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The Regionally Heterogeneous Impact of China's Environmental Regulation on the Transformation and Upgrading of Its Industrial Structure

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Abstract: Approaches to promoting the transformation and upgrading of China's industrial structure represent an important issue in high-quality economic development. The upgrading of industrial structures is beneficial not only for environmental protection but also for sustainable economic development. This article first tests the correlation between environmental regulation and the transformation and upgrading of industrial structure through an impulse response function and then uses provincial panel data to analyze the regionally heterogeneous impact of environmental regulation on industrial structure upgrading. The research results indicate that: (1) the presented impulse response graph indicates that environmental regulation shocks have a significant impact on the rationalization and upgrading of industrial structure, and subsequent variance decomposition indicates that environmental regulation has a strong explanatory power on the transformation and upgrading of industrial structure; (2) overall, strengthening the level of environmental regulation is not conducive to the rationalization of industrial structure (RIS), but a strong level of environmental regulation can significantly promote the upgrading of industrial structure (UIS); and (3) at the regional level, there is significant regional heterogeneity in the impact of environmental regulation on the transformation and upgrading of industrial structure in different regions. Environmental regulation can promote UIS in China's eastern and western regions, but it is not conducive to RIS. Environmental regulation can promote RIS in China's central region, but it has a negative impact on UIS. The conclusion of this article provides inspiration for sustainable economic development.

Keywords: environmental regulation; industrial structure; regional heterogeneity

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1. Introduction

After more than 40 years of sustained high-speed growth, the Chinese economy has entered a stage of high-quality growth. In this new era, accelerating the transformation and upgrading of industrial structure is an important measure in promoting high-quality economic growth. In fact, the process of industrial structure transformation and upgrading is the core driving force of China's economic growth and is related to whether China can overcome the middle-income trap. However, the upgrading of China's industrial structure faces dual constraints of "high pollution" and "structural adjustment". On the one hand, the long-term development model of "high energy consumption" and "high emissions" has brought about excessive resource consumption and serious degradation of the ecological environment. On the other hand, there are problems in China's industrial structure, such as weak independent research and development capabilities and homogenization of regional industrial structures, leading to oversupply in middle and low-end sectors. In this situation, the analysis of approaches to balancing the transformation and upgrading of China's industrial structure with environmental pollution and the promotion of high-quality economic development are of great practical significance.

Problems related to environmental pollution force China's government to actively intervene by means of environmental regulation, in order to solve the dual dilemma of "high pollution" and "structural adjustment", and achieve sustainable economic development. However, in the face of increasingly strict environmental regulations formulated by the central government, local governments at all levels may relax the standards associated with environmental regulation policy implementation or even choose not to implement them in an attempt to avoid decreases in their own fiscal revenue, leading to a trend of "bottom-up competition" in environmental regulation. Due to the severe environmental constraints and structural adjustment difficulties faced by China's industrial development, as well as the differences in resource endowments and varying levels of development in different regions, a deep analysis of the regionally heterogeneous impact of environmental regulation on the transformation and upgrading of China's industrial structure is of great significance in enhancing local environmental protection momentum and promoting high-quality industrial development.

In this article, the correlation between environmental regulation and industrial structure transformation and upgrading is tested by utilizing a panel vector autoregressive model. The research results show that environmental regulation has a significant impact on industrial structure transformation and upgrading. Specifically, the impact of environmental regulation shocks on the rationalization of industrial structure is significant, reaching 37.75%, and the contribution of variance of environmental regulation shocks to the upgrading of industrial structure is 23.65%. We further utilize dynamic panel models to analyze the regionally heterogeneous impact of China's environmental regulation on the advancement of its industrial structure upgrading. The test results indicate that environmental regulations are not conducive to the rationalization of industrial structure but are conducive to its upgrading. At the same time, the impact of environmental regulation on industrial structure upgrading shows obvious characteristics of regional heterogeneity.

2. Literature Review

The "three highs and one low" caused by the traditional development model poses great challenges to the high-quality growth of the Chinese economy, and industrial structural adjustment has become an inevitable trend of development. Therefore, approaches to promoting the transformation and upgrading of China's industrial structure have come to represent an important issue in high-quality economic development [1,2]. The famous Porter hypothesis points out that appropriate environmental regulations can stimulate technological innovation in enterprises, offset the production costs that environmental regulations may bring by increasing productivity, and achieve the dual goals of industrial upgrading and environmental improvement [3–5]. Numerous publications in the literature have analyzed whether the Porter hypothesis is established in China, and several studies have verified the significant role of environmental regulation in upgrading industrial structure in China [6,7]. However, it is worth noting that, due to China's vast territory and practical constraints such as differentiated resource endowments and uneven development levels in various regions, one cannot help but consider whether the above factors will lead to a heterogeneous impact of environmental regulation on industrial structure upgrading in China. Therefore, the focus of this article is on whether there are characteristics of heterogeneity in the impact of China's environmental regulation on the upgrading of its industrial structure.

Although most studies support the Porter hypothesis and verify the positive role of environmental regulation in industrial structure upgrading in China, it cannot be ignored that there are also numerous studies based on the perspective of economic development, and empirical results do not support the Porter hypothesis [8,9]. The main theoretical support for this type of research is the pollution shelter hypothesis. This theory suggests that developing countries, when prioritizing economic development, tend to overlook environmental protection to some extent. Therefore, developing countries with abundant environmental resources receive highly polluting industries from developed countries and become clusters of polluting industries. Wang et al. (2019) used Chinese enterprise data from 2011 to 2015 to empirically test the impact of environmental regulation on the location selection of polluting enterprises. The empirical results proved that environmental regulations do indeed affect the location selection of polluting industry enterprises [10]. Dou and Han (2019) studied the transfer of polluting industries in China from the perspective of industrial mobility and conducted empirical analysis based on provincial-level data from 2000 to 2015. The research results showed that polluting industries with strong liquidity tend to shift directly to areas with loose regulation, ultimately leading to the outward transfer of polluting industries, thus verifying the pollution shelter hypothesis [11].

However, some research findings do not support the pollution shelter hypothesis. Marconi (2012) used the changes in bilateral trade structure between China and 14 EU countries between 1996 and 2006 as a measure of comparative advantage. The research found that after controlling for some variables, no evidence was found to suggest that pollution shelter had an impact on the bilateral trade patterns between Europe and China [12]. Zheng and Shi (2017) used panel data from 30 provinces in China from 2004 to 2013 to empirically test whether different environmental regulations affect the domestic transfer of polluting industries in China. The empirical results indicate that differentiated environmental regulations can lead to the geographical transfer of polluting industries, and the effectiveness of the pollution shelter hypothesis is closely related to the type of environmental policy. Specifically, policies such as pollution discharge fees and environmental complaints encourage industrial transfer, while environmental policies such as laws and regulations prevent the transfer of polluting industries to other regions [13]. There are many reasons for the diversity of research conclusions, including differences in empirical methods [14–16] and differences in research perspectives [17–19], leading to a lack of consistent research conclusions.

