sustainability

MDPI

Article

The Impact of Green Finance and Resource Tax Policy on Regional Energy Efficiency Based on the Non-Desired Output Super-Efficiency SBM-Tobit Model

Yun Yang

School of Physical and Mathematical Sciences, Nanjing Tech University, Nanjing 211800, China; yycp2007@126.com

Abstract: With the continuous growth of the global population and rapid economic development, the demand for energy is increasing, and the increasing scarcity of energy resources and severity environmental problems have become important factors limiting sustainable economic and social development. Therefore, achieving sustainable energy development has received global attention. The main purpose of this work was to measure the energy efficiency (EE) of different regions based on China's 2008–2021 panel data using the super-efficient SBM model and to examine the roles of green finance and resource tax policies in promoting energy efficiency using the Tobit model, so as to further improve China's EE, optimize the energy structure, and improve environmental pollution. We concluded the following: First, the average EE value is about 0.549, and there is high regional heterogeneity, which is high in the east and low in the west. Second, the development of green finance at the national level and in the eastern regions promotes EE and achieves the mutual benefits of economic development and ecological protection, while in the western region, the development of green finance significantly suppresses the EE level and is too low to have a significant effect on EE improvement in the central region. The resource tax policy can significantly improve the EE at the national level and in the eastern region, but on the contrary, it does not have a significant effect on improving the EE in other big regions. Third, the degree of openness to the outside world significantly improves the EE at the national level and in the eastern region. However, in the other two big regions, this effect will not be significant. The effect of the industrialization level on the EE at the national level and in the central and western regions is significantly negative, while in the eastern region, it is negative but not significant. The effect of the energy price level on the EE at the national level and in the central and eastern regions is positive, while it is not significant in the western region. Human capital can improve the regional EE in all regions, and the central region has the highest elasticity coefficient.

Keywords: green finance; resource tax policies; energy efficiency; sustainable development

Citation: Yang, Y. The Impact of Green Finance and Resource Tax Policy on Regional Energy Efficiency Based on the Non-Desired Output Super-Efficiency SBM-Tobit Model. *Sustainability* **2023**, *15*, 11438. https://doi.org/10.3390/su151411438

Academic Editors: Roberto Cervelló-Royo, Donato Morea, Inmaculada Marqués Pérez, Inmaculada Guaita and Javier Oliver-Muncharaz

Received: 5 June 2023
Revised: 18 July 2023
Accepted: 20 July 2023
Published: 24 July 2023

1. Introduction

Energy is the cornerstone of modern social development, and it is important for the production, life, and development of human society. However, with the growing global population and rapid economic development, the energy demand is increasing, and the increasing scarcity of energy resources and environmental problems have become important factors that limit sustainable economic and social development [1,2]. Therefore, achieving sustainable energy development has become a global concern. China's territory is vast, and its total energy reserves are among the highest in the world, but most of them are non-renewable energy sources. In recent years, the Chinese economy has been growing rapidly, industrialization and urbanization have been accelerating, and the proportion of industrial industries in China has been gradually increasing, which has led to a continuous increase in the total energy consumption. The total energy consumption has increased from 980 million tons in 1990 to 5.41 billion tons of standard coal in 2022, an increase of 452.04% in

32 years. In addition, although China's total energy reserves are large, its per capita energy holdings are far from the world average due to its large population [3]. In addition, China's long-term overall energy efficiency is low, and there are large differences between regions and provinces, which will inhibit the sustainable and healthy development of the energy economy. Under the current background of the double carbon policy, adjusting the energy structure, improving the EE, and narrowing the large energy differences between regions are the issues that the country and society need to focus on continuously in the future. Improving the EE includes the efficient use of energy resources, which is an important way to solve energy conflicts in China. China included carbon neutrality in the 14th Five-Year Plan and as a national strategic goal in 2035, aiming to further strengthen the construction of ecological civilization and maintain a balance between economic development and energy use [4]. Therefore, the research on EE in this paper is of great significance both in theory and in reality.

