

The Impact of Environmental Regulation on Industrial Structure Upgrading—— Based on Panel Threshold Evidence

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Abstract: Environmental regulation is an important tool to solve the dilemma between sustainable economic growth and environmental deterioration, and it is the focus of policy makers. In order to facilitate the construction of China's "14th Five-Year Plan" and promote the green, low-carbon and sustainable development of the economy, it is of great significance to study the impact of environmental regulation policy intensity on the upgrading of industrial structure. Based on the panel data of twelve provinces in northern China from 2000 to 2019, this paper analyzes the impact path of environmental regulation policies on industrial structure transformation and upgrading through the supply and demand theory, and then establishes the panel regression model and the panel threshold model for empirical analysis. The results show that environmental regulation has a u-shaped impact on the optimization of industrial structure, and it can accelerate its positive impact on the optimization of industrial structure by improving the level of economic development and technological innovation. The results of threshold model show that there are double threshold effects of environmental regulation. With the increase of environmental regulation intensity, the effect of environmental regulation on industrial structure optimization is changed from promotion to inhibition and then to promotion.

Keywords: Environmental regulation ; Industrial structure upgrading; Panel regression model; Panel threshold model

I. Introduction

In 2021, China has started The 14th five-year plan."The central committee of the communist party of China to develop the national economy and social development of The 14th five-year plan and 2035 vision"insists on innovation in the core position in the global modernization construction in our country, promote the development of green low carbon, to build domestic large cycle as the main body, domestic and international new development pattern of two-cycle promote each other. In this new development pattern, whether on the supply side or the demand side, the adjustment and optimization of industrial structure is of vital importance. Since entering the 21st century, China's tertiary industrial structure has been significantly optimized. The growth rate of the primary industry has slowed down, while the secondary industry has grown rapidly and still dominates. The tertiary industry has broken

through the single development pattern dominated by catering and commerce, and accelerated the rapid development of financial services. However, no matter from the static or dynamic point of view, China's industrial structure at the present stage still has many problems. Throughout China's decades of economic development, the early days of rapid economic development came at the expense of the environment, and the negative effects have persisted. In 2005, General Secretary Xi Jinping put forward the scientific judgment that "clear waters and mountains are golden mountains and silver mountains". Due to the negative externalities of environmental pollution and the possible failure of market regulation, environmental regulation provides a new way of thinking for solving the problems of pollution discharge and industrial structure upgrading. China's environmental regulation mainly comes from two forces: one is the government's force, that is, formal environmental regulation. The government's formulation of pollutant emission standards, production and technology standards, implementation of carbon emission trading pilot policies and the imposition of pollution taxes are bound to affect the micro behavior and decision-making of enterprises, and ultimately affect the upgrading of industrial structure^[1](Zhou Haihua and Wang Shuanglong, 2016).The second is the voluntary power of the public (including ordinary people, media, environmental organizations, etc.), namely informal environmental regulation. Social organizations and residents with strong environmental awareness voluntarily initiate or participate in environmental protection actions, which exert pressure on enterprises, thus affecting the upgrading of industrial structure. At the same time, these two forces will also influence each other. On the one hand, the extensive social influence of formal environmental regulations led by the government can promote the formation of informal environmental regulations. On the other hand, informal environmental regulations with public participation will also have a supervisory effect on formal environmental regulations. It can be seen that the synergistic effect of the two is also an important part of the environmental regulation system^[2](Yu Donghua and Cui Yan, 2019).Therefore, it is of great theoretical and practical significance to discuss the logical relationship between environmental regulation and industrial structure upgrading.

Environmental regulation refers to the regulation of various behaviors that pollute the public environment for the purpose of protecting the environment. It mainly refers to a kind of institutional restriction put forward by the government on enterprises' production and pollutant discharge behaviors. The academic circles have experienced a process of understanding the specific connotation of environmental regulation. At first, people believed that environmental regulation was the government's direct intervention in the utilization of environmental resources in a non-market way. The typical feature was that the formulation and implementation of environmental standards were handled by the government administration alone, and the market and enterprises had no room for activity in the strict administrative regulation^[3]. In order to improve the ecological environment, the government has issued a series of environmental protection policies, but it is often the enterprises that carry out related production that are constrained. The purpose of environmental protection is to increase the production cost of enterprises and sacrifice the market share. However, with the application of environmental taxes, subsidies and economic incentives, people find that these measures also have the function of environmental regulation, but they do not belong to the original definition of environmental regulation. Therefore, people revise the meaning of environmental regulation, which is summarized as the government's direct and indirect intervention on environmental resources, and divided into formal environmental regulation and informal environmental regulation. Among the development and evolution of many social regulations, environmental regulation is one of the most popular regulatory

means in the world at present. It can better correct the system failure and form long-term effective management and control of enterprises. Many countries have achieved initial results of harmonious coexistence of environmental protection and economic development under environmental regulation.