On the basis of a proposed impact of environmental regulation on industrial structure upgrading—one that is effectively reversed—relevant research further studies the dynamic and nonlinear effects of its effects [20–23]. Chen et al. (2019) used the PSTR model to analyze the dynamic correlation mechanism between China's environmental regulation policies and industrial structure upgrading, and the research results found that there was a significant nonlinear characteristic between the two. The research results indicate that the relationship between China's environmental regulation policies and industrial structure upgrading is dynamic, and the dynamic nature of policies' effects cannot be ignored when formulating environmental policies [24]. Chen et al. (2022) empirically analyzed the impact of informal environmental regulations on industrial structure upgrading based on provincial-level data in China from 2000 to 2016. The research results indicate that informal environmental regulations have a significant positive impact on industrial structure upgrading and that there is also a significant threshold effect [25]. The research conclusion greatly enriches the utility of policies in stimulating industrial structure upgrading. In addition, there is also a wealth of works in the literature exploring other factors that affect industrial structure upgrading, greatly expanding the research boundaries of industrial economics [26–30].

Regarding the above literature review, it can be said that there has been extensive research on environmental regulation and industrial structure upgrading, but there is little research on the regionally heterogeneous impact of China's environmental regulation on industrial structure upgrading based on the fact that the country has a vast territory and different natural endowments in different regions. The regionally heterogeneous impact of environmental regulation refers to the inconsistent effects resulting from the implementation of identical environmental regulation policies in different regions on the upgrading of their respective industrial structures. An important implication of this impact is that the Chinese government should not adopt a one-size-fits-all mode when formulating environmental policies. Based on this, this article re-examines the effectiveness and heterogeneity of environmental regulation in China in order to provide new empirical evidence for policy authorities to formulate environmental regulation policies, constituting an important marginal contribution of this article.

Ensuring sustainable development is an important goal pursued by policy authorities, and the transformation and upgrading of industrial structure is necessary to achieve sustainable development. Therefore, it is particularly important to examine the factors promoting industrial upgrading. There have been numerous studies exploring the impact of tradition [31–33], but due to the constraints of insufficient policy space, the effectiveness of these tools has been greatly reduced. What impact will environmental policies, as effective supplements to traditional tools, have on industrial structure? Will they promote the upgrading of industrial structure and ensure sustainable economic development? This type of issue deserves in-depth research, with the aim of injecting new policy vitality into sustainable development. Therefore, this article examines the impact of environmental policies on the transformation and upgrading of industrial structure under the goal of sustainable development, in order to provide solid empirical evidence toward optimizing economic structure and achieving sustainable development.

3. Empirical Analysis of Environmental Regulation and Industrial Structure

3.1. Measurement of Industrial Structure Upgrading Indicators

China has a vast territory and significant differences in economic development across different regions. Overall, the transformation and upgrading of China's industrial structure have garnered significant achievements in recent years. However, from a regional perspective, there are significant differences in the effects of environmental regulation on industrial structure upgrading in different regions. The eastern, central, and western regions of China face different environmental pressures and industrial structure transformation and upgrading. The green adjustment of industrial structures represents an important approach to addressing the deterioration of the ecological environment and stable economic growth. From a dynamic perspective, the transformation and upgrading of industrial structure represent the process of achieving the upgrading and rationalization of industrial structure. This article mainly measures the degree of industrial structure transformation and upgrading across two dimensions: rationalization of industrial structure (RIS) and upgrading of industrial structure (UIS).

Due to different understandings of the connotations of RIS in the academic community, the indicators selected are also different in their understanding. In fact, there is still no unified standard in the academic community for RIS. RIS not only reflects the ability of inter-industry structural transformation but also reflects the degree of effective resource utilization and is a measure of the coordination between factor input and output structure [34]. In terms of this degree of coordination, researchers generally use the degree of structural deviation to measure RIS, but this indicator considers the economic status of China's three main industries to be equal, ignoring the importance of different industries in the economy [35]. To measure the level of RIS in various regions, this article selects the Thiel index, which takes into account the deviation between the output and employment structures of each industry as well as the differences in economic status of each industry [36]. The specific calculation formula is as follows:

$$TL = \sum_{m=1}^{3} \left(\frac{Y_m}{Y}\right) \ln\left(\frac{Y_m}{L_m} / \frac{Y}{L}\right) \quad m = 1, 2, 3 \tag{1}$$

In the above equation, TL represents the Theil index, Y represents the gross domestic product of each region, L represents the total employment of each region, Y_m represents the output value of the three major industries in each region, L_m represents the employment of the three major industries, and m represents the three major industries themselves. The Thiel index can better reflect the output and employment structures of China's three major industries. According to the definition, when $TL = 0$, the economy is in an equilibrium state, with coordinated development among various sectors of the national economy and a high degree of RIS. The larger the TL value, the easier it is for economic development to deviate from equilibrium, and the industrial structure is unreasonable. It is necessary to allocate production factors reasonably to promote coordinated industrial development.

UIS is an important component of industrial structure upgrading, reflecting the dynamic evolution process of industrial structure from low level to high level at different economic development levels and stages. According to Clark's law, the literature defines UIS as the increase in the proportion of non-agricultural output value, but this traditional measurement method that only focuses on increases in the contribution of industrial output cannot accurately reflect the essence of industrial structure evolution. UIS involves the evolution of the proportional relationship between industries and the improvement of labor productivity. A larger share of industries with higher labor productivity in an economy indicates a higher level of UIS. This article refers to the approach of Liu Wei et al. (2008) [37] and defines UIS as the product of the proportional relationship between industries and industrial labor productivity. The specific calculation formula is as follows:

$$ES = \sum_{m=1}^{3} \frac{Y_m}{Y} \times LP_m,\ m = 1, 2, 3 \tag{2}$$

In the formula, ES represents UIS, Y is as explained above, and LP_m represents the labor productivity of China's three major industries in each region, obtained by using the ratio of the added value of the regional industry to the number of employed people, measured at the end of the same period. If the ES value is on the rise, it means that the overall development level of the industry is constantly improving and the associated industrial structure is in the process of upgrading.

3.2. Impulse Response Analysis

In order to explore the correlation between environmental regulation and industrial structure transformation and upgrading, this section establishes a panel vector autoregressive model (referred to as PVAR). The PVAR model does not need to set causal relationships between variables in advance but instead treats all variables in the system as endogenous variables, analyzing the impact of each variable and its lagged variables on other variables in the model. The general expression of the model is as follows:

$$\begin{array}{l} Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \cdots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + u_i + e_{it} \\ i \in \{1, 2, \ldots N\}, t \in \{1, 2, \ldots, T_i\} \end{array} \tag{3}$$

In the expression above, Y_{it} is a $(1 \times k)$-dimensional vector, u_i is the individual fixed effect of the cross section, e_{it} is the error perturbation term, and matrices $A_1, A_2, \ldots A_{p-1}, A_p$ are coefficients to be estimated. This section selects 29 provinces (cities and regions) in China (excluding Xizang, Qinghai, Hong Kong, Macao, and Taiwan due to lack of data) as indicators to establish PVAR models; data from 2004 to 2021 are considered.