Improving EE is an important option for modern green economies. Green finance involves the innovation and optimization of traditional finance, reflecting the ecological concept. It mainly involves the transformation of the economic structure, the provision of financing services and risk management to low-emission industries, and the promotion of the progress of environmental protection technologies, which can help to improve the quality of the environment and enhance resources [5,6]. Therefore, we need to explore the impact of regional green finance on the EE in China and the mechanism through which it operates. This is essential to further increase green finance and promote EE.

Tax policies are an important tool through which the government manages the economy and society. Through tax policies, the government can regulate the market and social behavior to promote sustainable development [7–9]. At present, in order to cope with the traditional energy crisis, a reasonable taxation system is essential, and resource tax, as a taxation instrument with various taxable natural resources as the object and a separate taxation tool, has been widely adopted throughout the world. It is a crucial economic tool that the government can quickly integrate into resource allocation, and it will help China to enter into the ranks of other green, economical, and environmentally friendly countries. It helps to provide institutional support for China's entry into the ranks of green and environmentally friendly countries. By understanding the impact of resource tax on EE, enterprises can fully realize that the effective use of resources is of great significance to their own interests and the sustainable development of society as a whole and that they should try to conserve resources and protect the environment during the production process. For the taxation department, a clear understanding of the impact of resource tax on EE can allow for the dynamic supervision of resource use based on taxation and realize the function of resource tax while increasing the fiscal revenue. For the government, a full understanding of the different impacts of resource tax on the regional energy efficiency is a reference value for the adjustment and supplementation of the local resource tax system. This paper examines and analyzes the impact of resource tax on the EE and proposes more scientific and feasible countermeasures for the "double carbon" strategy. Therefore, the work explores the impacts of green finance and resource tax policy on the EE and measures the EE of different regions in China based on the super-efficient SBM. This paper focuses on China's resource tax, which can not only improve the existing theory of resource efficiency but can also provide a theoretical reference for China's future resource tax reform, government policy formulation, etc.

The main contributions of this paper are as follows: (1) At present, the factors influencing energy efficiency are mainly studied from the perspectives of the industrial structure, technological progress, and financial development at home and abroad. With the introduction of green finance pilot policies, numerous policy documents and the latest research show that green finance affects energy efficiency. The selected topic operates under the perspective of green finance and provides a new direction for the study of energy efficiency. (2) Since the resource situation of different provinces varies, considering the obvious regional differences in resource distribution, this paper analyzes the heterogeneity of different regional characteristics and studies the overall and local effects of green finance and resource tax on energy efficiency from the variable perspective and regional perspective, respectively. This can allow more targeted policy measures to be developed. (3) There have been many domestic studies on resource taxation, but there have been fewer empirical studies on energy efficiency, and the research in this paper can supplement and improve the related fields.

2. Literature Review

2.1. Energy Efficiency

2.1.1. Meaning of EE

EE describes the amount of energy consumed that contributes to the maintenance or promotion of sustainable development of the entire economic, social, and environmental system. Patterson [10] defines EE as the production of an equal amount of services or useful outputs with less energy input. With energy input reaching 19%, the World Energy Council introduced the general concept of input-based energy use efficiency, that is, a reduction in the energy input that meets the same energy consumption and service needs. EE refers to the consumption of less energy to produce a greater output, while technical EE refers to a reduction in energy consumption due to technological advances and management improvements, among other factors. In terms of connotations, technical EE is similar to EE in that it is the amount of energy consumed that contributes to the maintenance or promotion of the sustainable development of the entire economic, social, and environmental system. The difference is that EE highlights the ecological and environmental benefits of energy consumption. This paper argues that EE is about reducing energy consumption without reducing the quantity of the effective output or the quality of services provided while maintaining the good state and order of social and environmental systems to achieve sustainable development. By definition, EE means achieving the minimum energy input and undesired output with a certain desired output.