II. Journals Reviewed

The impact of environmental regulation on industrial structure upgrading has always been an important issue in academic research. Early viewpoints generally supported the "cost compliance theory", that is, they believed that environmental regulations increased the economic burden of enterprises, restricted their economic activities, and was not conducive to the upgrading of industrial structure. For example, Gray and Shadbegian (2003) point out that environmental regulations increase the pressure on production costs of resource-intensive industries^[4]; Wang Kai (2012) believed that environmental regulations would form short-term constraints on the export competitiveness of pollution-intensive industries^[5]; Zhao and Sun (2016) found that environmental regulation is not conducive to enterprises' competitiveness^[6] And so on.

Since then, the research has broken through the original analysis from the static perspective and started to study the relationship between the two from the long-term and dynamic perspective.

First, some scholars have analyzed the mechanism and path of environmental regulations affecting industrial structure upgrading. When studying the effect of a single mechanism on industrial structure upgrading of environmental regulation, Shi Le Le and Zhao Jun (2018), Yin Yufei and Yang Xuefeng (2020) empirically tested the relationship between environmental regulation, technological innovation and industrial structure upgrading based on provincial and municipal panel data respectively^{[7][8]}. Wang Shuangyan et al. (2016) believed that environmental regulation could alleviate the inhibiting effect of FDI on the upgrading of industrial structure in the short term^[9]. Tong Jian et al. (2016) believe that the impact of environmental regulations on industrial transformation and upgrading is nonlinear, and this feature is formed by the distorting effect of resource allocation and technical effect of environmental regulations^[10]. He Wenhai, Zhang Yongjiao (2021) believed that environmental regulation could promote the rationalization of industrial structure in both the short and long term, but it could promote and hinder the upgrading of industrial structure respectively^[11]. Sun Chaolei (2019) from the Angle of the flow of factors of production between industry, think that environmental regulation refers to the strict control of all kinds of pollutants, forcing all kinds of factors of production from low value-added, high energy consumption of manufacturing industry of exit turn into high value-added, high production efficiency, less energy consumption of industry to achieve industrial upgrading^[12].

In terms of multipath research, MAO Jianhui and Guan Chao (2019) believe that environmental regulation can affect industrial structure upgrading through R&D innovation, opening up, FDI inflow and investment demand, among which the first two mechanisms have positive transmission effect and the last two mechanisms have reverse effect^[13]. Mei Guoping and Gong Hailin (2013) believed that environmental regulation promoted industrial structure changes through entry barriers, technological innovation and international trade^[14]. Xu Kaijun and Yuan Yijun (2014) found that environmental regulation can promote the continuous upgrading and optimization of industrial structure through a series of transmission mechanisms such as inducing technological innovation, setting entry barriers, changing trade openness and inter-regional industrial transfer^[15]. Li Jiang et al. (2020) believe that command-and-control environmental regulation has a partial mediating effect on

industrial structure upgrading through investment structure, consumption structure and technological innovation. There is a single threshold effect between environmental regulation and industrial structure upgrading. With the increase of environmental regulation intensity, the positive effect of environmental regulation on industrial structure upgrading becomes greater. The level of foreign capital utilization and financial development are conducive to the upgrading of industrial structure^[16].