The PVAR model requires variables to have stationarity, and non-stationary data lead to the phenomenon of pseudo-regression. This article first conducts a stationarity test on panel data. In order to ensure the effectiveness of the unit root of the panel, this article adopts three methods, namely the LLC test, the IPS test, and the ADF–Fisher test, to test the stationarity of the panel data, in order to overcome the errors that may arise from a single test method. This study used the above three methods to conduct unit root tests on RIS, UIS, and environmental regulation variables; the results are shown in Table 1. All variables significantly rejected the null hypothesis containing unit roots at the 1% level, thus indicating that the data are stationary. Here, we assert that the figures and tables presented in this paper are calculated by the authors and there is no possibility of copying the results of others. To avoid repetition, we do not elaborate further on each figure or table in the following text.

Table 1. Unit root test results.

Variable	LLC t-Value	Ips t-Bar	ADF–Fisher			
			P	Z	L	Pm
TL	−13.5874 ***	−13.3130 ***	97.6505 ***	−6.7029 ***	−7.5516 ***	10.6305 ***
ES	−13.0592 ***	−13.5865 ***	118.9495 ***	−7.8894 ***	−9.4195 ***	13.7084 ***
ER	−10.7883 ***	−11.4245 ***	49.9767 ***	−2.7543 ***	−2.9287 ***	3.7494 ***

Note: *** indicates rejection of the original hypothesis of the existence of unit roots at a significance level of 1%.

According to the results in Table 1, it can be seen that environmental regulation, RIS, and UIS form a stable panel sequence. An additional PVAR model is constructed to analyze the relationship between environmental regulation and industrial structure transformation and upgrading. The model settings are as follows:

$$\begin{bmatrix} TL_{it} \\ ES_{it} \\ ER_{it} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \end{bmatrix} + \sum_{j=1}^{p} \begin{bmatrix} a_{11}^{j} & a_{12}^{j} & a_{13}^{j} \\ a_{21}^{j} & a_{22}^{j} & a_{23}^{j} \\ a_{31}^{j} & a_{32}^{j} & a_{33}^{j} \end{bmatrix} \begin{bmatrix} TL_{it-j} \\ ES_{it-j} \\ ER_{it-j} \end{bmatrix} + \begin{bmatrix} u_{1i} \\ u_{2i} \\ u_{3i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \end{bmatrix} \quad (4)$$

The subscripts i and t represent each province, city, and observation year, respectively. p represents the lag order of the model, u_i represents unobservable fixed effects, and ε_{it} represents the error perturbation term. The PVAR model must determine the optimal lag order, which is determined according to AIC, BIC, and HQIC. The results shown in Table 2 consistently indicate that the optimal lag order of the model is 2, that is, p in the model is equal to 2.

Table 2. PVAR lag order test results.

Lag Order	AIC	BIC	HQIC
Lagging one period	109.4901	10.5941	69.8609
Lagging two periods	71.1443 *	5.2110 *	44.7222 *
Lagging three periods	73.8405	40.8738	60.6294

Note: * represents the lag order selected based on information criteria.

This article uses the generalized moment estimation method (GMM) to estimate the model. After 500 Monte Carlo simulations, a consistent estimation of the PVAR model is obtained, as shown in Table 3.

Table 3. GMM estimation results of the model.

Variables	*TL*		*ES*		*ER*	
TL (−1)	0.2611 **	(2.41)	−0.2353 *	(−1.68)	0.8473 ***	(3.87)
ES (−1)	−0.0799 ***	(−4.02)	0.1609 ***	(3.01)	−0.2330 ***	(−4.00)
ER (−1)	−0.0551 **	(−2.14)	0.2960 ***	(4.36)	−0.1333	(−1.32)
TL (−2)	0.5713 ***	(7.72)	−0.6762 ***	(−3.29)	1.6557 ***	(6.68)
ES (−2)	−0.0040	(−0.23)	−0.0806	(−1.63)	0.1119 *	(1.83)
ER (−2)	−0.1007 ***	(−3.23)	−1.1919 *	(−1.18)	−0.5436 ***	(−4.81)

Note: The values in parentheses are z values, and ***, **, and * represent significant values at 1%, 5%, and 10% confidence levels, respectively.

In order to more intuitively describe the correlation between variables, an impulse response function (IRF) is selected for analysis. An impulse response function can describe the response of an endogenous variable to the shock brought by an error term. Figure 1 shows impulse response curves depicting the responses of *TL* and *ES* to environmental regulation (*ER*). The solid black line in the middle represents the response function curve, and the gray area represents the confidence interval of twice the standard deviation.

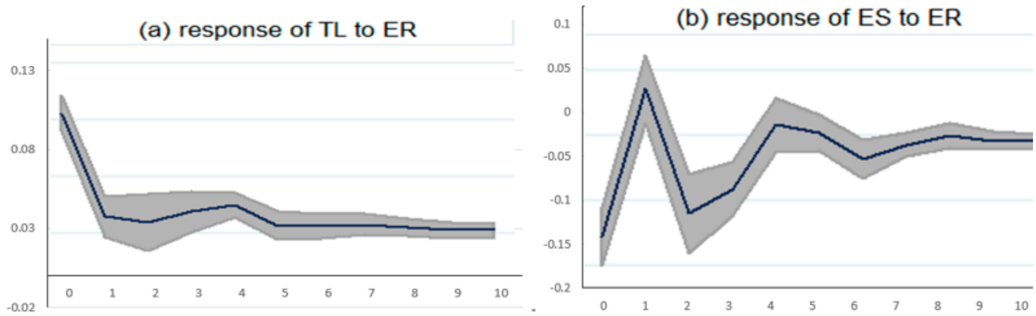

Figure 1. Impulse response curves.

From the impulse response estimation results in Figure 1, it can be observed that there is a significant lag in the impact of environmental regulation on the transformation and upgrading of China's industrial structure. Firstly, looking at (a) in Figure 1, if *ER* is subjected to a standard deviation shock in a given period, *TL* has a strong response in the same period, with the positive response value reaching its maximum. Subsequently, the degree of impact decreases significantly, with small fluctuations and a gradual decrease in periods 3–5. At the end of the period, it gradually weakens, almost to zero. Next, we turn to (b) in Figure 1. In a given period, when *ER* is subjected to a standard deviation shock, *ES* has a strong response in the same period, with the negative response reaching its maximum and then showing an upward trend. It reaches its peak in the first period and then drops back to a negative value in the second period. The impact of the shock gradually decreases in periods 3–5 and converges to 0 around the 10th period. In summary, environmental regulation shocks have an impact on both RIS and UIS. Environmental regulation shocks have a positive impact on RIS, while their impact on UIS is relatively complex, initially having a negative impact followed by a positive impact and, in the long run, the degree of impact decreases and stabilizes.

Next, the variance decomposition method is used to obtain the degree of impact of environmental regulation shocks on industrial structure transformation and upgrading in different VAR equations for the sake of accurate characterization and examination. Table 4 lists the variance decomposition results for the first, fifth, and tenth prediction periods.

