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Exploring the Role of Foreign Direct Investment and Environmental Regulation in Regional Ecological Efficiency in the Context of Sustainable Development

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Abstract: Eco-efficiency (EE) is an important indicator of regional sustainable development, which reflects the efficiency of regional economic development in using resources effectively to reduce environmental pressures, and foreign direct investment and environmental regulation are very important in promoting regional economic growth and enhancing eco-efficiency. In this paper, we chose China's panel data from 2009 to 2021, measured China's regional eco-efficiency using the super-efficient SBM model, and explored environmental regulation and the impact of FDI on EE in different regions using the Tobit model, with conclusions as follows: (1) The average value of national EE in China during 2009–2021 was about 0.631, which was at a low level, and there were significant differences between regions, with the highest EE in the eastern region, and the central and western regions being lower than the national average. (2) FDI at the national level had a significant promoting effect on regional EE, with an elasticity coefficient of 0.0213, which verifies that the "pollution paradise" effect does not exist at national level. FDI promoted EE in the eastern region, while not being significant in the other two regions. The impact of the environmental regulation act on EE at the national level did not pass the significance test, but the impact passed the significance test with positive coefficients for both the eastern and central regions, while in the western region it was not significant. (3) Financial investment in science and technology promoted EE in the national, east, and central regions significantly, while not being significant in the western region. The economic development level of all regions was positively correlated with EE; the impact of urbanization on EE was significantly positive in national, central, and western regions, but was not significant in the eastern region. The industrial structure of all regions was not conducive to the improvement of EE, with the western region having the most negative impact on EE. The study in this paper represents an important addition and refinement to research in related fields.

Keywords: foreign direct investment; environmental regulation; ecological efficiency

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Citation: Wu, Y.; Wang, R.; Wang, F. Exploring the Role of Foreign Direct Investment and Environmental Regulation in Regional Ecological Efficiency in the Context of Sustainable Development. *Sustainability* **2023**, *15*, 9104. https://doi.org/10.3390/su15119104

Academic Editor: Corrado lo Storto

Received: 28 April 2023
Revised: 31 May 2023
Accepted: 2 June 2023
Published: 5 June 2023

1. Introduction

As China's economy has taken off and its international status and influence have increased significantly, environmental pollution has become a significant problem. Currently, resource consumption and the emissions of various pollutants are causing China to approach its environmental carrying limit [1]. Therefore, shifting from a quantitative growth model that relies excessively on resource consumption to a qualitative growth model that takes into account resource and environmental constraints is important for achieving sustainable development. The development of a green economy is a reasonable path for this economic transformation, leading to better and higher quality development. Therefore, China should put environmental protection and the prevention of environmental pollution on its agenda. In order to reverse the deterioration of the ecological environment, China introduced the concept of "ecological civilization" and further emphasized the need to vigorously promote the construction of an ecological civilization. As a comprehensive indicator that can measure both economic and environmental performance, the core of "EE" is "more output, less input and less emission", which meets the sustainable development goal of "economic, green and efficient" and the requirements of an ecological civilization. Therefore, it is necessary to enhance EE [2], which is obviously in line with the requirement introduced in the national development strategy to increase ecosystem protection and also in line with the background of strengthening ecological civilization and sustainable economic development.

FDI has provided advanced technical support and abundant capital investments to develop industrial ecosystems, and its impact on China's economic development cannot be ignored [3]. The rapid development of FDI has been a strong impetus for the rapid growth of China's economy. According to the public data of the Ministry of Commerce, the amount of foreign investment absorbed in China reached 1 trillion and 200 billion in 2022, while the scale of capital attraction also reached a new high. Realistically, the expanding scale of FDI will, on the one hand, drive upstream and downstream industries to improve and increase production efficiency through industrial linkage effects, enhance regional scientific and technological innovation through demonstration effects, and improve regional business management through human capital flows, thus promoting the green economy; the importance of FDI to China's economic development cannot be overstated. However, on the other hand, while promoting China's economic growth, foreign investment can cause many problems, such as unbalanced industrial development caused by ignoring the structure of foreign investment, disparities in regional development caused by differences in the distribution of foreign investment between regions, and a negative impact on the ecological environment, which cannot be ignored. In China, how to achieve green economic growth, improve regional EE, and obtain a win—win development path is an important factor in green development [4].

At the same time, due to the public goods nature of the environment, the negative externalities of pollution, and unclear property rights, the market mechanism fails in the field of ecological protection. The negative externalities that rely only on "invisible hand" regulation will lead to market failure; thus, the government is objectively required to govern the environment. According to Porter's hypothesis, the innovation effect of a reasonable environmental regulation policy can compensate for environmental costs and reduce environmental pollution, while also effectively stimulating enterprises to promote technological innovation and thus improve their competitiveness [5]. Therefore, how to formulate a reasonable environmental regulation policy to promote green development is an urgent issue for the government to address. Based on this, the present study discusses the impact of environmental regulation on EE, in order to provide a reference for achieving green development. As EE is an important tool for environmental governance in China, the core question of this study asks: can environmental regulation promote EE and how can it do so?

In this study, we explored the impact of environmental regulation and FDI on EE and calculated the EE of different regions in China. By combining geostatistics and spatial econometrics, this work expands on the current body of research on EE issues. Our results can provide a scientific basis for formulating targeted countermeasures to improve regional EE.

2. Literature Review

2.1. Ecological Efficiency

2.1.1. Meaning of Ecological Efficiency

Schaltegger and Burritt proposed the concept of EE and expressed it as the ratio of economic output and environmental input [6]. Claude Fussler introduced the concept again in "The Development of Industrial EE", where he described the five elements of EE and defines EE as a broad performance ratio [7]. The World Business Council for Sustainable Development defines it as "the production of more goods and services while using fewer resources and producing less waste and pollution". Foreign studies on EE mostly focus on specific industries, enterprises, agricultural cultivation, and other micro areas [8]. However, in China, EE is widely used in macro-level ecological performance evaluation, which reflects the sustainable development capacity of the economy in general or specific regions.