Based on the study of different influence factors, some scholars focus on the transmission path of technological innovation are discussed in this paper, to find suitable environmental regulation can stimulate the enterprise technology innovation, and technological innovation can not only make up the environmental cost, also can produce more value, namely the realization of "innovation" (Poter, Vander, 1995), so as to promote the transformation and upgrading of industrial structure. Studies by many scholars support this conclusion. Yan Ying, Sun Yarong et al. (2020) believe that sustained R&D investment and environmental regulation policies are the decisive factors for innovation of Chinese industrial enterprises, and new product sales in innovation output is the realistic driving force for green growth of Chinese industry^[17]. Based on the research on the correlation between environmental regulation and technological innovation, the academic community has further expanded the research from multiple levels to the impact of environmental regulation on corporate profits, competitiveness, international trade and international competitiveness. At the micro level, Liu and Xuesong Gu (2020) established dynamic and static panel models and threshold models to find that the impact of environmental regulations on corporate profits has a threshold effect, which depends on the technology level of enterprises^[18]; In terms of the research on the overall economic development, Shangguan Xuming (2020) believes that China's scientific and technological innovation and environmental regulation have a significant direct promotion effect on economic development^[19]; Qin Bingtao et al. (2020) believed that, within a certain level, environmental regulation would force the optimization of industrial structure, which would improve the allocation of labor and capital^[20]; The empirical study of Fan Qingquan, Chuchengjun and Gao Jianing (2020) shows that under environmental regulations, industrial structure upgrading has a non-linear empirical impact on labor productivity. The government should further strengthen the strategic focus of pollution prevention and control and gradually tighten environmental control measures^[21]. Xue Yaozu (2016) believes that improving the intensity of environmental regulation can widen the profit gap between enterprises, promote labor flow to high-profit enterprises, and then promote the optimization and upgrading of industrial structure^[22]; Li Qiang (2013) believed that the existence of environmental regulations would increase the proportion of the service sector relative to the industrial sector, thus promoting the upgrading of the industrial structure^[23]; Xu Kaijun and Yuan Yijun (2014) analyzed the intensity of environmental regulations from two aspects of unit wastewater and waste gas treatment facilities and operating costs, and found that the harsher environmental regulations are, the more conducive to the optimization and upgrading of industrial structure.

In addition, some scholars have taken the effects of regional heterogeneity and firm heterogeneity into consideration. In terms of regional heterogeneity, Li Kai and Shangguan Xuming (2021) believe that the impact of R&D investment and environmental regulations on the economic development quality of large and medium-sized cities is significantly lower than that of small cities^[24]. The research of Meng Wangsheng and Shao Fangqin (2020) shows that environmental regulations in the Yellow River Basin can improve the efficiency of green economic growth through both the upgrading and rationalization of industrial structure changes^[25]. Yin Qingmin (2020) studied

the impact of environmental regulations and industrial structure on green economic efficiency in China and different regional levels, and put forward some policy suggestions, such as reasonable regulation of environmental regulations, control of the scale of secondary industry, and establishment of foreign access mechanism^[26]. In terms of firm heterogeneity, Yongwang Zhang (2019) finds that the impact of environmental regulation on trade competitiveness presents a "U-shaped" relationship. Meanwhile, the impact of environmental regulation on trade competitiveness has a threshold effect. Environmental regulation can effectively promote trade competitiveness only when the technological development level or cost affordability exceeds a certain threshold^[27]; Chen Yan (2020) measured the spatial and temporal levels of structural rationalization and upgrading in industrial transformation, and proposed to formulate environmental protection regulations based on the characteristics of industrial enterprises and production links through panel capacity analysis, so as to avoid the policy effect of "one-size fits-all"^[28].

Based on the analysis of the existing literature, the author found that the scholars in the environment and upgrade of industrial structure regulation between the research mainly focuses on the influence of environmental regulation on the transformation and upgrading of industrial structure and influencing factors, and the comparison of research on the effect of technological innovation path, think it will be a certain effects on the upgrading of industrial structure; Domestic scholars in our country's environmental regulation policy research on the influence of the upgrading of industrial structure is mainly through the establishment of empirical model, selection of differentiation in some parts of the data analysis, but through the carding found in the literature, the scholars in our country north of environmental regulation on the study of the influence of the upgrading of industrial structure is not enough in-depth, especially for our country in the north environmental regulation policy research is still in a blank stage. Threshold model, therefore, the author attempts to use panel is introduced into environmental regulation of square environment regulation and nonlinear direct relationship between industrial structure upgrade, through descriptive statistics, hausman test, threshold regression is applied to study the relations, to promote the transformation and upgrading of industrial structure in north China.