Table 4. Analysis of variance results.

Variables	Periods	*ER*	*TL*	*ES*
	1	1.0000	0.0000	0.0000
ER	5	0.7879	0.1832	0.0289
	10	0.7720	0.1926	0.0354
	1	0.4863	0.5137	0.0000
TL	5	0.3854	0.5770	0.0376
	10	0.3775	0.5832	0.0393
	1	0.1401	0.0298	0.8301
ES	5	0.2337	0.0780	0.6883
	10	0.2365	0.0863	0.6772

Note: The results were obtained through Monte Carlo simulation 200 times.

The following is shown in Table 4: (1) environmental regulation shocks are significantly influenced by themselves, with a variance contribution of 77.2% to their own fluctuations. UIS and RIS are also sources of environmental regulation fluctuations, but the impact is relatively small: 19.26% and 3.54%, respectively; (2) RIS is mainly influenced by its own impact, while the impact of environmental regulation has a significant contribution to RIS, reaching 37.75%, indicating that RIS is highly impacted by environmental regulation; and (3) the variance contribution of environmental regulation shocks to UIS reached 23.65%, and the variance contribution rate of RIS shocks to UIS was 8.63%. This also proves that RIS is a prerequisite for achieving UIS [38].

4. Methodology

4.1. Model Settings

To test the impact of environmental regulation on the transformation and upgrading of China's industrial structure, the following static panel data model is first established:

$$\begin{aligned} TL_{it} &= \alpha_0 + \alpha_1 ER_{it} + \alpha_2 Pgdp_{it} \\ &+ \alpha_3 Urban_{it} + \alpha_4 Fiscal_{it} + \alpha_5 Open_{it} + \alpha_6 Edu_{it} + \mu_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} ES_{it} &= \beta_0 + \beta_1 ER_{it} + \beta_2 Pgdp_{it} \\ &+ \beta_3 Urban_{it} + \beta_4 Fiscal_{it} + \beta_5 Open_{it} + \beta_6 Edu_{it} + \mu_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (6)$$

In the above expressions, the subscripts $i = 1, 2, 3 \ldots 29$ represent various provinces and cities in China, $t = 1, 2, 3 \ldots$ represents the period, and TL_{it}, ES_{it}, ER_{it} $Pgdp_{it}$, $Urban_{it}$, $Fiscal_{it}$, $Open_{it}$, and Edu_{it} represent the RIS, UIS, environmental regulation, economic development, urbanization process, fiscal freedom, openness to the outside world, and human capital level of the *i-th* province's *t-th* period; μ_i is the individual effect, η_t is the time effect, and ε_{it} is a random error term.

For static models (5) and (6), fixed-effects models or random-effects models are usually chosen to obtain estimation results. Compared to fixed-effects models, random-effects models are relatively more effective but require that exogenous variables are not related to individual effects. Fixed-effects models do not require exogenous variables or individual fixed effects but they consume more degrees of freedom, and each fixed-effects model has its own advantages and disadvantages when used. This article uses the Hausman test method to determine which estimation method to choose. Meanwhile, due to the frequent issues of heteroscedasticity and autocorrelation encountered in panel data model estimation, this paper tests this and further uses the FGLS estimation method to estimate the model.

It is worth noting that models (5) and (6) implicitly assume that RIS and UIS undergo immediate changes with changes in control variables: there is no lag effect between the two. In fact, any economic factor change itself has a certain inertia, and early results often have an impact on the later period [39]. The adjustment of many factors that affect the transformation and upgrading of industrial structure, such as energy structure, consumption structure, and urbanization development level, is long-term and slow. The sensitivity of industrial structure transformation and upgrading to these macro-factors also determines the lag associated with industrial structure transformation and upgrading. At the same time, the transformation and upgrading of industrial structure are a sublation of the original industrial structure, which, to some extent, represents selective retention and development. The current situation of RIS and UIS is the result of preserving and developing earlier versions of the industrial structure. Early stages of RIS and UIS have lagging effects on later stages of RIS and UIS. Based on this, this article introduces the following dynamic panel model:

$$\begin{aligned} TL_{it} &= \alpha_0 + \lambda_0 TL_{i(t-1)} + \alpha_1 ER_{it} + \alpha_2 Pgdp_{it} \\ &+ \alpha_3 Urban_{it} + \alpha_4 Fiscal_{it} + \alpha_5 Open_{it} + \alpha_6 Edu_{it} + \mu_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (7)$$

$$\begin{aligned} ES_{it} &= \beta_0 + \lambda_1 ES_{i(t-1)} + \beta_1 ER_{it} + \beta_2 Pgdp_{it} \\ &+ \beta_3 Urban_{it} + \beta_4 Fiscal_{it} + \beta_5 Open_{it} + \beta_6 Edu_{it} + \mu_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (8)$$

In the above expressions, $TL_{i(t-1)}$ is the first-order lag term of TL_{it}, $ES_{i(t-1)}$ is the first-order lag term of ES_{it}, and the adjustment coefficient λ represents the impact of the rationalization and upgrading of the previous industrial structure on the current period.

It is worth emphasizing that for dynamic panel models (7) and (8), due to endogeneity issues, both random- and fixed-effects estimators are biased, so instrumental variables are needed for estimation. The instrumental variable method requires the selected instrumental variable to be related to the variable it is replacing and independent of the random error term. In fact, due to the lack of uniqueness in the selection of instrumental variables and the unobservability of random error terms, it is difficult to find suitable instrumental variables to estimate the model.

In response to this issue, Arellano and Bond (1991) [40] proposed the differential generalized moment estimation method (Difference GMM), which first performs a first-order difference on the estimation equation and then uses the lag value of the explanatory variable as the instrumental variable. However, research has shown that there is a weak instrumental variable problem in differential generalized moment estimation, resulting in estimation bias. To address this issue, Blundell and Bond (1998) [41] proposed the system generalized moment estimation method. System generalized moment estimation estimates the difference equation and the level equation as a system. Compared to differential generalized moment estimation, system generalized moment estimation is more effective. This article uses system generalized moment estimation to estimate dynamic models (7) and (8).

4.2. Variables and Data

Explanatory variable: The explanatory variable of this article is the level of industrial structure upgrading, mainly measured across two dimensions: RIS and UIS. Please refer to the above text for the specific calculation method.

Core explanatory variable: The core explanatory variable of this article is the level of environmental regulation, and there are various methods proposed in existing publications within in literature related to the measurement of environmental regulation variables. This article adopts the comprehensive index method to construct environmental regulatory indicators. The specific approach is to select four individual indicators, namely sulfur dioxide removal rate, industrial smoke, dust removal rate, and comprehensive utilization rate of industrial solid waste, and weight them to obtain environmental regulatory indicators.

Control variables: Referring to the work of Jin and Shen (2018) [42], the following variables were introduced as control variables: economic development level ($Pgdp$), urbanization process ($Urban$), fiscal freedom ($Fiscal$), openness to the outside world ($Open$), and human capital level (Edu). The selection and calculation method of control variables in this article are shown in Table 5.