2.1.2. Measurement of EE

The measurement of EE at home and abroad is divided into the measurement of single-factor EE and full-factor EE. Regarding the measurement of single-factor EE, Qu [11] considers EE to be the energy consumed per unit of GDP, which is a simple and easy concept to calculate. Chen and Li [12] calculated the energy intensity and then took the inverse of the result to be the single-factor EE. Juan Antonio Duro [13] considered the energy intensity to be a traditional proxy for the EE, which is simple to calculate but has strong one-sidedness. There are parametric methods (SFA) and non-parametric methods (DEA) for measuring the total-factor EE at home and abroad. Scholars, such as Yang et al. [14], Zhao et al. [15], and Chen et al. [16], have used stochastic frontier analysis to measure EE. However, this method makes certain subjective assumptions about the specific production function and is not conducive to the selection of empirical data. Therefore, more scholars are using DEA to measure the efficiency. Wang et al. [17] used a three-stage DEA method to measure the EE between 2010 and 2017 and compared the efficiency values. Luo and Wang [18] measured the total-factor EE using the SE-SBM method and quantified the path of effect using the regression control method and the mediating effect model. Mo et al. [19] measured the green total-factor EE through the SBM-GML index model.

2.2. Research on the Impact of Green Finance on the Regional EE

Scholars have started to explore the relationship between green finance and EE. An [20], Luo [21] argue that the mechanism of green finance can increase the financing pressure of the "three high" enterprises, control the investment scale of these enterprises, and force these enterprises to shift to the field of environmental protection in the future. Du and Ma [22] studied the impacts of carbon-trading pilot policies on carbon emissions through a double difference method and concluded that financial policies can significantly reduce carbon emissions. Yuan [23] studied financial product innovation by financial institutions by considering environmental risk factors in their business operations as green finance. This can guide the use of capital to support energy conservation projects, which can improve the EE and achieve sustainable social development. Li and Wang [24] used the PSM-DID model to study the impact of green finance on the sulfur dioxide concentration with panel data from various provinces and found that the policy can reduce SO2. Zhang et al. [25] found that finance is significantly associated with reductions in the energy intensity. Long et al. [26] concluded that green finance promotes total-factor EE in China through capital financing, cost internalization, and information transfer and is mediated by improving technology.

2.3. Impact of Resource Tax on the Regional EE

In terms of resource taxation and EE, foreign scholars believe that resource taxation can, to a certain extent, reduce resource waste and improve EE. By studying the impact of resource taxation on improving the energy use efficiency and consumer durable prices, Conrad [27] found that taxing energy increases the price of energy and makes it more expensive for consumers to use cars while prompting car manufacturers to develop more energy-efficient vehicles to ensure sales, thereby increasing the energy use efficiency. By presenting and evaluating three scenarios of natural resource extraction at the European and global levels, Giljum et al. [28] argued that government taxes on natural resources can reduce resource consumption and contribute to the sustainability of resource use as countries' demand for natural resources grows. Allcott [29] analyzed the positive and negative externality scenarios of social welfare. By focusing on the impact of the energy resource policy, they argued that the imposition of resource taxes can promote industrial technology upgrades and eliminate negative externalities in energy resource consumption, thus improving the utilization level and efficiency of resource use. Mitch Kunce et al. [30] studied the relationship between resource taxes and fees and resource extraction in the US oil industry by constructing a regression model, suggesting that the government should increase the resource tax rate in the early stage of extraction to increase the tax burden of enterprises and thereby reduce resource extraction. Then, it should reduce the tax burden of enterprises by lowering the resource tax rate, followed by an improvement in the resource utilization rate.