2.1.2. Measurement of EE

Domestic and foreign scholars have adopted the following methods to evaluate EE: the ratio evaluation method, indicator evaluation method, and data envelopment analysis method. The World Business Council for Sustainable Development (WBCSD) proposed the ratio method to measure EE, and Muller and Sterm [9] used the ratio of output to environmental pollution to measure regional EE. There are some shortcomings in using a single ratio method, and it is only used for single factors on EE. The indicator evaluation method is currently the most commonly used method for evaluating EE. The most influential is the evaluation of the EE index proposed by the German scholars Hoh et al. in 2002, which is composed of six different types of natural element [10]. In 2007, based on the EE index constructed by these German economists, Qiu Shoufeng and Zhu Dajian added three indicators to evaluate the EE of China, including sulfur dioxide emissions, wastewater emissions, and pollutant emissions [11]. Finally, the data envelopment analysis method has become the most widely used method to evaluate EE in recent years. Liu [12] used three-stage DEA and Cai and Wang [13] used super-efficient DEA to identify and improve the input–output terms of the model, in order to measure regional EE. Sun Yitou and Zhu [14] analyzed the regional EE in Shandong province using an SBM model and comparative analysis to study the differences between regions. Mengjie Chang [15] analyzed the EE of the provinces in the Yellow River basin using a super-efficient SBM model to provide solutions for ecological conservation.

2.2. Impact of FDI on Regional EE

In the literature regarding the influence of FDI on EE, scholars have mostly introduced FDI as a direct influence in the analytical framework. Wang [16] measured the EE of the provinces along the Silk Road Economic Belt and found that FDI had a significant inhibitory impact on EE, while the impact of the industrial structure was not significant. Grimes and Kentor [17] studied the impact of FDI on underdeveloped countries with a high concentration of energy consuming industries and concluded that FDI generated more severe environmental pollution. Chen and Zhi [18] found that the direct impact of FDI on urban clusters along the Yangtze River Economic Belt was significantly positive in a study using data from 77 cities. Saboori et al. [19] concluded that FDI has a certain impact on the environment of the host country; however, there is a threshold effect and an inverted "U" curve relationship between the two. Khalil and Inam [20], Baek and Koo [21] found that the increasing influx of FDI increases pollution emissions in host countries based on cross-country or regional panel data. Shahbaz and Nasreen [22] argued that the inflow of FDI causes significant deterioration in the environmental quality of the host country. On the other hand, Bakhsh et al. [23] found a positive relationship between the two using panel data from Pakistan.

FDI can also have an indirect effect on EE through both economic efficiency and resource efficiency. Baek [24] and Sapkota and Bastola [25] successively argued that capital-chasing competitive behavior attracts low-quality investments and results in high pollution in the host country. Although it promotes economic development to some extent, it also makes the local area a "pollution sanctuary" and has a considerable negative impact on the environment. Shan and Zhang [26] found that FDI can significantly contribute to the improvement of EE in China, and its direct effect is smaller than its indirect effect. Han [27] explored the mechanism underlying the influence of FDI on industrial EE with respect to four aspects—the effect of income, technology, structure, and scale—and empirically tested the impact of FDI and environmental regulation on industrial EE. It was concluded that increases in FDI inhibited the overall eco-efficiency of China's urban agglomerations, confirming the existence of "pollution sanctuaries", i.e., the inflow of FDI has to a certain extent damaged China's environment, where FDI expansion is prioritized over increasing the "green" nature of FDI. Li et al. [28] stated that the inflow of foreign capital can bring advanced and green production technologies and production processes, promote local technological innovation and technological spillover, and further improve eco-efficiency. In 2012, Sheng and Lv [29] empirically analyzed the environmental effects of FDI based on panel data from the industrial sector and found that the positive effect of technology was greater than the negative effects of scale and structure. They concluded that FDI promotes reductions in industrial pollutant emissions in China.

2.3. Impact of Environmental Regulation on Regional EE

In the relevant literature, scholars have had difficulty reaching a consensus on the relationship between environmental regulation and EE. First, some believe that environmental regulation negatively affects regional eco-efficiency. Jorgenson et al. studied the U.S. economy and found that environmental regulation increased firms' production costs to some extent, which in turn led to a loss of productivity. Gollop and Roberts [30] found that government environmental regulation led to a 0.6% reduction in firm productivity in a study related to U.S. electric utilities. Barbera and Mcconnell [31] examined the performance of U.S. non-metal, chemical, paper, and steel industries through the perspective of environmental pollution control investments and found that pollution control investments led to a 10–30% decrease in productivity.

On the other hand, some scholars suggest that environmental regulation positively affects regional eco-efficiency. Andrei et al. [32] analyzed the relationship between GDP and environmental damage, energy production, and environmental taxation in Romania and found that for emerging economies, taxing pollutant-emitting firms can both increase GDP and prevent environmental degradation, leading to green economic development. Panayotou [33] also analyzed the impact of environmental regulation on environmental quality in the context of the environmental Kutznets curve (EKC) and argued that strengthening environmental regulation can flatten the EKC curve and improve environmental quality. Cole et al. [34] conducted an empirical study focusing on British industry and found that environmental regulation effectively reduced industrial emissions. Dasgupta et al. [35] also demonstrated that strict environmental regulations could reduce pollution emissions and lead to both a flattening of the EKC curve and an earlier inflection point.

Other scholars have shown that the impact of environmental regulations on eco-efficiency is non-linear, i.e., within a certain range, environmental regulation can improve EE. However, when these regulations exceed a certain "degree", they inhibit EE. There are regional differences among the eastern, central, and western regions, which are in the declining, smoothly rising, and rapidly rising stages of the curve, respectively. Li and Tao [36] took the Chinese manufacturing industry as a study target and found that the relationship between environmental regulation and EE exhibited a "U" shape. Zhang [37] also found that the impact of environmental regulations on the ecological environment was inverted and "U" shaped. In addition, Zhang et al. [38] found that the impact of environmental regulations on green economic efficiency was characterized by an inverted U-shaped curve, first promoting and then inhibiting green economic efficiency.

Many studies have been conducted in this area. The existing literature has laid the foundation for this paper; however, after reviewing the relevant literature, we believe that there are still some areas worth expanding and improving. For example, many studies explored the impact of industries or enterprises on EE, while little research has been carried out with respect to their impact on regional EE. Furthermore, most studies ignored regional heterogeneity. Therefore, we investigated the impact of environmental regulation and FDI on EE in different regions, with the aim of providing a decision-making basis for local governments to improve regional environmental performance and conduct environmental supervision.

3. Methodology

3.1. Ecological Efficiency Measurement Method

3.1.1. Super-Efficient SBM Model

According to the Organization for Economic Cooperation and Development (OECD), "EE is the efficiency of using ecological resources to meet human needs, and this efficiency is expressed as the ratio of output to input". It can be seen that EE is the unity of economic efficiency and environmental efficiency, and the higher the eco-efficiency, the better. Here, we measured provincial EE based on the above description and understanding of EE.