Table 5. Control variables and calculation methods.

Variables	Calculation Methods
$Pgdp$	Per capita gross regional product
$Urban$	Ratio of urban population to total population at the end of the year in the region
$Fiscal$	Ratio of government public fiscal revenue to fiscal expenditure
$Open$	Ratio of foreign direct investment stock to regional GDP
Edu	Per capita education years for population aged 6 and above

This paper uses panel data from 29 provinces and cities in China from 2004 to 2021 (excluding Xizang, Qinghai, Hong Kong, Macao, and Taiwan due to lack of data) to study the impact of China's environmental regulation implementation on the transformation and upgrading of its industrial structure. The required raw data were obtained from the China Environmental Yearbook, the China Industrial Statistical Yearbook, the China Economic Network Statistical Database, and the China Statistical Yearbook. The price index indicators mentioned in this article have been adjusted to constant prices based on the year 2004, and the descriptive statistics of the variables are shown in Table 6.

Table 6. Statistical description of variables.

Variables	Mean	SD	Min	Max
TL	0.2484	0.1534	0.0161	0.8771
ES	0.7660	0.5090	0.0939	2.8188
ER	0.0041	0.0034	0.0004	0.0285
Pgdp	9.9567	0.5686	8.3703	11.1634
Urban	0.3948	0.1725	0.1576	0.9032
Fiscal	0.5317	0.1872	0.2306	0.9509
Open	1.9793	2.1058	0.2478	14.0070
Edu	8.6315	0.9672	6.3778	12.0807

5. Empirical Analysis

In order to investigate whether there is substantial multicollinearity in the econometric model, this article uses a stepwise regression method to estimate the dynamic panel models (7) and (8). At the same time, the system generalized moment estimation method is used to regress the dynamic panel to solve the endogeneity problem in the model, and the *Sargan test* and the *Arellano Bond test* are used to identify the effectiveness of instrumental variables and the rationality of model settings. Among them, the *Sargan test* is used to test whether there is an overidentification problem, that is, to test whether all instrumental variables are valid. The original assumption was that all instrumental variables are valid. The *Arellano Bond test* is divided into two types: AR (1) and AR (2), which are used to test whether the disturbance term has first-order and second-order autocorrelation. The original assumption was that there is no autocorrelation.

5.1. Estimation Results of Environmental Regulation on RIS at the National Level

Full-sample estimation results of the impact of China's environmental regulation on the rationalization of its industrial structure are shown in Table 7. According to the test results in Table 7, the *Sargan test* assumes that the overidentification constraints of each stepwise regression model are valid and that all instrumental variables are valid. The AR (1) statistic rejects the original assumption that the first-order sequence has no autocorrelation, but the AR (2) statistic accepts the original assumption that the second-order sequence has no autocorrelation, indicating that the model setting is reasonable. Next, we analyze the impact of China's environmental regulation on the rationalization of its industrial structure.

The (1) column in Table 7 shows the estimation results of the system without any control variables. The results show that the regression coefficient of the variable *ER* is significantly positive at the 1% level, indicating that environmental regulation has not promoted UIS. From columns (2) to (6), we have gradually introduced control variables such as economic development level, urbanization process, openness to the outside world, human capital level, and fiscal freedom. According to the results, the regression coefficient of the variable *ER* is still very significant, and the fluctuation range of the estimated coefficient is relatively small. On the one hand, this indicates that the various regression models set are not severely affected by multicollinearity issues, and the model settings are reasonable. On the other hand, this indicates that enhancing the intensity of environmental regulation is not conducive to UIS.

In terms of control variables, the estimated coefficient of the variable *Pgdp* is significantly negative at the 1% level, indicating that the higher the level of economic development, the more it can promote RIS. The higher the level of economic development, the more per capita disposable income there is and, thus, the demand for goods becomes more diverse, giving rise to new industries, bringing new economic growth points, and promoting the evolution of industrial structure. The estimated coefficient of the variable *Urban* is significantly positive, indicating that the urbanization process has a negative impact on RIS. A possible reason is that the development of urbanization in China is driven by production factors such as land, capital, and labor, and the total factor productivity is low, resulting in low quality of urbanization development. The urbanization process under the traditional extensive economic growth model is not conducive to RIS. The estimated coefficient of the variable *Open* is significantly negative, indicating that a higher degree of openness to the outside world promotes RIS. The estimated coefficient of variable *Edu* is significantly negative, indicating that the higher the level of human capital, the more favorable it is to suppress the deviation of industrial structure from balanced development. In fact, the quantity, quality, and structure of human capital possessed by a country can determine its ability to adjust its industrial structure. Therefore, it is possible to promote RIS by improving the level of human capital. The estimated coefficient of the variable *Fiscal* is negative but not significant, indicating that the existing degree of fiscal freedom has played a small promoting role in industrial structure adjustment.

Table 7. Estimated results of the impact of environmental regulation on RIS.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
TL (−1)	0.2238 ** (2.20)	0.1698 *** (4.55)	0.1603 *** (3.14)	0.1572 *** (2.73)	0.1509 ** (2.20)	0.1296 *** (3.07)
ER	0.1973 *** (7.94)	0.1298 *** (8.95)	0.1313 *** (13.92)	0.1367 *** (12.03)	0.1274 *** (10.67)	0.1197 *** (8.16)
Pgdp		−0.1474 *** (−19.96)	−0.1649 *** (−14.68)	−0.1481 *** (−6.49)	−0.1278 *** (−4.04)	−0.0870 ** (−2.19)
Urban			0.0724 ** (2.08)	0.2689 *** (3.06)	0.4794 *** (3.07)	0.4122 *** (4.57)
Open				−0.0267 *** (−7.70)	−0.0278 *** (−5.42)	−0.0269 *** (−8.76)
Edu					−0.0612 *** (−4.45)	−0.0550 *** (−3.01)
Fiscal						−0.0831 (−0.81)
Constant	0.0528 (1.24)	1.5800 *** (21.89)	1.7279 *** (14.51)	1.5335 *** (7.43)	1.7838 *** (5.56)	11.4075 *** (3.31)
AR (1)	−2.8703 (0.0041)	−3.1880 (0.0014)	−3.1727 (0.0015)	−3.0742 (0.0021)	−3.0351 (0.0024)	−3.0714 (0.0021)
AR (2)	1.6023 (0.1132)	1.4564 (0.1471)	1.524 (0.1132)	−0.3463 (0.7291)	−1.518 (0.1290)	−1.5172 (0.1221)
Sargan	11.9919	11.9742	11.9568	11.8629	11.8411	10.3314

Note: The values shown in parentheses are z values. The values in parentheses in the second row of AR (1) and AR (2) tests represent the probability of the corresponding statistic, with ***, ** representing significance at confidence levels of 1%, 5%, respectively.