III. Theoretical Analysis and Influence Mechanism

In economics research, the relationship between supply and demand is the theoretical cornerstone of the development of the whole economics. Supply and demand are often interrelated and affect each other. As for the content to be studied by the author, that is, the impact of environmental regulation on the upgrading of industrial structure, it can also be used as the starting point to analyze the impact path. Enterprises are the objects of environmental regulation restriction and incentive, and their production nature is related to the upgrading of industrial structure, so we can analyze the path of environmental regulation adjusting industrial structure by acting on enterprise production from the perspective of demand and supply. First of all, from the perspective of demand, investment demand and consumption demand are external factors that affect enterprises' adjustment of production mode, which are mainly manifested in the changes of consumption structure and investment structure^[29]. Environmental regulation of the change of production market, consumer market and consumer choice, and pollution emissions of negative externalities will cause the increase of the intensity of environmental regulation, and thus lead to the increase of production cost, intuitively characterized by rising commodity prices, consumers under the condition of invariable in the propensity to consume is bound to change their consumption habits, by buying substitutes to maintain

the balance of payments, which changed the consumption demand of the market. Negative externalities of pollution emissions have another effect, which is to change the demand for investment in the market^[30]. When an investor inspects an industry, he or she will calculate his or her expected return and the industry's development prospects. When the pollution emission of industries affected by environmental regulations reaches a certain level, it is bound to increase the cost of pollution control, which will greatly reduce the actual returns of investors, thus changing the investment preference in the market. In addition, the processes with high pollution and high energy consumption in the production process will gradually be replaced by green environmental protection processes, and some production equipment with low utilization rate and energy conversion rate will be gradually phased out with the progress of the production process, which will also affect the investment cost of fixed assets of investors, thus affecting the investment demand in the market. Secondly, from the perspective of supply, the improvement of production efficiency is an internal factor for enterprises to change the production mode, which is mainly reflected in the improvement of technological innovation level. Relevant policies of environmental regulation, such as the formulation of standards for energy conservation and emission reduction, can stimulate the internal technological innovation of enterprises, thus stimulating the changes and adjustment within the industry, making the high-pollution and energy-consuming industries gradually eliminated, and the new energy industry occupying more market share, thus achieving the effect of adjusting the industrial structure.

3.1 Consumption Structure

From the demand side, environmental regulation can promote the upgrading of industrial structure through the optimization of consumption structure. According to the concept of consumer preference and demand theorem, on the one hand, the implementation of environmental regulations will improve the environmental literacy and awareness of consumers, resulting in the change of consumers' consumption preferences, so that consumers are more inclined to use environmental alternatives, so as to optimize the consumption structure; Enterprises that make production decisions based on market demand will then change their production strategies, promote the cleanliness of the production process, and optimize and upgrade the industrial structure. On the other hand, the additional costs brought by environmental regulations to enterprises will be passed on to consumers. Driven by the demand theorem, rational consumers will reduce their consumption of products from such enterprises and increase their consumption of similar environmental substitutes, which will lead to changes in the consumption structure and ultimately promote the optimization and upgrading of the industrial structure.

3.2 Investment Structure

Also from the perspective of demand, environmental regulation can promote the upgrading of industrial structure through the optimization of investment structure. Specifically, the change of investment structure under environmental regulations is mainly manifested in two aspects: on the one hand, the investment scale of pollution-intensive enterprises represented by "high pollution, high emission and high energy consumption" is constantly decreasing, and the market share of enterprises is constantly decreasing. Such enterprises are limited by environmental protection threshold, environmental protection technology and capital flight^[31], will continue to die out or transfer, so as to clean up the industrial structure and promote the optimization and upgrading of the industrial structure. On the other hand is the "high output, low energy consumption, clean and green" represented by the expanding scale of investment in environmental protection enterprises, enterprise market share

gradually increase, such companies benefit from their own environmental protection technology and cost-effective advantages, will continue to attract investment and expand the scale, make cleaning industry accounted for further improve, and then promote upgrading of the industrial structure.

3.3 Technological innovation

From the perspective of supply, environmental regulation can promote the upgrading of industrial structure through the improvement of technological innovation level. The competitive advantage of an enterprise in the process of operation and development mainly comes from technological innovation, which is also the fundamental driving force to promote the sustainable development of an enterprise and the core factor to promote the structural upgrading of the industry in which the enterprise is located. The reason why environmental regulation can promote the upgrading of industrial structure through technological innovation is based on the porter hypothesis. In the long run, environmental regulation to implement the "innovation effect" greater than "follow the cost effect", namely the benefits brought by the enterprise technical innovation and environmental regulation of additional costs will offset each other, the enterprise in order to avoid the additional cost of environmental regulation, and achieve the goal of economic efficiency and competitiveness, will take the initiative to increase R&D investment, to carry out technical innovation activities. Technological innovation will promote the emergence of new production processes and production tools, continuously improve production efficiency, promote industrial division of labor and the rise of emerging industries, and ultimately guide the optimization and upgrading of industrial structure.

Figure1 analyzes the path of environmental regulation affecting industrial structure upgrading from the perspective of demand and supply.