The selection of a reasonable method for the scientific measurement and evaluation of eco-efficiency was an objective prerequisite for the subsequent analysis. Existing research methods for measuring eco-efficiency include the economic-to-environmental ratio evaluation method, the indicator evaluation method, stochastic frontier analysis, data envelopment analysis (DEA), etc. Each method has its own advantages and disadvantages and scope of application. The single ratio method cannot distinguish the influence of different environments, while the indicator system method has to analyze the relationship between the environment and the economy through weights, where the weighting process cannot exclude the influence of subjective factors. Meanwhile, the basic assumptions of the SFA model are more complicated, and the specific forms of the production function and technical inefficiency terms need to be determined in advance [39], while DEA only requires input–output data. SFA data are also more demanding, and if the basic assumptions are not met, the problem of bias in ε may arise. Moreover, the efficiency calculated using the DEA method is a comprehensive index, which fully takes into account the substitutability between different types of input factors and is suitable for efficiency evaluation under multiple input and output situations. In view of the advantages of the DEA method and the fact that the "eco-environmental impact" item in the eco-efficiency index contains various resource inputs and pollution emissions, and that its measurement units are not consistent, the use of DEA to measure eco-efficiency has become a common choice.

Traditional DEA considers efficient production as obtaining more output with less resource input, ignoring the impact of pollution emissions on EE. However, these results are not accurate enough, because during economic production activities, various input factors not only generate products and bring economic benefits but also bring undesired outputs, such as waste gas. Pittman [40] used DEA to take this undesired output into consideration for the first time. Chung et al. [41] and Fare et al. [42] further expanded on this basis to form the directional distance function (DDF) and proposed the Malmquist index, which is more suitable for the green concept. Liu et al. [43] and Ren et al. [44] also studied DEA models that consider non-desired outputs in depth. However, traditional DEA uses a radial-angle based model, which ignores the slackness of the variables, and there is a gap between the calculated results and the objective reality. The SBM model is an efficiency measure that takes slack variables into account; however, its results can only be in the (0, 1) interval and an efficiency value of 1 cannot be compared. Tone [45] proposed the super-efficient SBM model, which solves the slack measure problem and the inability to compare decision units, and where the efficiency value can exceed 1. Therefore, in this work, this method was used to measure the EE of 30 Chinese provinces, assuming n decision units, m production input factors per decision unit, s desired outputs, and t non-desired variables are obtained, with the following linear programming expressions:

Suppose there are i provinces and municipalities (decision units), each covering the input X, desired output Y, and undesired output Z, where:

$$X = (x_1, x_2, \cdots, x_N) \in R_N^+, Y = (y_1, y_2, \cdots, y_M) \in R_M^+, Z = (z_1, z_2, \cdots, z_J) \in R_J^+$$

Then, the production possibility set is: $\mathrm{P}(x) = \{(y,z) : x \to (y,z)\}$. The mode is as follows:

$$\mathrm{D}(x_i, y_i, z_i) = min \frac{1 + \frac{1}{N}\sum_{n=1}^{N} \frac{s_n^x}{x_n^i}}{1 - \frac{1}{M+J}\left(\sum_{m=1}^{M} \frac{S_m^y}{y_m^i} + \sum_{j=1}^{J} \frac{S_j^z}{z_j^i}\right)}$$

$$s.t.\begin{cases} x_{i,n} \geq \sum\limits_{i=1}^{I} w_i x_{i,n} - s_n^x, n = 1, 2, \cdots, N \\ y_{i,m} \leq \sum\limits_{i=1}^{I} w_i y_{i,n} + S_m^y, m = 1, 2, \cdots, M \\ z_{i,j} \geq \sum\limits_{i=1}^{I} w_i z_{i,j} - S_j^z, j = 1, 2, \cdots, J \\ 1 - \frac{1}{M+J}\left(\sum\limits_{m=1}^{M} \frac{S_m^y}{y_m^i} + \sum\limits_{j=1}^{J} \frac{S_j^z}{z_j^i}\right) > 0 \\ \sum\limits_{i}^{I} w_i, w_i \geq 0, s_n^x, S_m^y, S_j^z \geq 0, i = 1, 2, \cdots, I \end{cases}$$

where D represents the EE value; (x_i, y_i, z_i) represent the inputs and outputs; s_n^x, S_m^y, S_j^z represent the excess of inputs, the lack of desired outputs, and the excess of non-desired outputs, respectively; i is the number of decision units; and N, M, and J represent the number of inputs, desired outputs, and non-desired outputs, respectively.

3.1.2. Variable Selection

Based on academic research, we considered EE as the efficiency of ecological resources to meet human needs, representing the relationship between economic performance and environmental performance. Thus, EE can be measured using the impact of resource consumption and pollution on the environment. The evaluation index system of EE includes two dimensions: "input" and "output". There were five input factors involved in this study, namely capital, labor, energy, land, and water. The output factors were divided into two categories, namely desired output and non-desired output. Desired output refers to the type of economic benefits obtained, i.e., regional GDP, which reflect the total economic income of a region. Non-desired output refers to additional output from the production process, including total wastewater emissions, sulfur dioxide emissions, and smoke (dust) emissions, which can reflect the negative impact on the regional environment from several perspectives. Taking into account the characteristics of this study and based on the negative correlation between non-desired output indicators and EE, we considered non-desired output indicators as input indicators. The specific indicators are shown in Table 1.

Table 1. Input–output indicator system.

Indicators	Category	Content
Input Indicators	Labor input	Number of employees in urban units at the end of the period
	Capital input	Capital stock
	Energy input	Electricity consumption of the whole society
		Total water consumption of the whole society
		Construction land area
Output Indicators	Desired output	Real GDP
	Non-desired output	Wastewater emissions
		Sulfur dioxide emissions
		Smoke and dust emissions

All data were obtained from the China Statistical Yearbook (2009–2021) and the statistical bulletin of each region from 2009 to 2021.

3.2. Regression Analysis

3.2.1. Tobit Model

The EE values calculated based on the DEA model are not only influenced by input-output indicators and external macro-environmental factors, but also by micro factors. When analyzing the influencing factors in the next step, the EE values measured have truncated characteristics because they range in the interval from 0 to 2. At this point, if ordinary least squares (OLS) regression is used, consistent results cannot be obtained. Therefore, most scholars have used Tobit regression models to solve this problem with the data and carry out the analysis of other influencing factors. The Tobit model is constrained in the following form:

$$y^* = \beta' x_i + \mu_i$$

$$y^* = \begin{cases} y_i & if\ y_i^* > 0 \\ 0 & if\ y_i^* \leq 0 \end{cases}$$

where y^* is the potential dependent variable, x_i represents independent variables, β denotes coefficients, and μ_i is the error term. A more general case, which can be intercepted on either side of any finite point, is as follows:

$$y_i = \begin{cases} c^- & if y_i^* \leq c^- \\ y_i^* & if c^- \leq y_i^* \leq c^+ \\ c^+ & c^+ \leq y_i^* \end{cases}$$

3.2.2. Variable Selection

(1) Explained variables

Ecological efficiency (EE). The larger the value of this indicator, the more harmonious the economy and environment of the region are.