Domestic scholars Xu and Zhang [31] analyzed the economic impact of resource tax on Heilongjiang Province and concluded that resource tax reform improved the utilization rate of resources and also narrowed the economic gap between resource-based and non-resource-based regions. Based on the changes in tax burden levels due to the advalorem reform of coal, crude oil, and natural gas, Zhang [32] pointed out that resource taxes will cause a decrease in the profit level of resource extraction enterprises but will promote enterprises to improve their resource utilization efficiency from several perspectives, such as updating production technology or improving the energy utilization composition. Yu et al. [33] concluded that the introduction of resource tax can effectively improve the resource utilization efficiency through a time series model of the consumption of the above three types of resources and the GDP unit with the resource tax revenue.

In terms of academic research on resource tax policy and the impact of green finance on the EE, there have been many theoretical and empirical studies. However, there are also shortcomings. Firstly, few empirical studies have been conducted on the impact of green finance on EE using data from a single country or region, and there are also insufficient studies involving comparisons between provinces. Secondly, with the emergence of resource and environmental problems, there have been more studies on resource tax and environmental protection, but most of them have adopted qualitative analysis methods, and most of the quantitative analyses have focused on the study of resource tax in an ecological environment or economic structure, and not many scholars have adopted empirical methods to study the impact of resource tax on the EE. In this paper, through the combination of domestic and foreign literature materials closely related to the research topic, we organically link theoretical experience with empirical analysis, use panel regression models, and conduct regional heterogeneity tests to explore the impacts of resource tax policies and green finance on EE, which is conducive to the implementation of differentiated policies according to the local conditions.

3. Theoretical Hypothesis

3.1. Impact of Green Finance on Energy Efficiency

Green finance is used to provide financial support for clean and low-carbon-related projects to solve environmentally caused problems and improve the energy efficiency. First, green finance not only builds a green technology innovation system by broadening financing channels, it also supports zero-carbon emission communities, regions, and city pilots, and promotes the efficient use of green energy. Secondly, green finance supports the continuous improvement of the environmental quality and uses green finance tools to strengthen multi-pollution synergistic management and regional synergistic governance, improve the output level of unit resources, and enhance resource utilization. Finally, green finance drives green consumption, forcing the transformation and upgrade of the front-end industry through green consumption demands at the end, enhancing the effective supply of green products and improving the energy efficiency. Therefore, this paper proposes hypothesis 1: At the national level, green finance has a positive impact on the EE.

Meanwhile, according to the classification of the National Bureau of Statistics, China is divided into three major economic zones: east, central, and west. These areas have different development bases and industrial structures and different economic characteristics, and eastern China is more developed than other regions [34], which may lead to different effects in different regions. But the relationship between green finance and energy efficiency in different regions has not yet been studied. So this paper proposes hypothesis 2: There are differences in the effect of green finance on energy efficiency in different regions.

3.2. Impact of Resource Taxes on Regional Energy Efficiency

In the field of production, the levy of resource taxes will cause the price of energy and mineral resources to rise, and when such a change occurs, rational enterprises will reduce the amount of energy and mineral resources invested, and correspondingly increase the investment of other capital. At the same time, enterprises will also reduce the impact of resource tax burden on enterprise profits through other ways, such as innovative production mechanism, improve the production level, and improve the utilization rate of resources. By analyzing the mechanism of resource tax, it can be found that resource tax can play its role of regulating and controlling the utilization of energy and mineral resources in the production process of enterprises. The implementation of the resource tax system can optimize the production mode of enterprises, promote the rational use of energy and mineral resources by enterprises, and is conducive to the sustainable development of resources.

In the field of consumption, under the price conduction mechanism, increasing the levy of resource tax makes the price of taxable resource products rise, and at that time, rational consumers will choose to reduce the consumption of products using energy and mineral resources and increase the consumption of their substitutes, as well as reduce the waste of energy resources and improve the utilization rate of energy and mineral resources. Resource taxes can play a role in regulating the utilization of energy and mineral resources under the substitution effect of consumer demand.

Accordingly, hypothesis 3 is proposed: Resource taxation can promote energy efficiency at the national level.