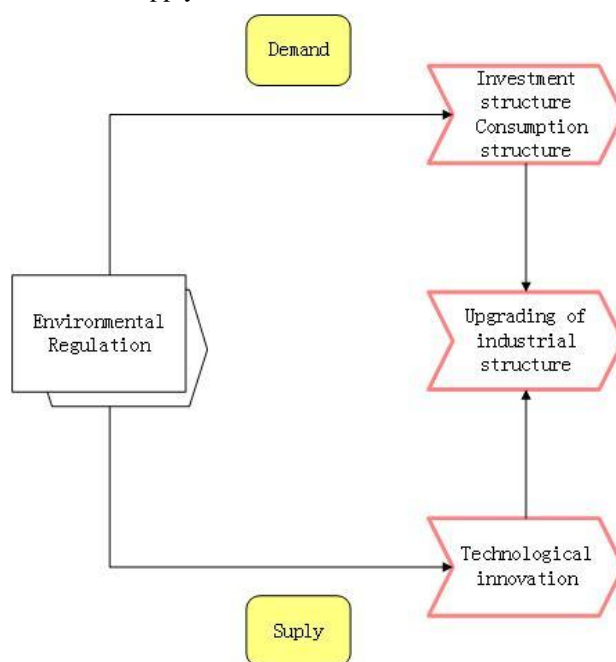


Figure 1

IV. Empirical analysis

4.1 Model construction

A comprehensive analysis of the impact of environmental regulations on the upgrading of industrial structure is undoubtedly of theoretical and practical significance to the realization of the regional economic sustainable development and the win-win goal of ecological civilization in the

northern area of China at the present stage. Based on the consideration of the accuracy and rigor of the study, the author will use the panel model for the study. The panel data model is different from the time series data model and the section data model. It is to construct and test the time series data of different individuals. Panel data can increase the number of contained data, reduce the multicollinearity between explanatory variables, and improve the accuracy of model estimation. At the same time, the panel data model can also study the temporal dynamic changes of individuals and the differences between different individuals^[32]. Because the related variables in the model involve both absolute and relative indexes, it is easy to produce estimator bias and heteroscedasticity problems if the model is directly estimated, which will affect the estimation results of the model. In order to avoid this problem, all variables involved in this paper are processed with logarithm. In addition, since the direct impact of environmental regulation on industrial structure upgrading is not a single linear relationship, the square term of environmental regulation is included to empirically test the nonlinear impact of environmental regulation.

The panel regression model is as follows:

$$\ln INU_{it} = \beta_0 + \beta_1 \ln ER_{it} + \beta_2 \ln ER_{it}^2 + \beta_3 \ln TI_{it} + \beta_4 \ln GDP_{it} + \beta_5 \ln IS_{it} + \varepsilon_{it} \quad (1)$$

Where, i represents each provincial administrative unit ($i = 1, 2, \dots$); t represents time; β_0 is a constant term, and ε_{it} is a random interference term. $\ln INU_{it}$ represents the upgrading of industrial structure, $\ln ER_{it}$ represents environmental regulation, $\ln ER_{it}^2$ represents the second term of environmental regulation, and other control variables include technological innovation ($\ln TI_{it}$), fixed asset investment ($\ln IS_{it}$) and economic development level ($\ln GDP_{it}$).

Due to the different effects of different environmental regulation intensity on industrial structure optimization, the following single-threshold regression model is set by referring to the analysis framework of Hansen (1999) :

$$\ln INU_{it} = \beta_0 + \beta_1 \ln ER_{it} I(th < \theta) + \beta_2 \ln ER_{it} I(th > \theta) + \beta_3 \ln TI_{it} + \beta_4 \ln GDP_{it} + \beta_5 \ln IS_{it} + \varepsilon_{it} \quad (2)$$

Where, th represents the threshold variable and is strictly exogenous; θ is the threshold value of the threshold variable to be estimated; $I(\cdot)$ is an indicator function, ε_{it} is a random interference; β_1 and β_2 respectively represent the elastic coefficient of environmental regulation intensity affecting industrial structure optimization when $th < \theta$ and $th > \theta$. Model (3) considers the existence of a single threshold, and further extends to the following double threshold model:

$$\ln INU_{it} = \beta_0 + \beta_1 \ln ER_{it} I(th < \theta_1) + \beta_2 \ln ER_{it} I(\theta_1 < th < \theta_2) + \beta_{13} \ln ER_{it} I(th > \theta_2) + \beta_4 \ln TI_{it} + \beta_5 \ln GDP_{it} + \beta_6 \ln IS_{it} + \varepsilon_{it} \quad (3)$$