(2) Explanatory variables

Foreign direct investment (FDI). Some scholars agree with the "pollution sanctuary" view, which states that foreign investment has polluted China's ecological environment, while others agree with the "pollution halo hypothesis", which suggests that foreign capital inflows have promoted China's technological progress and reduced environmental pollution. In this work, in order to test the impact of FDI on EE, the amount of actual foreign investment was used as the variable.

Environmental regulation (ER). Environmental regulation is also a core explanatory variable in this paper. It is part of the social policy formulated by the government to reduce the ecological externalities caused by the production activities of enterprises. Currently, scholars use a variety of indicators to measure the level of environmental regulation; this paper draws on the approach of Tian and Hao [46], which uses the share of industrial pollution control investment in the industrial value added by each region to represent the regional level of environmental regulation.

(3) Control variables

Financial science and technology input (FTI). R&D expenditure or R&D/GDP are most commonly used to represent FTI; however, the direct use of R&D expenditure cannot intuitively reflect the role and size of the local government's FTI in the total investment, while the use of R&D/GDP is an common practice internationally [47]. Therefore, we adopted FTI/GDP to measure fiscal science and technology investment, drawing on international common practice.

Economic development level (GDP). Panayotou [48] defined the inverted U-shaped relationship between economic development and environmental pollution as the environmental Kuznets curve. This hypothesis suggests that when a country's economic development is low, the degree of environmental pollution is low; however, with an increase in per capita income, the degree of environmental pollution tends to increase, and the degree of environmental degradation increases with economic growth. Grossman and Krueger [49] proposed that economic growth affects environmental quality through scale, technology, and structural effects. This study draws on previous scholarly research by using GDP per capita to reflect the regional economic development level and further takes the logarithmic treatment of GDP per capita in order to dequantize it.

Urbanization level (URB). People are the core of cities, and the level of population urbanization is an important indicator reflecting economic development; it is also a basic element of urban system planning. While urbanization significantly improves peoples' lives, it also causes a series of environmental problems, such as the heat island effect and resource shortages. On the other hand, compared to areas with low urbanization levels, a high urbanization rate leads to advantages in pollution control technology that can better manage environmental pollution; thus, the level of urbanization will have an impact on EE. In this work, referring to the study conducted by Chen in 2016 [50], the ratio of the regional urban population to the total population was selected to represent the urbanization level.

Industrial structure (STR). In this study, the impact of industrial structure was measured using the ratio of secondary industry output value to GDP. The industrialization process may cause more serious environmental pollution; thus, it reduces EE [51]. The higher the value of this ratio, the more developed the industry in the region is, and the larger the negative impact.

According to the variable selection results, we selected eco-efficiency as the explanatory variable and the influencing factors screened out above as the explanatory variables, using a sample interval of 2009–2021, and established a corresponding regression analysis model. In addition, a logarithm of the data for each variable was taken, for the following reasons: (1) Logarithmic treatment can significantly reduce the numerical size of variables, which is conducive to the convenience of calculation, because if the value is too large, it may exceed the range of possible values. (2) In a particular environment, the sensitivity to differences in the small part of the value is higher than that to differences in the large part of the value. The logarithmic treatment of variables will not change their nature and correlation but instead will compress the scale of the variables, which can enhance sensitivity. However, compressing the scale of the variables can enhance the smoothness of the data and also help to reduce the possible existence of multicollinearity, heteroskedasticity, etc. The eco-efficiency impact model established in this work can be expressed as follows:

$$lnEE_{it} = \beta_0 + \beta_1 lnFDI_{it} + \beta_2 lnER_{it} + \beta_3 lnFTI_{it} + \beta_4 lnGDP_{it} + \beta_5 lnURB_{it} + \beta_6 lnSTR_{it} + \varepsilon_{it}$$

where i is the region; t is the year; the constant term is represented by β_0; β_i denotes the coefficient corresponding to the respective variable; ε_{it} denotes random error; $lnEE_{it}$ is the EE of the explained variable; and $lnER_{it}$, $lnFDI_{it}$, $lnFTI_{it}$, $lnGDP_{it}$, $lnURB_{it}$, and $lnSTR_{it}$ are the explanatory variables of environmental regulation, foreign direct investment, financial investment in science and technology, economic development level, urbanization, and industrial structure, respectively.

4. Results

4.1. Regional EE Measurement Results

In this study, we used MAX DEA to calculate the EE index using the data for each region from 2009 to 2021. We obtained the EE value of 30 regions in China, which are shown in Appendix A.

In Appendix A, it can be seen that the national EE value was about 0.631, although it fluctuated up and down during the period of 2009–2021. The eastern region had the highest EE value of about 0.968, while the central and western regions had values of only 0.579 and 0.347, below the national average. Beijing was found to have the highest EE, with a value higher than 2, showing a continuous, upward trend on the whole. In addition, Tianjin's EE value was always above 1, reaching its maximum in 2011 and with a decreasing trend afterwards. Fujian's EE value basically fluctuated around 1. The EE values of the five northwestern provinces, Shaanxi, Tibet, Ningxia, Xinjiang, and

Gansu, were all lower than the national average, while the EE values of Beijing, Tianjin, Hunan, Fujian, Zhejiang, Shaanxi, Inner Mongolia, Jiangsu, Hebei, and Guangdong were above the national average. The EE values of Chinese localities showed a rapid rise after 2018, indicating the regions' determination to build an ecological civilization. In addition, industrial restructuring, energy conservation and emission reduction, and the role played by science and technology in environmental management and economic development could all be behind the significant increase in EE levels.

4.2. Analysis of the Impact on Regional EE

4.2.1. Multicollinearity Test

To solve the problem of multicollinearity among variables, we used Stata.16 software to conduct a variance inflation factor (VIF) test; the specific results are shown in Table 2. In this work, we referred to the findings of O'brien [52] as a measure. As can be seen from the data in the table, the VIF values were all less than 4; thus, we could exclude the problem of multiple cointegration between these variables.

Table 2. Results of the multicollinearity test.

