{it-1} \cdot I(\text{ERS}_{it-1} < \gamma) + \beta_2 \text{ERS}_{it-1} \cdot I(\text{ERS}_{it-1} \geq \gamma) + \lambda_1 \text{SL}_{it} + \lambda_2 \text{PQ}_{it} + \varepsilon_{it}$$

$$\text{HQD}_{it} = c + \beta_1 \text{ERS}_{it-1} \cdot I(\text{PGDP}_{it} < \tau) + \beta_2 \text{ERS}_{it-1} \cdot I(\text{PGDP}_{it} \geq \tau) + \lambda_1 \text{SL}_{it} + \lambda_2 \text{PQ}_{it} + \varepsilon_{it}$$

Where, $I(\cdot)$ represents the indicative function; PGDP_{it} represents the per capita GDP of the i provincial region in phase t; γ, τ are threshold values; SL_{it} and SL_{it} are control variables, respectively representing the scientific and technological level and population quality of the phase t of the i th provincial region, which are measured by the number of patent grants (positive indicator) and illiteracy rate (negative indicator).

3. Empirical analysis

3.1. Data declaration

This paper takes the data of 30 provincial regions in mainland China except Tibet from 2006 to 2018 as the sample data. Among them, the data of industrial "three wastes" emission and treatment investment, GDP, employment and the number of doctors per 10000 people are from *China Statistical Yearbook*; The data of

per capita education expenditure comes from the *China Regional Economic Statistics Yearbook*; The Internet penetration rate comes from the *China Tertiary Industry Statistical Yearbook*; The forest coverage rate comes from *China Environmental Statistics Yearbook*; The greening rate of the built-up area comes from the *Statistical Yearbook of Chinese Urban Construction*; Other data are from China's macroeconomic database and China's high-tech industry database included in EPS.

3.2. Index measure results

Based on the measurement results, the weight of industrial "three wastes" regulation intensity presents obvious regional characteristics - China's industrial wastewater discharge intensity shows the characteristics of "high in the south and low in the north," while the discharge intensity of industrial waste gas and solid waste shows the characteristics of "high in the north and low in the south." In addition, the measurement results of environmental regulation intensity also show obvious regional characteristics, which are higher in the eastern and western regions and lower in the central region. This may be due to the fact that the eastern part of the country is economically developed and has a strong capacity to eliminate outdated production capacity, as well as greater investment in pollution control, while the western part of the country is economically underdeveloped and has less environmental pollution caused by economic activities and higher environmental regulation intensity The economic development level of the central region is in the middle, there is a certain dependence on high pollution production capacity, and the intensity of environmental regulation is low.

The measurement results of high-quality development level show that there is a large gap in the measurement results of most Chinese provinces. The provinces and regions with higher average annual level of economic subsystem are Beijing, Shanghai and Guangdong; The average annual average level of social subsystem was higher in Beijing, Shanghai and Tianjin. The average annual average level of environment subsystem was higher in Fujian, Jiangxi and Zhejiang, showing the characteristics of higher overall level in southern provinces and lower overall level in northern provinces.

3.3. Model estimation results

The regression results of threshold model are shown in **Table 2** and **Table 3**. **Table 2** shows that in the threshold model with environmental regulation intensity as the threshold variable, there is a significant threshold effect in the relationship between high-quality development level and environmental regulation intensity. The coefficient of environmental regulation intensity lagging behind the first period is negative before and after the threshold, and environmental regulation has a negative impact on high-quality development. The absolute value of the coefficient of environmental regulation intensity lagging behind the first period decreases significantly after the threshold value, indicating that although the later environmental regulation has no positive impact on high-quality development, its negative impact is significantly reduced.

Table 2. Estimation results of threshold model with environmental regulation intensity as threshold variable

Explanatory variable	Parameter estimate	t value	F value
C	0.52**	22.31	87.74
ERS_{it-1} （$ERS_{it-1} \leq 0.1189$）	-0.49***	-4.02	Prob （F）
ERS_{it-1} （$ERS_{it-1} > 0.1189$）	-0.15***	-2.64	
SL	0.27***	6.16	0.0000
PQ	-0.16*	-11.91	

Note: *, * *, * * * respectively mean significant at the significance level of 0.10, 0.05 and 0.01.

Table 3 shows that in the threshold model with per capital GDP as the threshold variable, there is also a significant threshold effect in the relationship between high-quality development level and environmental regulation intensity. The environmental regulation intensity coefficient of the first lag period is negative and positive before and after the threshold value respectively. It shows that before reaching the threshold, environmental regulation has a negative impact on high-quality development; After reaching the threshold, environmental regulation has a positive impact on high-quality development.

Table 3. Estimation results of threshold model with per capital GDP as threshold variable

Explanatory variable	Parameter estimate	t value	F value
C	0.46***	22.31	108.78
ERS_{it-1}（PGDP ≤ 37072）	-0.38***	-5.93	Prob （F）
ERS_{it-1}（PGDP > 37072）	0.20***	2.89	
SL	0.26*	6.37	0.0000
PQ	-0.14***	-10.54	

Note: *, * *, * * * respectively mean significant at the significance level of 0.10, 0.05 and 0.01.

The estimation results of the two models verify the conclusions of the theoretical model: The impact of environmental regulation on high-quality development has a threshold effect. Before reaching the threshold, the "economic effect" of environmental regulation is negative and the "non-economic effect" is 0. Environmental regulation inhibits high-quality development; After reaching the threshold value, the "economic effect" of environmental regulation is uncertain, and the "non-economic effect" is positive. There may be a short period of uncertainty for the impact of increasing environmental regulation intensity on high-quality development, and then it will be positive. According to the regression results of the threshold model with per capita GDP as the threshold variable, at present, except Yunnan and Gansu, other provincial regions in China have reached or exceeded the threshold.

4. Policy suggestions

In view of the above conclusions and combined with practice, this paper puts forward relevant policy suggestions: Government environmental regulation should be combined with the local stage to avoid the misunderstanding of blindly improving the intensity of environmental regulation. Regions that have reached or exceeded the threshold should adopt active environmental regulation policies to stimulate enterprises to improve the efficiency of cleaner production, increase "innovation compensation" and "non-economic benefits," and promote high-quality development. In addition, in order to increase the income of "innovation compensation" and reduce the "cost burden," the government should also take measures to subsidize enterprises that invest in cleaner production and innovation; Regions that have not yet reached the threshold (Yunnan and Gansu) should pay attention to avoid the misunderstanding of blindly improving the intensity of environmental regulation. On the basis of economic development, they should implement incentive environmental protection policies with subsidies and return mechanisms, so as to slow down the decline stage of the "U" curve and speed up the rise stage

Disclosure statement

The author declares no conflict of interest.

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