Additionally, based on the characteristics of different regions, and economic development in eastern China is generally better than in central and western China, and thus may produce different results in different regions [34]. For example, Yu et al. [33] analyzed the impact of heterogeneity on the utilization efficiency of coal, oil, and natural gas and concluded that the introduction of resource tax can effectively improve EE through a time series model of the above three types of resources and the unit GDP consumption and resource tax revenue. So, hypothesis 4 is proposed: The impact of resource tax on energy efficiency varies across regions.

4. Materials and Methods

4.1. Materials

In recent years, the policy on resource taxation is constantly being improved, focusing on the change in the taxation method. The Ministry of Finance of the State Council proposed a change in the existing resource tax from a quantitative levy to a combination of quantitative and ad valorem taxation with a proportional tax rate of 5% to 10% [35]. Then, the Resource Tax Law was issued and implemented in 2020. It is the ninth substantive tax law in China after the legislation on income tax, vehicle tax, and environmental protection tax, and it improves and consolidates the national tax legalization system [36]. Therefore, based on the availability and timeliness of data, this study extensively collected and collated information from the China Statistical Yearbook, China Taxation Yearbook, China Economic Yearbook, China Energy Statistical Yearbook, China Regional Economic Statistical Yearbook, and other shared platforms, such as the National Bureau of Statistics, provincial finance and taxation bureaus, the foresight database, and wind information. In addition, data on energy saving and environmental protection expenditure, which is a tertiary indicator that is used to measure the development of local green finance, are only available from the Statistical Yearbook for 2008. In this study, panel data from 30 provinces, municipalities, and autonomous regions collected from 2008 to 2021 were used as the sample for empirical analysis to make up for the lack of a macroscopic perspective in existing studies. In particular, in terms of the selection of cross-sectional data, due to the lack of some data on logistics and energy consumption, the paper only selects 30 regions as the object of study in China. In addition, due to the different levels of economic development among the regions, the development of the regions shows unbalanced characteristics; thus, this paper considers three different regions in China to verify and explore the regional differentiation characteristics.

4.2. Method

4.2.1. Super-Efficient SBM Model

Energy efficiency measurement methods are mainly divided into parametric and non-parametric methods. The popular data envelopment analysis and stochastic frontier analysis are both frontier technology analysis methods, both of which can obtain the EE and its decomposition term. Data envelopment analysis is a non-parametric method that does not need to consider the form of the production function and has the advantages of avoiding model misspecification, simplicity, easy decomposition of the constituent terms, easy economic interpretation, and better handling of multiple output scenarios, including pollution data. Therefore, this paper used data envelopment analysis as the main method to account for EE [37]. Traditionally, energy efficiency was mainly measured by radial DEA, which can eliminate the influences of the external environment and random errors and make the energy efficiency value more realistic but does not consider slack variables or the influence of non-expected outputs. Later, following continuous improvement and refinement by scholars, the SBM model was developed, which can solve the problems that exist in traditional DEA. The SBM model solves the problem of the presence of non-desired outputs in the output variables [38,39].

However, when determining the efficiency value according to the SBM model, the efficiency value of the decision variables is generally less than 1. However, on many occasions, the value is 1, and in such cases, the values cannot be used to judge the research object. In such cases, the super-SBM model, also called the super-efficiency model, is used. This model can further compare the efficiency value of the production along the surface, assuming that there are n decision units, that each decision unit has m production input factors and s desired outputs, and that t non-desired variables are obtained. This covers the input X, the desired output Y, and the non-desired output Z, where

$X = (x_1, x_2, \cdots, x_N) \in R_N^+, Y = (y_1, y_2, \cdots, y_M) \in R_M^+, Z = (z_1, z_2, \cdots, z_K) \in R_K^+$. Then, the production possibility set is $P(x) = \{(y, z) : x \to (y, z)\}$. The model is as follows:

$$\rho = min \frac{1 + \frac{1}{N}\sum_{n=1}^{N} \frac{s_n^x}{x_n^i}}{1 - \frac{1}{M+K}\left(\sum_{m=1}^{M} \frac{S_m^y}{y_m^i} + \sum_{j=1}^{J} \frac{S_k^z}{z_k^i}\right)}$$