Variable	VIF	1/VIF
lnER	2.21	0.452
lnFDI	2.49	0.402
lnGDP	1.77	0.565
lnFTI	1.55	0.645
lnURB	2.36	0.424
lnSTR	3.36	0.298
Mean VIF	2.29	

4.2.2. Tests of Stationarity and Cointegration

It is necessary to conduct unit root tests for each variable before model analysis, to avoid spurious regressions and ensure valid results [53]. The unit root test of the panel data can be divided in two ways, according to the different hypotheses to be tested: homogeneous and heterogeneous cases. In order to overcome the possible errors of a single method, each variable was tested using the LLC test for homogeneous panel data hypothesis and the Fisher-ADF test for heterogeneity. The results are presented in Table 3.

Table 3. Tests of stationarity.

Variables	ADF Test		LLC Test		Test Results
	ADF Test Value	*p* Value	LLC Test Value	*p* Value	
lnEE	109.24	0.0000	−9.11	0.0000	Stable
lnER	75.35	0.0000	−8.35	0.0000	Stable
lnFDI	77.45	0.0000	−61.49	0.0000	Stable
lnGDP	99.34	0.0001	−9.58	0.0000	Stable
lnFTI	87.22	0.0001	−14.57	0.0000	Stable
lnURB	101.34	0.0000	−32.33	0.0000	Stable
lnSTR	98.17	0.0001	−11.47	0.0000	Stable

With respect to the above validation results, it can be seen that for the variables of interest, we could accept the alternative hypotheses tested at the 1% level and each variable was homogeneous and passed the stationarity test. The ADF-based Kao cointegration test was used to determine whether there was a long-term dynamic equilibrium between the variables. The results are shown in Table 4. The variables all passed the significance test and the original hypothesis of no cointegration relationship was rejected. Thus, a panel model estimation was developed subsequently.

Table 4. Cointegration test results.

Test Method	Null Hypothesis: H0	*t*-Statistic	*p* Value
Kao cointegration test	No cointegration relationship exists	−3.8895	0.0000

4.2.3. Hausman Test

The regression analysis included fixed effects, random effects, and mixed regression. The premise of using mixed regression is that there are no individual effects, and the premise of random effects regression is that the random error term is independent of all explanatory variables. In order to avoid incorrect model settings and improve the validity of parameter estimation, it is necessary to distinguish the form of the panel data model before regression. In Table 5, it can be seen that the hypothesis of no difference between the fixed-effects estimates and the random-effects estimates was rejected. Therefore, in this study, the fixed-effects model estimates were relatively good. The next step was to apply the fixed effects model for the study. The fixed effect units in this paper are for each region in China.

Table 5. Hausman test results.

Test Method	LLC Statistical Quantities	*p* Value	Results
Hausman test	11.37	0.0000	Reject the original hypothesis

4.2.4. Regression Results

We used the Tobit model for regression estimation, and the results are shown in Table 6.

Table 6. Regression results.

Variable	National	East	Central	West
lnER	0.1321	0.1214 ***	0.0712 ***	0.0348
	(0.78)	(3.45)	(3.77)	(1.09)
lnFDI	0.0342 *	0.1687 ***	−0.0123	−0.0489
	(1.91)	(4.33)	(−0.82)	(−1.21)
lnFTI	0.1345 ***	0.2217 ***	0.2453 ***	0.1239 ***
	(5.56)	(6.89)	(3.47)	(4.56)
lnGDP	0.1034 ***	0.1125 ***	0.1458 ***	0.0804 **
	(5.33)	(5.79)	(4.56)	(2.23)
lnURB	0.2054 *	0.0325	0.1822 ***	0.2120 ***
	(1.94)	(1.04)	(3.78)	(4.45)
lnSTR	−0.1786 ***	−0.0568 ***	−0.1345 ***	−0.3239 ***
	(−5.33)	(−4.45)	(−4.59)	(−5.23)
Number of observations	390	143	104	143
R^2	0.9022	0.8933	0.9872	0.9123

Note: *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. Values in parentheses are *t*-values.

(1) Analysis of the effect of core variables on EE

The positive effect of FDI at the national level was quite obvious, with a significantly positive coefficient but a low significance level of 10% and an elasticity coefficient of 0.0342%. This can be explained in two ways: First, the initial introduction of FDI is mostly concentrated in manufacturing and energy extraction industries, which consume a great deal of energy and cause serious pollution; however, as the economy improves, domestic industries continue to transform and upgrade in the direction of more favorable economic and social development. Coupled with a gradual improvement in living standards, this increases the public's awareness of environmental protection and the government's attention to environmental regulations. Second, the influx of multinational companies brings more advanced and cleaner production technologies to the local area and, through the technology spillover effect, improves the efficiency of resource utilization and effectively reduces pollutant emissions, which ultimately has a catalytic effect on EE. Thus, FDI is conducive to EE, and the "pollution paradise" effect does not exist in China. This is consistent with the results of most studies [28,29], they all found that FDI promotes reductions in industrial pollutant emissions in China.

Environmental regulation does not have a positive effect on regional EE at the national level, which is not consistent with the Porter hypothesis [54]. On the one hand, local governments are under pressure, as they know that these industries can become engines for regional economic growth and big tax payers; if severe environmental regulations are imposed, these industries will certainly move to other regions with lower regulatory standards. Under this pressure, the increasingly fierce competition for environmental regulations makes local governments' environmental policies dysfunctional. On the other hand, this may be due to the fact that the effect of environmental regulation on "pushing" technological innovation has not yet been realized. The same conclusion has been reached by most scholars [55–57]; they all argued that environmental degradation due to policy lag causes environmental regulation to inhibit regional eco-efficiency.

In terms of the effects of regional explanatory variables on EE, first, the performance of the FDI term varied significantly across regions. FDI was found to improve EE in the eastern region, implying that FDI can help to achieve the coordinated development of local economic growth, resources, and the environment. However, this relationship was not significant in the central and western regions. There was less FDI compared to the east, and although the entry of foreign investment drives local economic development, this driving effect may be realized more through the spatial effect of FDI in the east, which involves the demand for economic development in the east with respect to human resources, natural resources, etc. On the other hand, FDI investment projects in the central and western regions may pay more attention to resource development and utilization, and the acquisition of natural resources may cause deep irreversible effects on the ecological environment. The combination of these two effects makes FDI not only have a relatively limited effect on the economic development of the two regions but may also be associated with more serious environmental pollution and resource consumption; thus, the estimated results show a negative effect. Second, the effect of environmental regulation on EE in the eastern and central regions passed the significance test with positive coefficients, while this relationship was not significant in the western region. The spatial heterogeneity of the effect of environmental regulation on EE shows that the eastern and central regions exhibit an "innovation compensation effect" on EE through environmental regulation, while the western region needs to improve technological innovation to enhance the positive impact on EE.