5.2. Estimation Results of Impact of Environmental Regulation on UIS at the National Level

The estimated impact of environmental regulation on UIS is shown in Table 8. From the test results in Table 8, it can be seen that the *Sargan test* cannot reject the null hypothesis, i.e., that the instrumental variable is valid. Therefore, the system generalized moment estimation is valid. At the same time, the AR (1) statistic rejects the original assumption that first-order sequences have no autocorrelation, but the AR (2) statistic accepts the original assumption that second-order sequences have no autocorrelation, indicating that the model setting is reasonable. In addition, the estimation coefficient of the first-order lag term of the dependent variable *ES* in the model is significantly positive, indicating that there is significant inertia in industrial structure adjustment. The setting of the dynamic model in this article is, therefore, reasonable.

The (1) column in Table 8 shows the estimation results without any control variables. The regression coefficient of the variable *ER* is significantly positive at the 1% level, indicating that environmental regulation can promote UIS. From columns (2) to (6), we have gradually introduced control variables such as economic development level, urbanization process, openness to the outside world, human capital level, and fiscal freedom. It can be found that regardless of whether a control variable is added or not, the regression coefficient of the variable *ER* is still very significant. On the one hand, it indicates that the various regression models set are severely affected by multicollinearity issues, and the model settings are reasonable. On the other hand, it indicates that enhancing the intensity of environmental regulation is beneficial for UIS.

Table 8. Estimated results of the impact of environmental regulation on UIS.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
ES (−1)	0.1367 * (1.66)	0.0503 ** (2.32)	0.0305 * (1.85)	0.0371 * (1.76)	0.0278 ** (2.01)	0.0248 ** (2.13)
ER	0.1114 *** (6.12)	0.1630 (6.65)	0.2124 *** (9.44)	0.2099 *** (8.40)	0.2098 *** (8.60)	0.2141 *** (8.26)
Pgdp		0.7959 *** (12.01)	0.4689 *** (6.19)	0.4655 *** (5.22)	0.4934 *** (5.04)	0.4439 *** (2.88)
Urban			1.3916 *** (6.20)	1.5815 *** (5.14)	1.5266 *** (4.19)	1.5517 *** (4.06)
Open				−0.0124 ** (−2.05)	−0.0138 * (−1.92)	−0.0166 (−1.64)
Edu					0.0182 *** (3.24)	0.0125 *** (3.01)
Fiscal						0.0881 (0.48)
Constant	0.6996 (8.16)	−7.2602 (−11.26)	−4.5981 (6.60)	−4.5829 *** (−5.66)	−4.7071 *** (4.58)	−4.3253 *** (−3.08)
AR (1)	−3.0156 (0.0026)	−3.1124 (0.0019)	−3.2081 (0.0013)	−3.1788 (0.0015)	−3.1812 (0.0015)	−3.2001 (0.0014)
AR (2)	−1.1013 (0.3106)	0.3222 (0.7473)	0.4132 (0.6125)	1.2541 (0.4205)	0.5612 (0.4892)	1.4160 (0.1621)
Sargan	11.9253	11.6169	11.6025	11.5830	11.1837	10.8318

Note: Same as Table 7. ***, **, and * represent significant values at 1%, 5%, and 10% confidence levels, respectively.

Among other influencing factors, the higher the level of economic development, the more it can promote UIS. In areas with high levels of economic development, the factor endowment is dominant, and factors such as capital, labor, and management are fully utilized, providing a strong impetus for economic development, which is conducive to the rapid improvement of technology and industrial upgrading. The process of urbanization can significantly promote UIS and drive the upgrading of industrial structure. With the development of urbanization, the process of industrial agglomeration has been accelerated, and professional division of labor and an agglomeration economy have improved the level of production technology, thereby providing a strong driving force for industrial upgrading.

In addition, urban development attracts continuous population agglomeration, accelerating the accumulation of human capital and knowledge spillover, triggering technological innovation and promoting industrial upgrading. A high degree of opening up to the outside world is not conducive to UIS, possibly due to the fact that after a large influx of foreign investment into China, the vast majority enters the manufacturing industry, promoting the development of capital and technology in said industry, while less flows into the service industry. The higher the level of human capital, the more it can promote UIS. Human capital, as a carrier of technological progress, can trigger technological innovation through learning by doing and knowledge spillover, improving technology absorption and research and development efficiency. The accumulation of human capital has positive impacts on technological progress and the improvement of social productivity; therefore, increasing human capital is conducive to UIS. Regional fiscal freedom has a positive effect on UIS, but the results are not very significant.

5.3. Estimation Results of Impact of Environmental Regulation on RIS at the Regional Level

Due to China's vast territory and extremely uneven regional development, there are also significant differences in the environmental regulatory policies formulated by different regions. Due to its geographical advantages the eastern region of China historically achieved industrialization earlier and developed its economy earlier and at a higher level of development. The legal system and environmental policy formulation are relatively complete, and correspondingly, the region faces strong environmental regulation. Due to relatively weak infrastructure and a lack of geographical advantages, the economic development level in the central and western regions of China is relatively low, and there exist industries that sacrifice the environment for the sake of economic growth. Therefore, the introduction of environmental policies in this region was relatively late, and the phenomenon of incomplete implementation of environmental regulatory policies is relatively common. There are significant differences in industrial development among different regions in China, resulting in industrial gradients. Therefore, there is significant regional heterogeneity in the impact of environmental regulation on the transformation and upgrading of industrial structure. In order to avoid biased conclusions, this article further divides the national sample into three major regions, namely eastern, central, and western regions, in order to study the regional heterogeneity of the impact of environmental regulation on the rationalization and elevation of industrial structure in each region.

Table 9 reports the estimated results of the impact of environmental regulation on RIS in the eastern, central, and western regions of China. Among them, columns (1) and (2) represent the estimated results for the eastern region, columns (3) and (4) represent the estimated results for the central region, and columns (5) and (6) represent the estimated results for the western region. According to the estimated results shown in the table, the estimated coefficients of environmental regulation variables in both the eastern and western regions are significantly positive at the 1% level, indicating that the implementation of environmental regulation is not conducive to RIS. The estimated coefficient of environmental regulation variables in the central region is significantly negative, indicating that environmental regulation has promoted RIS. From this, it can be seen that the effect of environmental regulation on RIS varies significantly in different regions of China: the eastern and western regions exhibit inhibitory effects, while the central region exhibits promoting effects.

Table 9. Regional estimation results of the impact of environmental regulation on RIS.