Where, θ_1 and θ_2 are threshold values, and $\theta_1 < \theta_2$. Multiple threshold regression model can be further expanded on the basis of single threshold model. The intensity of environmental regulation may not only have a single threshold. Further, this paper establishes the following double threshold regression model:

$$\ln INU_{it} = \beta_0 + \beta_1 \ln ER_{it} I(\ln ER < \theta_1) + \beta_2 \ln ER_{it} I(\theta_1 < \ln ER < \theta_2) + \beta_{13} \ln ER_{it} I(\ln ER > \theta_2) + \beta_4 \ln TI_{it} + \beta_5 \ln GDP_{it} + \beta_6 \ln IS_{it} + \varepsilon_{it} \quad (4)$$

4.2 Variable selection and data processing

Environmental regulation (ER) : As one of the most important explanatory variables, the

measurement standard of environmental regulation in existing research methods is mainly based on its intensity, such as environmental regulation policy, industrial pollution control investment, pollution control facilities cost, pollution emission change and other perspectives. For the measurement of environmental regulation has not unified standard, different scholars from different research Angle is given different measures, such as industrial wastewater emissions success rate, environmental pollution control investment as a share of GDP, discharge accounted for the proportion of local fiscal revenue, industry waste water, waste gas management operation cost accounts for the proportion of gross industrial output value, etc. Based on the research core and data availability, this paper selects the investment amount of industrial pollution control as the research variable of environmental regulation.

Industrial structure upgrading (INU) : About the variable selection of industrial structure upgrading, different scholars have published relevant views in their papers. Among them, many scholars agree that a kind of economic structure as a service to the effective method of the quantitative, the method through calculation of the tertiary industry output value of the ratio between the output of the second industry and, as a measure of economic structure as a service, and further can be used as the standard that industrial structure upgrade or not, if the increase of the ratio between the two, the industrial structure to the tertiary industry transfer the economic structure as a service, the trend of the industrial structure upgrade is more obvious; If the ratio does not increase, it means that the industrial structure has not been transferred to the tertiary industry, that is, the phenomenon of economic structure being service-oriented is not obvious, and the trend of industrial structure upgrading is not obvious. Therefore, this paper also calculates the ratio of secondary and tertiary industries and uses the calculated ratio results to measure the upgrading of industrial structure.

The process of industrial structure upgrading is influenced by various factors. In addition to environmental regulation, it also includes many other factors, such as the level of economic development, the level of financial market, and the degree of opening to the outside world. In view of the availability of data, this paper selects economic development level, technological innovation and investment as control variables. Based on data availability and variable correlation, the author takes GROSS domestic product (GDP), number of invention patent applications accepted (TI) and total fixed asset investment (IS) as the variables of economic development level, technological innovation level and investment level.

The data used in this study are all from the official website of the National Bureau of Statistics and EPS database, and the relevant data of 12 provinces and municipalities in northern China from 2000 to 2019 are selected (for the convenience of research, the data of Anhui and Jiangsu are selected in this paper). The descriptive statistical results after logarithmic analysis of all variables are shown in Table 1.

Table 1

Variable	Obs	Mean	Std. Dev.	Min	Max
lnTI	240	8.819	1.592	5.69	12.2
lnINU	240	-.117	.457	-.704	1.643
lnER	228	2.742	.922	-.314	4.953
lnIS	216	8.701	1.165	6.307	10.919
lnGDP	240	9.421	.92	7.402	11.509
lnER2	228	8.363	5.102	.008	24.532