(2) Analysis of the effects of control variables on regional EE

The coefficient of financial investment in science and technology at the national level was significantly positive, which indicates that it significantly contributes to improving national EE. The coefficient of financial science and technology investment in the eastern region was also significantly positive, again suggesting that it contributes to the improvement of EE. A possible reason for this is that the eastern region possesses financial strength, a sufficient budget for science and technology expenditure, and a large number of high-tech innovators who invest more in eco-environmental science and technology innovation, which in turn contributes to the improvement of EE. The coefficient of financial investment in science and technology in the central region was also positive. A possible reason for this is that the central region has accelerated the transformation and upgrading of the energy industry and increased regional industrial and agricultural eco-environmental protection and pollution control, which in turn has improved EE. The coefficient of financial science and technology investment in the western region was not significant, potentially because the western region is economically backward, with imperfect local legislation on ecological environmental protection, a lack of law enforcement and supervision, and a poorer ability to control environmental pollution.

It was found that economic development can improve EE in China at a 1% significance level with a coefficient of 0.1034; i.e., for each percentage point increase in economic development, EE increases by 0.1034 percentage points. On the one hand, a high level of economic development provides a material guarantee of controlling environmental pollution and the necessary financial support for regional ecological civilization construction, while also bringing about certain industrial agglomeration. Through scale, economies improve EE. On the other hand, with the improvement of living standards, the awareness of environmental protection has also increased, which will certainly further industry upgrades, eliminate old resource-intensive industries, and develop new green industries. At the same time, existing enterprises will be forced to improve EE. In terms of different regions, all three regions passed the significance test at the 1% confidence level. In terms of coefficients, the impact of economic development on EE was higher in the east and central regions than in the west.

The level of urbanization was found to affect national EE at a 10% significance level, with a deeper influence; with each unit increase in urbanization level, EE can be expected to increase by 0.2054 units. In the current development context, urbanization is not simply an increase in the proportion of the urban population but, more importantly, follows the law of ecological development. By adjusting the corresponding urban industrial structure, the level of urbanization is improved, environmental pollution and damage is reduced, and ecological environmental protection is realized. The effect of urbanization on EE was significantly positive in the central and western regions, likely because the urbanization level in these regions is improving and the industrial structure of the towns has been optimized, resulting in an improvement in the quality of life. However, this relationship was not significant in the eastern region, perhaps because the urbanization level has reached a high level and the impact on economy and ecology has reached a stable state.

Industrial structure was found to inhibit EE at the national level, at a 1% significance level. In this paper, the proportion of the output value of secondary industry to GDP was used as a proxy variable for industrial structure; as industry is an important component of secondary industry, the higher the indicator, the higher the degree of industrialization. Industry mostly covers high-consumption, resource-intensive industries, such as the energy industry, iron and steel industry, and machinery industry. These industries not only consume large amounts of resources in the production process, but also produce a large amount of environmental pollutants, due to low-level technologies, among other reasons. Some enterprises, in the pursuit of profit maximization, directly discharge pollutants without treatment, which increases the pressure of environmental management, is not conducive to improving environmental quality, and further inhibits the improvement of EE. The industrial structures in the east, central, and west regions all had a negative impact on EE at a 1% confidence level, where the western industrial structure had the greatest impact on EE. It is worth considering that the influence of industrial structure on EE may have been enhanced in the western regions, where urban agglomerations require industrial restructuring and increase the proportion of tertiary industry; at the same time, this region could pay attention to the development of high-tech industries, such that the industrial structure can change from "high pollution, high consumption and high emission" to "low pollution, low consumption and low emission".

4.3. Robustness Tests

In this work, a regression analysis was carried out using the original data, in the form of logarithms for each influencing factor. In order to verify the smoothness of the regression analysis, we carried out an additional analysis where we did not take the logarithm of the original data and compared the regression results of the two methods. The robustness test results are shown in Table 7.

Table 7. Robustness test results.

Variable	National	East	Central	West
ER	0.1213	0.0999 ***	0.0900 ***	0.0452
	(1.33)	(3.28)	(3.98)	(1.53)
FDI	0.0288 *	0.2765 **	−0.0176	−0.0897
	(1.91)	(2.29)	(−1.22)	(−0.98)
FTI	0.1658 ***	0.2278 ***	0.2431 ***	0.0319 ***
	(3.92)	(6.21)	(4.88)	(4.27)
GDP	0.0932 ***	0.1128 ***	0.1542 ***	0.0678 ***
	(4.73)	(2.99)	(3.78)	(3.47)
URB	0.2124 *	0.0564	0.1674 **	0.1907 ***
	(1.93)	(1.09)	(2.35)	(3.21)
STR	−0.2907 ***	−0.0423 ***	−0.1703 ***	−0.3764 **
	(−5.67)	(−4.58)	(−3.44)	(−2.33)
Number of observations	390	143	104	143
R2	0.9213	0.9256	0.9129	0.9677

Note: *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. The values in parentheses are *t*-values.

The regression analysis revealed a small change in the significance level of the individual variables, which did not have a large impact on the results of this study. Thus, the regression model can be considered robust.

5. Conclusions and Implications

5.1. Conclusions

Based on the measurement of regional EE, we explored the impact of environmental regulation and FDI on EE in different regions, with the aim of providing a decision-making basis for local governments to improve regional environmental performance and conduct environmental supervision. Our conclusions are as follows:

(1) The average value of national EE in China during the period of 2009–2021 was about 0.631, which is relatively low. In addition, there were significant differences between regions, with the highest EE in the eastern region and the lowest EE in the western region. Although there is still room for improvement, most regions have experienced faster growth in EE in recent years.

(2) FDI at the national level had a significant positive effect on regional EE, with an elasticity coefficient of 0.0213%. This verifies that the "pollution paradise" effect does not exist in China. FDI was found to promote EE in the eastern region, while this relationship was not significant in the central and western regions.

The coefficient for the impact of environmental regulation at the national level was 0.114 but not significant, suggesting that environmental regulation does not have a positive effect on regional EE. The impact of environmental regulation of EE passed the significance test with positive coefficients for the eastern and central regions, while the impact of environmental regulation on EE for the western urban agglomerations was not significant, indicating that the western region still needs to make adjustments. The western region should adjust its industrial structure and improve technological innovation to enhance the positive impact on EE.