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

where ρ represents the EE value; and s_n^x, S_m^y and S_j^z are slack variables of the input, desired output, and non-desired output, respectively. i represents the input type; and N, M, and K represent the number of variables for the input, desired output, and non-desired output, respectively. When the values of the slack variables are all 0, then ρ = 1, and the decision unit has no room for improvement; if the slack value is not 0, then the decision unit still has room for improvement.

4.2.2. Variable Selection

Based on the combining of domestic and foreign index systems for EE, the EE index system of this paper was established. In order to measure EE more accurately, both the expected output and non-expected output were considered, so the input factors of the selected areas of EE in this paper were labor, capital, and energy, and the regional GDP was taken as the expected output, while the sulfur dioxide, wastewater, and soot emissions were selected as the non-expected outputs. The indicators are specifically described as follows:

(1) Labor input: labor input should be considered in terms of the quantity, quality, and labor time. Since the labor quality and labor time are difficult to quantify, the degree of social employment in the current year was selected as input indicator in this paper. The calculation formula was as follows: Current year employment = (number of employees at the end of the current year + number of employees at the end of the previous year)/2.

(2) Capital input: Capital stock data cannot be obtained directly and must be calculated according to the relevant formula. After a lot of research, it was found that the most commonly used method was the following formula:

$$K_{it} = K_{it-1}(1 - \delta_{it}) + I_{it}$$

where K_{it} denotes the capital stock in year t, I_{it} denotes the fixed asset investment in year t, and δ_{it} is the depreciation rate. In this paper, we used a weighted average of 10.96% as the economic depreciation rate by referring to the study conducted by Shan [40], and Shan and Shi [41], and the net fixed assets value in 2008 was taken as the base period capital stock, in accordance with Zhang et al. [42]. We constructed a fixed-base index for each province's fixed assets investment index, with 2008 being the base period for the fixed assets investment. The sequence was deflated to obtain the fixed asset investment sequence for comparable prices, and finally, the actual capital stock of each province for 2008–2021 was calculated in billion yuan using the above formula.

(3) Energy input: The total energy consumption was used as the energy input index.
(4) Desired output: The real regional GDP was used as the desired output, and the regional GDP of the 30 regions for 2008–2021 was converted into the real regional GDP based on constant 2008 prices.
(5) Non-desired output: This refers to the factors generated in the process of energy consumption that are unfavorable for the environment. Due to the availability of data and realistic conditions, most of the regional pollution originates from industrial pollution; therefore, wastewater, sulfur dioxide, and soot emissions were selected as non-desired outputs.

If there were missing or omitted data for some years, the data were filled in through the websites of local governments and relevant departments, and if the data were still unavailable, the average value of the data point for the adjacent two years was used. The input–output indicators are shown in Table 1.

Table 1. Input–output indicator system.

Indicator	Category	Content
Input Indicators	Labor input	Social employment for the year in each region
	Capital inputs	Capital stock
	Energy input	Total energy consumption
Output Indicators	Desired output	Real GDP
	Non-desired output	Wastewater emissions
		Sulfur dioxide emissions
		Soot emissions

Note: Data come from the Statistical Yearbook.

4.2.3. Regression Analysis Method

Tobit Model

For the regression analysis of unrestricted dependent variables, the Tobit regression model was chosen to analyze the impacts of influencing factors on the regional EE [43]. The Tobit model takes the following specific form:

$$y_i^* = \alpha_0 + \sum_{j=1}^{l} \alpha_j x_{ij} + \varepsilon_i$$

$$\begin{cases} y_i = y_i^* & 0 < y_i^* \leq 1 \\ y_i = 0 & y_i^* < 0 \\ y_i = 1 & y_i^* > 0 \end{cases}$$

where y_i^* is the potential dependent variable; y_i represents the observed actual dependent variable; x_i represents the independent variables vector; α_0 is the constant term; α_j is the vector of the correlation coefficients; and ε_i is the error term, which is independent and follows a normal distribution.