4.3 Panel regression model analysis

According to the results of Hausman test for model (1), the fixed effects model should be selected. The regression results of the fixed effects model are shown in Table 2. According to the regression results, the first term regression coefficient of environmental regulation intensity is significantly negative, and the second term regression coefficient is positive, but not significant. It can be seen that environmental regulation intensity has a U-shaped impact on industrial structure optimization. This shows that the process of environmental regulation from zero to continuously enhanced is not conducive to the optimization of industrial structure. This may be because, compared with other regions with higher environmental regulations, the northern region still has a cost advantage to some extent due to the weak environmental regulation intensity. Therefore, industries with high pollution emission intensity will be transferred to the northern region to increase the proportion of polluting industries, which is not conducive to the upgrading and optimization of industrial structure. With the improvement of regional development level, the public is more concerned about environmental quality. When the degree of environmental regulation is increased to a certain degree, the stricter the environmental regulation is, the more beneficial it will be to the optimization of industrial structure. This may be due to the "pollution haven effect" after the intensity of environmental regulation has crossed a certain inflection point. The production links with high pollution and high emission will be transferred to the regions with relatively loose environmental regulations, and the local industrial structure will be optimized and upgraded. Through the test of the positive impact effect of technological innovation, it shows that the innovation compensation effect of technological innovation is relatively obvious to promote the upgrading of industrial structure in northern China, and the result also suggests that the region should pay more attention to the important factor of technological innovation in the process of seeking for development. For other control variables, when the level of economic development increases by 1% at the significance level of 1%, the degree of industrial structure upgrading will increase by 3% accordingly, indicating that the improvement of the overall regional economic level will promote the transformation and upgrading of the regional industrial structure to some extent. Fixed asset investment is also not conducive to industrial upgrading, possibly because the government's actions are sometimes short-sighted. China's fixed assets investment is too much intervention by the government, and the investment is often too inclined or other unreasonable situations, which is not conducive to the upgrading of industrial structure.

Table 2

lnINU	Coef.	St.Err.	t-value	p-value	[95% Conf Interval]	Sig	
lnER	-.222	.089	-2.48	.014	-.398	-.046	**
lnER2	.026	.017	1.59	.114	-.006	.059	
lnTI	.109	.039	2.77	.006	.031	.186	***
lnGDP	.314	.112	2.81	.005	.094	.534	***
lnIS	-.235	.067	-3.51	.001	-.368	-.103	***
Constant	-1.599	.445	-3.59	0	-2.478	-.721	***
Mean dependent var	-0.168		SD dependent var	0.431			
R-squared	0.277		Number of obs	216.000			
F-test	15.274		Prob > F	0.000			

Akaike crit. (AIC) -76.304 Bayesian crit. (BIC) -56.053

*** $p < .01$, ** $p < .05$, * $p < .1$

4.4 Panel threshold model analysis

In this paper, the intensity of environmental regulation was selected as the threshold variable, and the Bootstrap method was used for 300 repeated samples to conduct self-sampling test of the threshold. All of the samples passed the 5% significance test, indicating that there was a double threshold effect of environmental regulation intensity. The threshold estimates and confidence interval estimates are shown in Table 3. According to the results, the double threshold values of environmental regulation intensity are 1.562 and 1.587, and the 95% confidence interval is [1.209,1.566] and [1.510,1.593], respectively.

Table 3

model	Threshold	Lower	Upper
Th-1	1.514	1.229	1.518
Th-21	1.562	1.209	1.566
Th-22	1.587	1.510	1.593

When the environmental regulation intensity is less than 1.562, the environmental regulation intensity is between 1.562 and 1.587, and the environmental regulation intensity is greater than 1.587. The estimation results of the threshold model are shown in Table 4. According to the results, when the intensity of environmental regulation is lower than 1.562, the intensity of environmental regulation will promote the optimization of industrial structure, but the result is not significant. When the intensity of environmental regulation increases between 1.562 and 1.587, the intensity of environmental regulation significantly inhibits the optimization of industrial structure at the 5% level. However, when the intensity of environmental regulation becomes more strict and exceeds 1.587, the inhibitory effect of environmental regulation intensity on industrial structure optimization is obviously weakened and gradually tends to be positive. This shows that the intensity of environmental regulation will have a significant impact on the upgrading of industrial structure, and changes with the intensity. When the intensity of environmental regulation is weak, that is, the regional environmental regulation is in the initial stage, environmental regulation will have a positive impact on the upgrading of industrial structure. However, with the increasing intensity of environmental regulation, this weak positive effect is gradually replaced, and then produces a restraining effect. This effect will be maintained for a long time in the process of industrial structure upgrading in northern China. When the intensity of environmental regulation in this region reaches a certain level, the inhibitory effect is obviously weakened and will gradually transform into a positive promoting effect. Therefore, the northern government departments in formulating and implementing environmental regulation policy, in combination with the practical situation of the local market and industrial development, to select the appropriate environmental regulation, use of environmental regulation on the existing industrial layout stringent environmental constraints to reversed transmission structure optimization and upgrading, get rid of the constraints of industrial structure and development model, the greening of the industrial structure adjustment.