(3) At the national level, the coefficients of fiscal science and technology investment in the east and central regions were significantly positive, indicating their significant

contribution to the improvement of national EE, while the effect of fiscal science and technology investment on EE in the western region was not significant. The economic development in all regions was positively correlated with EE; from the coefficients, the impact of economic development on EE was higher in the east and central regions than in the west. In addition, the impact of urbanization on EE was significantly positive at the national level and in the central and western regions but not significant in the eastern region, perhaps because its urbanization has reached a high level and the impact on economy and ecology has reached a stable state. It was found that the industrial structure of all regions was not conducive to the improvement of EE, among which the industrial structure in the western region had the most negative impact on EE.

5.2. Suggestions

(1) When introducing FDI, each region should correctly recognize the "double-edged sword" impact of FDI on the ecological environment, formulate regionally differentiated policies according to the real situation and their respective development stages, and make reasonable use of foreign investment. In developed regions, while actively introducing foreign capital, attention should be paid to the impact of FDI on the ecological environment; the relationship between the introduction of foreign capital and ecological protection should be correctly handled; foreign capital should be guided toward clean industries, foreign enterprises with advantages in environmental protection technology should be introduced; high value-added industries should be developed; the quality of FDI should be improved, while also paying attention to its scale; and importance should be attached to the role of FDI in improving the ecological environment. In lower level economic regions, full use should be made of the role of foreign capital in promoting economic development, an external environment that is favorable to the entry of foreign capital should be created, the introduction of foreign capital should be enhanced, and the degree of openness to the outside world should be increased. However, at the same time, the ecological environment must be managed and protected to realize the positive spillover effect of FDI on the ecological environment.

(2) In the process of selecting investment regions, FDI not only considers the economic cost of investment, but also values the environment, technology, infrastructure construction, and market development prospects of the region that can improve the competitive advantage of enterprises and provide long-term comprehensive benefits. Therefore, local governments should actively improve the transportation conditions of the region, strengthen infrastructure construction, improve the quality of the ecological environment, and guide residents to establish resource conservation and ecological environment protection practices, to create a favorable external environment for the entry of FDI quality enterprises. This must be achieved in order to promote a harmonious win–win situation between the introduction of foreign investment and ecological environmental protection and to encourage coordinated economic and ecological development.

(3) Diversified environmental regulations should be developed, regionally differentiated management should be implemented, enterprises should be guided and encouraged to achieve cleaner productions via policy, and the transformation from an end-of-pipe treatment to ex ante prevention should be carried out. China's environmental issues are now mainly promoted and implemented by the administrative power of the government, and the inefficiency of direct control is gradually emerging. China's current economic means of environmental regulation are relatively limited, and the full use of a series of market-based mechanisms for a pollution control system has not been fully established. Thus, market-based environmental regulation should be actively developed and implemented. Regional economic development is diversified, and the type of environmental pollution and the ability of enterprises to control it differ between regions; thus, the one-size-fits-all approach of compulsory instruments is likely to cause inefficiencies in environmental regulation. Local governments have the best understanding of the environmental situation in their areas and can formulate policies that are more targeted and functional. They should be encour-

aged to formulate and implement environmental policies that allow for the differentiated management of environmental regulations and give full play to their enthusiasm.

(4) The regional layout of foreign investment should be optimized, and the quality of investment attraction should be improved. Each city cluster should develop differentiated strategies to attract foreign investment, according to its own resource endowment and its unique development advantages and to optimize the layout of foreign direct investment within the city cluster. The Beijing–Tianjin–Hebei city cluster should improve its levels of linkage development, rely on the development advantages of the modern service industries and strategic emerging industries in Beijing and Tianjin, and vigorously introduce international investment projects with a high technology content. The prefecture-level cities in Hebei, while giving full play to their traditional advantages in manufacturing, should raise the entry threshold for foreign investment enterprises with high pollution, high emissions, and low technology levels, and increase the introduction of foreign investment in green production and technology. In addition, an advanced industrial structure should be promoted to reduce the introduction of negative externalities into the ecological environment.

(5) Green innovation-driven development should be prioritized. In the current context of actively advocating for the construction of an ecological civilization, enterprises should increase investment in environmental protection, accelerate the pace of green innovation, and actively carry out green transformation. On the one hand, enterprises should adopt the concept of green governance and increase investment in green innovation. The purchase of pollution control equipment and other direct environmental protection investments may help to achieve significant emission reductions in the short term; however, this will increase the cost of business operations, potentially inhibiting long-term sustainable development. Emission reduction technologies can reduce the consumption of resources in the production process and improve the utilization rate of resources, thus enhancing the long-term economic profits of enterprises. Therefore, companies should implement proactive environmental management strategies and carry out green innovation activities, with the aim of improving sustainable performance. On the other hand, it is important to bring in research talent and strengthen cooperation with research institutes, to enhance technology absorption and independent innovation capabilities. The treatment of scientific researchers should be improved and long-term incentive mechanisms implemented, to fundamentally increase the motivation and willingness of scientific researchers to carry out R&D activities.

(6) The performance assessment mechanism should be improved and the improvement of EE in Chinese cities should be promoted by changing the development concept. Under the dual effect of promotion incentives and economic pressure, local governments tend to invest their limited financial resources in production, to pursue rapid economic growth, while neglecting to invest in public services, infrastructure, and the ecological environment, resulting in the deterioration of EE, while distorting the allocation of production factors. Adopting the single performance appraisal method and constructing a comprehensive appraisal mechanism that includes economic, livelihood, and environmental indicators can reduce the negative externalities of regional competition and fully motivate local governments to improve EE and achieve high-quality development.

5.3. Main Contributions of This Paper

The main contributions of this paper are as follows: (1) Since the ecological environment and economic development levels of different regions in China differ greatly, the impact of environmental regulations on regional EE also varies. Currently, only a few scholars have studied this relationship at the regional level. (2) The measurement of regional eco-efficiency can enable each region to recognize its own shortcomings and formulate corresponding development policies according to regional resources, energy use, and environmental pressure, while also providing a theoretical reference for the proposal of regionally differentiated policies. (3) The relationship between FDI, environmental regulation, and EE has been a popular topic of research; however, previous studies have mainly considered the relationships between two factors but not the interrelationship between the three. This study included an exploration of a new research object, which is conducive to academic innovation.

5.4. Limitations and Prospects of This Paper

(1) FDI, environmental regulation, and EE represent a complex process of mutual influence and interaction. In this paper, we mainly studied a one-way influence and did not consider the reverse effect of these factors on eco-efficiency. Therefore, in future research, a joint cubic equation model should be established to comprehensively study the interaction between the above variables, in order to obtain more accurate results.