Variables	**Eastern Region**		**Central Region**		**Western Region**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
TL (−1)	0.1966 * (1.68)	0.2947 *** (3.39)	10.0842 * (1.73)	0.0344 * (1.82)	0.1127 * (1.89)	0.1968 ** (2.15)
ER	0.1307 *** (10.00)	0.1591 *** (5.37)	−0.1518 *** (4.93)	−0.0918 ** (2.43)	0.1476 *** (4.78)	0.1625 *** (5.83)
Pgdp		−0.0963 * (−1.83)		−0.0927 ** (−2.14)		−0.6072 *** (−2.68)
Urban		0.2849 *** (2.60)		0.3741 ** (2.47)		0.6799 (1.24)
Open		−0.0142 *** (−4.67)		−0.0695 *** (−2.94)		−0.1963 *** (−5.74)
Edu		−0.0645 ** (−2.59)		−0.0304 *** (3.14)		−0.0329 (0.95)
Fiscal		−0.0987 (−1.01)		0.6542 ** (2.08)		0.6330 ** (2.18)
Constant	0.0377 ** (2.39)	1.4071 *** (4.74)	0.3543 *** (11.88)	0.6781 *** (5.27)	0.2758 *** (4.37)	0.5391 *** (3.28)
AR (1)	−2.5132 (0.0120)	−2.7513 (0.0059)	−2.5395 (0.0111)	−2.1221 (0.0338)	−2.4180 (0.0156)	−2.3444 (0.0191)
AR (2)	−1.5029 (0.1329)	1.5331 (0.1253)	(−1.2381) (0.2157	0.3119 (0.7551)	−0.5741 (0.5659)	−1.5736 (0.1156)
Sargan	11.9795	11.9794	11.9846	9.1148	11.9138	9.4677

Note: Same as Table 7. ***, **, and * represent significant values at 1%, 5%, and 10% confidence levels, respectively.

For a long time, the eastern region has relied on its geographical advantages and policy preferences to achieve rapid economic development. There is no longer a need to sacrifice the environment for economic development. The demand for environmental governance is stronger, and the level of environmental regulation is higher. Pollution-intensive, high-energy-consumption, and low-end backward industries face high environmental cost pressure, shortening the life cycle of enterprises or motivating industries to transfer to areas with more relaxed environmental policies. The friction brought about by industrial changes has increased the cost of factor replacement, which is not conducive to the optimal allocation of resources among industries and inhibits RIS.

Compared with the eastern region of China, the country's central region presents another trend. The central region of China is densely populated, with fertile land and abundant natural resources. Transportation, communication, and energy infrastructure are becoming increasingly perfect, and the market environment, investment environment, and institutional environment have greatly improved. Low labor costs and abundant natural resources attract industrial transfer and production factor flow to the eastern region of China. Compared to local industries, eastern-transfer industries are technologically advanced and have higher production efficiency, which can further strengthen the correlation between industries and promote RIS.

The foundation of the western region of China is weak, economic development in the area historically started relatively late, the region's construction process is slow, and there is a lack of characteristic advantages in leading industries. Low-level repetitive construction leads to the convergence of industrial structure, a low degree of correlation between enterprises, poor collaboration ability, and failure to form a reasonable division of labor. Therefore, the formulation of environmental regulation policies has not effectively achieved coordinated development with the local economy, which is not conducive to RIS.

5.4. Estimation Results of Impact of Environmental Regulation on UIS at the Regional Level

Table 10 reports the estimated results of the impact of environmental regulation on UIS in the eastern, central, and western regions of China. Columns (1) and (2) represent the estimated results for the eastern region, columns (3) and (4) represent the estimated results for the central region, and columns (5) and (6) represent the estimated results for the western region. Furthermore, this article examines the regionally heterogeneous impact of China's environmental regulation on its UIS. According to the estimated results in Table 10, the estimated coefficients of environmental regulation in the eastern and western regions of China are significantly positive at the 1% level, indicating that environmental regulation can significantly drive UIS. The estimated coefficient of environmental regulation in the central region of China is significantly negative, indicating that environmental regulation is not conducive to promoting UIS in the region but rather suppresses UIS.

A possible explanation for this is that the eastern region has experienced an early economic takeoff, rapid economic development, a high degree of marketization, and a strong willingness for enterprises to pursue high profits and defeat competitors. Historically, the government in this region introduced a series of environmental protection policies, regulations, and laws earlier and promoted the sound and healthy operation of institutional mechanisms. The higher intensity of environmental regulation increases the cost of pollution control for polluting enterprises, forcing pollution-intensive industries to migrate to areas with higher levels of environmental regulation tolerance or increasing innovative investment in green and clean technologies to reduce pollution costs. At the same time, with the improvement of environmental regulation intensity, highly polluting enterprises are gradually being phased out, and the remaining enterprises have high market competitiveness and attach more importance to scientific research and innovation capabilities, thereby promoting UIS.

The central region of China is rich in resources and densely populated. In the process of development, there is a high demand for investment attraction and it is easy to fall into the dilemma of pollution shelters. In addition, the central region has weak basic innovation capabilities and high innovation costs, making it easier to seek end-of-life pollution control methods when facing the pressure of tightening environmental protection. The increase in pollution control costs has squeezed the profit space of enterprises, which is not conducive to increasing technological innovation investment, making it difficult to improve associated technological levels, further hindering the green innovation and product upgrading of enterprises. The implementation of environmental regulation is not conducive to promoting UIS in the region.

Table 10. Regional estimation results of the impact of environmental regulation on UIS.

Variables	Eastern Region		Central Region		Western Region	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ES (−1)	0.0196 * (1.78)	0.0216 ** (2.32)	0.3157 ** (2.27)	0.2014 ** (2.43)	0.0866 * (1.75)	0.0486 ** (2.41)
ER	0.2741 *** (12.01)	0.2115 *** (10.21)	−0.5165 *** (−3.08)	−0.5164 *** (3.94)	0.0925 *** (5.16)	0.1996 *** (5.75)
Pgdp		0.0153 ** (2.11)		0.6440 *** (5.41)		0.7521 *** (3.64)
Urban		0.3657 *** (3.43)		0.2154 *** (4.23)		0.5655 (4.21)
Open		0.0203 ** (2.54)		0.1199 *** (3.78)		−0.3389 *** (−7.00)
Edu		0.3486 (8.63)		0.0566 * 78)		0.2128 *** (3.14)
Fiscal		1.6224 *** (6.71)		0.4549 (0.5)		0.7764 * (1.92)
Constant	1.1603 (15.5)	11.2507 *** (3.49)	0.6485 *** (4.00)	5.3939 (7.29)	0.5259 *** (4.23)	2.3049 * (1.76)
AR (1)	−2.2116 (0.0270)	−3.0093 (0.0026)	−1.9567 (0.0504)	−1.8729 (0.0312)	−2.1356 (0.0327)	−3.0223 (0.0025)
AR (2)	−1.5213 (0.1421)	0.7645 (0.4445)	−0.2794 (0.7799)	−0.6972 (0.4857)	−1.4125 (0.1365)	−0.9414 (0.3465)
Sargan	11.7946	6.9449	11.9647	0.8907	11.9505	7.6565

Note: Same as Table 7. ***, **, and * represent significant values at 1%, 5%, and 10% confidence levels, respectively.

The western region of China is at a disadvantage in terms of geographical location, environment, and education. The region's economy started relatively late and developed slowly. For a long time, agriculture and animal husbandry have occupied the main position in its economic development, with low-end core industries and a lack of high-tech industries willing to play a leading role in promoting economic development. In order to aid in the economic development of the western region, the Western Development Strategy proposed in 2000 aims to improve the economic and social development level of the western region of China. The release of policy dividends has gradually promoted the coordination of economic development with population, resources, and the environment in the western region, promoting the improvement of its ecological environment, business environment, and innovation environment. Environmental regulation can stimulate the innovation compensation effect in the region and ultimately promote its UIS.