Table 4

lnINU	Coef.	Std.Err.	t	P>t	[95%Conf.	Interval]
lnTI	0.117	0.038	3.050	0.003	0.041	0.192

lnIS	-0.221	0.067	-3.300	0.001	-0.354	-0.089	
lnGDP	0.285	0.111	2.560	0.011	0.066	0.505	
<i>_cat#c.lnER</i>							
0	0.004	0.064	0.070	0.945	-0.122	0.130	
1	-0.296	0.140	-2.110	0.036	-0.573	-0.019	
2	-0.072	0.033	-2.170	0.031	-0.137	-0.006	
<i>_cons</i>	-1.721	0.437	-3.940	0.000	-2.583	-0.859	
<i>sigma_u</i>		0.291					
<i>sigma_e</i>		0.204					
<i>rho</i>	0.670	(fraction	of	variance	due	to	<i>u_i</i>)

V. Conclusion and suggestion

5.1 Improve environmental regulation policies according to local conditions

Perfect environmental regulation policy is the system guarantee to realize the coordinated development of economy and environment. First, the government should be the development priority zones division, the implementation of the sustainable development of environmental protection concept, at the same time reference each place the maximum carrying capacity, resources and environment according to the priority and key, a small, banned the four development pattern to carry on the reasonable division, on the premise of guarantee environment adequately protect give full play to the region's growth potential^[33]. Secondly, through overall planning, the advantages of each region are comprehensively extracted and the disadvantages of each region are complementary. Finally, establish and improve the means of environmental regulation compensation mechanism, through the government participation to increase funding and other measures to reduce the local environmental regulation pressure.

5.2 Establish and improve market mechanisms to promote green development

In the future, the government of northern China should put the rationalization of industrial structure in a more prominent position. From the perspective of the supply side, the allocation of factors among industries should be optimized to avoid the convergence of industrial structure. At the same time, combining with their own resource endowment, promote industrial transfer and acceptance, and strengthen the weak industrial links. We will vigorously develop higher education and vocational education, improve the quality of the labor force, and promote the coupling of the supply side and the demand side of the labor market. We will establish a fair, just, unified and open competitive market system, remove regional barriers, and promote the free flow of industrial factors. Promote the establishment of an environmental regulation system in which market incentives play a decisive role, improve the trading system of pollutant emission rights, and promote the construction of a market price formation mechanism^[34]; We will improve the green pricing mechanism and implement policies on electricity and water prices for environmental protection enterprises. Improve the green tax mechanism, and implement positive incentive measures of tax reduction and exemption for enterprises with high green production level; We will improve the mechanism for introducing long-term funds from social capital and encourage enterprises to actively participate in the development of green industries^[35].

5.3 Improve the efficiency of environmental law enforcement and improve the construction of laws and

regulations

Environmental regulation can have a very obvious positive impact on economic growth, so further improving the efficiency of environmental law enforcement is one of the key means of reform. The government should deepen the reform of the rule of law, strengthen the supervision and inspection of enterprises, the government and civil servants, further improve the implementation effect of laws compatible with environmental protection, ensure the smooth implementation of environmental regulation mechanisms, and optimize the unified allocation of environmental resources. At the same time, the government should implement scientific legislation, strictly enforce the law, and severely crack down on illegal acts of environmental pollution, so as to establish a sound legal system to coordinate environmental and economic development.

5.4 Strengthen the construction of technological innovation capacity to drive the transformation and upgrading of industrial structure

In northern China's technology innovation level has obvious regional differences, the low level of technology innovation of region, the first thing to strengthen enterprise technology innovation main body status, through the fiscal and taxation policy support to enterprise's technology innovation, continuously strengthen technical innovation service system construction, push forward construction of the incubator and public research and development platform; We will strengthen support for science, technology and finance. Create a good atmosphere for technological innovation, constantly improve the level of technological innovation, create a good atmosphere for technological innovation. Secondly, improving the innovation-driven capacity is conducive to the transformation of the northern region's industrial structure to technology-intensive. The northern region should increase the investment in scientific research and technology, accelerate the organic combination of existing industries and information technology, enhance the level of technological innovation in various fields, promote the vigorous development of emerging industries, and inject new vitality into the economic development in the northern region of China.

5.5 Actively improve the consumption structure and investment structure

We should strengthen the concept of environmental protection of residents, advocate green consumption, and give appropriate subsidies to enterprises based on transformation and technology research and development, so as to ease the pain brought by environmental regulations to enterprises, improve the consumption structure and investment structure, and promote the upgrading of industrial structure.

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