(2) Our policy recommendations could be more targeted and actionable. The paths and models of eco-efficiency improvement proposed in the paper are not comprehensive enough, and the regional policy recommendations are mostly given from a macro perspective; thus, they are not detailed and specific enough. Follow-up studies may consider carrying out a deeper refinement of the metrics, by extending them to the level of small and micro enterprises and key polluting industries and counties.

(3) In the choice of methods, all have their advantages and disadvantages. With the super-efficient SBM model, Tobit model selection can only try to determine the model that causes the least deviation in the results. Future research should consider more models for validation; a comparison of the results obtained will provide an additional reference for research in this field.

Author Contributions: Conceptualization, F.W.; methodology, F.W.; formal analysis, Y.W.; investigation, Y.W.; resources, Y.W.; data curation, Y.W.; writing—original draft preparation, Y.W.; writing—review and editing, R.W.; visualization, R.W.; supervision, F.W.; project administration, R.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Philosophy and Social Science Fund Project of Jiangsu Education Department for Universities (2022SJYB0601), and Jiangsu Provincial Social Science Fund (21GLD010).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The eco-efficiency measurement results.

	Region	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
Eastern	Beijing	2.025	2.032	2.052	2.102	2.145	2.194	2.245	2.264	2.257	3.327	2.478	2.502	2.631	2.327
	Tianjin	1.019	1.029	1.076	1.131	1.159	1.226	1.245	1.264	1.293	1.226	1.376	1.408	1.526	1.229
	Hebei	0.426	0.431	0.442	0.522	0.538	0.512	0.619	0.634	0.613	0.624	0.735	0.818	0.927	0.603
	Liaoning	0.437	0.448	0.503	0.433	0.448	0.603	0.678	0.685	0.691	0.708	0.719	0.732	0.821	0.608
	Shanghai	0.919	0.929	1.036	1.027	1.039	1.146	1.185	1.204	1.213	1.226	1.296	1.318	1.426	1.151
	Jiangsu	0.657	0.668	0.695	0.751	0.748	0.735	0.793	0.821	0.989	1.043	1.136	1.228	1.288	0.889
	Zhejiang	0.697	0.605	0.796	0.795	0.705	0.816	0.829	0.838	0.941	1.059	1.165	1.225	1.261	0.902
	Fujian	0.626	0.647	0.622	0.779	0.747	0.822	0.845	0.881	0.912	0.961	0.985	1.011	1.072	0.839
	Shandong	0.421	0.436	0.432	0.427	0.516	0.562	0.523	0.575	0.643	0.657	0.772	0.814	0.919	0.592
	Guangdong	0.668	0.684	0.696	0.768	0.724	0.826	0.835	0.941	1.029	1.072	1.126	1.152	1.217	0.903
	Hainan	0.428	0.435	0.429	0.458	0.495	0.528	0.577	0.656	0.683	0.616	0.741	0.868	0.932	0.604

Table A1. *Cont.*

Region		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
Eastern mean		0.757	0.759	0.798	0.836	0.842	0.906	0.943	0.978	1.024	1.138	1.139	1.189	1.275	0.968
Central	Shanxi	0.377	0.386	0.449	0.477	0.424	0.427	0.562	0.593	0.629	0.665	0.771	0.832	0.832	0.571
	Jilin	0.365	0.397	0.455	0.461	0.448	0.487	0.511	0.526	0.533	0.606	0.758	0.827	0.891	0.559
	Heilongjiang	0.359	0.383	0.446	0.475	0.469	0.508	0.527	0.546	0.566	0.673	0.713	0.743	0.768	0.552
	Anhui	0.393	0.427	0.485	0.397	0.362	0.328	0.423	0.554	0.673	0.732	0.864	0.911	0.983	0.579
	Jiangxi	0.345	0.355	0.443	0.495	0.437	0.422	0.509	0.549	0.574	0.631	0.738	0.855	0.895	0.558
	Henan	0.382	0.381	0.438	0.471	0.441	0.453	0.548	0.567	0.659	0.764	0.806	0.928	0.982	0.602
	Hubei	0.357	0.373	0.446	0.485	0.449	0.423	0.534	0.541	0.548	0.632	0.762	0.816	0.988	0.566
	Hunan	0.353	0.382	0.456	0.591	0.577	0.538	0.654	0.677	0.715	0.722	0.834	0.953	0.974	0.648
Central mean		0.366	0.386	0.452	0.482	0.451	0.448	0.534	0.569	0.612	0.678	0.781	0.858	0.914	0.579
Western	Neimenggu	0.249	0.259	0.251	0.249	0.263	0.221	0.236	0.343	0.357	0.362	0.467	0.564	0.627	0.342
	Guangxi	0.248	0.253	0.267	0.258	0.223	0.221	0.335	0.353	0.342	0.359	0.372	0.481	0.583	0.330
	Chongqing	0.247	0.267	0.271	0.347	0.341	0.328	0.412	0.437	0.559	0.593	0.622	0.648	0.752	0.448
	Sichuan	0.373	0.388	0.392	0.363	0.345	0.336	0.484	0.493	0.595	0.603	0.711	0.716	0.518	0.486
	Guizhou	0.189	0.199	0.162	0.259	0.246	0.237	0.233	0.236	0.238	0.242	0.244	0.258	0.361	0.239
	Yunnan	0.377	0.397	0.381	0.372	0.366	0.353	0.355	0.365	0.372	0.326	0.431	0.555	0.662	0.409
	Shanxi	0.187	0.193	0.268	0.253	0.243	0.229	0.254	0.282	0.315	0.413	0.522	0.637	0.742	0.349
	Gansu	0.179	0.199	0.157	0.159	0.141	0.234	0.236	0.237	0.345	0.442	0.448	0.465	0.559	0.292
	Qinghai	0.217	0.218	0.226	0.231	0.228	0.316	0.328	0.339	0.342	0.452	0.461	0.472	0.488	0.332
	Ningxia	0.153	0.153	0.168	0.253	0.183	0.229	0.254	0.282	0.315	0.313	0.422	0.537	0.542	0.293
	Xinjiang	0.183	0.193	0.181	0.186	0.176	0.169	0.214	0.282	0.315	0.352	0.412	0.527	0.632	0.294
Western mean		0.237	0.247	0.248	0.266	0.250	0.261	0.304	0.332	0.372	0.405	0.465	0.533	0.588	0.347
National mean		0.453	0.464	0.499	0.528	0.515	0.539	0.593	0.626	0.669	0.740	0.795	0.860	0.926	0.631

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