5.5. Robust Test

In order to verify the robustness of the above findings on the impact of China's environmental regulation on the transformation and upgrading of industrial structure, the ratio of pollution discharge fee income to the industrial added value in each region was further used as a substitute to regress the model. The results of robustness regression are shown in Table 11. To save space, Table 11 does not provide regression results for the control variables. Compared with the above regression results, the size of the coefficient of environmental regulatory variables has changed, but the significance and direction have not changed, which better proves the robustness of the above research conclusions.

Table 11. Robustness test results.

Variables	Eastern Region		Central Region		Western Region	
	TL	*ES*	*TL*	*ES*	*TL*	*ES*
ES (−1)/*TL* (−1)	0.3236 *** (3.41)	0.0275 ** (2.47)	0.0416 ** (2.36)	0.1843 ** (2.52)	0.1853 ** (2.24)	0.0501 ** (2.38)
ER	0.1732 *** (4.52)	0.2538 *** (7.33)	−0.0724 ** (2.18)	−0.4053 *** (3.49)	0.1431 *** (4.13)	0.2163 *** (6.05)
Constant	1.6202 *** (4.94)	9.1532 *** (4.16)	0.7262 *** (3.71)	3.1634 *** (5.09)	1.2644 *** (3.53)	2.1532 *** (4.82)
AR (1)	−2.5117 (0.0048)	−3.0184 (0.0032)	−2.2645 (0.0247)	−1.6562 (0.0402)	−2.1043 (0.0238)	−3.1349 (0.0036)
AR (2)	1.6216 (0.1308)	0.5835 (0.3275)	0.3536 (0.6211)	−0.5874 (0.4163)	−1.4483 (0.1742)	−0.7264 (0.3537)
Sargan	10.8592	6.2446	8.4262	8.9173	8..2 167	7.3174

Note: Same as Table 7.

6. Conclusions and Policy Recommendations

Realizing sustainable economic development is an important goal pursued by policy authorities, and the transformation and upgrading of industrial structure constitute a necessary means to achieving sustainable development. Therefore, it is particularly important to examine those factors promoting industrial upgrading. Previous research findings have confirmed that traditional tools such as financial instruments and fiscal policies have a significant impact on industrial structure upgrading. However, due to the current constraints of insufficient policy space, the policy implementation of these tools is greatly limited. Therefore, we recommend shifting the focus of research to environmental policies as effective supplements to traditional tools, delving into their impact on industrial structure, in order to compensate for the ineffectiveness of traditional policies and inject new policy momentum into sustainable economic development.

This article analyzes the correlation between China's environmental regulation and the transformation and upgrading of its industrial structure. Environmental regulation has a significant impact on RIS and UIS. Based on the correlation between environmental regulation and industrial structure transformation and upgrading, we established a dynamic panel model and analyzed the impact of China's environmental regulation on its industrial structure transformation and upgrading. In addition, considering the extremely uneven development of China's regions and the significant differences in environmental regulation policies formulated by different regions, the national sample is further divided into three major regions, namely eastern, central, and western regions, in order to study the regional heterogeneity of the impact of environmental regulation on RIS and UIS in each region. The main conclusions drawn in this article are as follows:

(1) This article establishes a PVAR model to explore the correlation between environmental regulation and the transformation and upgrading of industrial structure. According to presented impulse response curves, it can be seen that the impact of environmental regulation on RIS and UIS is very significant. Specifically, the impact of environmental regulation has a positive impact on RIS, while the impact on UIS is relatively complex, initially having a negative impact followed by a positive impact and, in the long run, the degree of impact decreases and stabilizes. We also analyzed the impact of environmental regulation on RIS and UIS through variance decomposition. Fluctuations in environmental regulation can explain 37.75% of changes in RIS, and the fluctuation of environmental regulation can explain 23.5% of changes in UIS;

(2) Overall, by controlling variables such as economic development level, urbanization process, openness to the outside world, human capital level, and fiscal freedom, it is found that strengthening the level of environmental regulation is not conducive to RIS, but a strong level of environmental regulation can significantly promote UIS. Variables such as economic development level and human capital level promote RIS and UIS. Urbanization is not conducive to RIS, but it promotes UIS. The degree of

openness to the outside world is conducive to RIS but not conducive to UIS. The impact of fiscal freedom on RIS and UIS is not significant.

(3) At the regional level, there is significant regional heterogeneity in the impact of China's environmental regulations on the transformation and upgrading of industrial structures in different regions. Environmental regulatory policies can promote UIS in the eastern and western regions of China but are not conducive to RIS. For the central region of China, environmental regulations promote RIS but have a negative impact on UIS. A possible reason for this is that the demand for environmental governance in the eastern region of China is stronger due to advantages associated with its location, which promotes UIS. However, the friction brought about by industrial changes has increased the cost of factor replacement, which is not conducive to the optimal allocation of resources among industries and inhibits RIS. The technology of eastern-transfer industries from the central region is perfect, which promotes RIS, but the central region's basic innovation ability is weak, which is not conducive to UIS.

Based on the above research conclusions, this article proposes the following policy recommendations: (1) The government should fully explore and leverage the positive role of environmental regulation in industrial structure transformation. It is also necessary to pay attention to the impact of environmental regulation on the transformation and upgrading of local industrial structures. Properly increasing the intensity of environmental regulation can help improve the ecological environment and promote the upgrading of industrial structure. The government should consider the carrying capacity of economic entities when formulating environmental regulation policies and gradually adjust the intensity of environmental regulation to avoid generating excessive environmental costs that inhibit the innovation enthusiasm of enterprises. (2) China's regional development is imbalanced, and there are significant differences in environmental regulation levels among different regions. A one-size-fits-all environmental policy cannot meet the environmental governance needs of different regions. The government's formulation of environmental regulation policies needs to combine regional characteristics, pay attention to the regional heterogeneity of environmental regulation's impact on industrial structure transformation and upgrading, and formulate differentiated environmental protection policies tailored to local conditions. (3) In the mechanism path of environmental regulation affecting industrial structure transformation and upgrading, full leverage of the positive role of human capital should be utilized in industrial transformation and upgrading. Relevant departments should strengthen the introduction of high-tech human capital, establish diversified talent introduction mechanisms, and attract high-level human resource clusters through generous material rewards and spiritual incentives, which can help promote the process of industrial structure transformation and upgrading.

Finally, it should be pointed out that this study is an empirical analysis based on provincial panel data and does not include industry factors in its scope. Due to differences in policy orientation, energy dependence, and pollution emissions, the impact of environmental regulation on industrial structure will vary in different industries. Therefore, when formulating and implementing environmental regulation policies, not only regional differences but also industry characteristics should be taken into account. In addition, the types of environmental regulation can be divided into command-and-control types, economic incentive types, and voluntary types. The indicators selected in this paper only consider the intensity of command-and-control environmental regulation, without examining the industrial adjustment effects of other types of environmental regulation. This is also the direction and focus of our future research.

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