Variable Selection

(1) Explained Variables

Energy efficiency (EE): EE describes the level of energy consumption that contributes to the maintenance and promotion of sustainable human development. EE is a relative concept with no uniform measurement standard, but it is measured through the quantification of a series of indicators. In this work, the regional EE value was measured through the super-efficient SBM model.

(2) Explanatory Variables

Green finance (GF): By combing existing studies and literature, we found that scholars often adopt single indicators, such as green credit and green investment, to measure the development level of green finance at the inter-provincial level. Considering that a single indicator cannot reflect the level of regional green finance development comprehensively, this paper referred to Yang and Wang [44] and chose the entropy method to construct the indicator system. The method applied in this paper selects five indicators: green credit, green securities, green insurance, green investment, and carbon finance. The specific indicator system was constructed as shown in Table 2.

Table 2. Indicator system.

Primary Indicators	Secondary Indicators
Green Credit	Interest expenses of high energy-consuming enterprises/interest expenses of industrial industries
Green Securities	Total market value of energy-saving and environmental protection enterprises/total market value of A-shares
Green Insurance	Agricultural insurance income/property insurance income
Green Investment	Fiscal expenditure of the energy-saving and environmental protection industry/total fiscal expenditure
Carbon Finance	Carbon emissions/GDP

Note: The data are mainly derived from the Banking Social Responsibility Report published by the China Banking Association, the Wind database, the China Insurance Yearbook and the China Statistical Yearbook.

Resource tax policy (RT): Resource tax revenue can reflect the impact generated by the national resource tax policy. This work aimed to investigate the impact of resource tax on the EE, so the annual mineral resource tax revenue was chosen as the core explanatory variable to visualize the resource tax collection in 30 provinces in the country.

(3) Control variables

Openness to the outside world (OP): Openness to the outside world can allow advanced technology and management techniques to be learnt from abroad and thus can improve the country's EE [45]. In this paper, the ratio of the total regional import and export trade to the GDP is used to express this variable.

Industrialization level (IN): The ratio of the regional industrial output value to the GDP is used to measure this indicator. In this paper, the indicators of industrialization adopted from Gao and Sun [46] were mainly chosen to represent the proportion of the gross industrial output value in the GDP. The data were taken from the Statistical Yearbook, the Compilation of 60 Years of New China Statistics, and the China Industrial Statistics Yearbook.

Energy price level (EP): Since energy prices are difficult to obtain directly, with reference to Jiang and Chen [47] and the data characteristics of China, this paper adopted the provincial power and fuel purchase price index, which is widely used by scholars, to represent the energy price level, and the data are mainly from the China Statistical Yearbook.

Human capital stock (HC): The quality of human capital is expressed in terms of educational attainment. In this paper, we adopted the method of measuring educational attainment proposed by Fu and Wu [48] and classified the educational attainment of employees into five categories according to the composition of China's education system: illiterate and semi-literate, elementary school, junior high school, high school, and college and above. We artificially set the years of education as 2, 6, 9, 12, and 16 years, respectively. The average number of years of education of employees in each region was calculated according to the following formula:

$$\text{EDU} = \sum_{i=1}^{6} edu_{it} P_{it}$$

where edu_{it} is the years of education at each level, and P_{it} is the share of employees with different levels of education. Finally, each year's EDU, the average number of years of education, was multiplied by the number of people employed in the region to obtain the human capital stock. The original data were obtained from the Demographic and Labor

Yearbook for each year. Based on the selection of variables above, the regression model was developed as follows:

$$lnEE_{it} = \beta_0 + \beta_1 lnGF_{it} + \beta_2 lnRT_{it} + \beta_3 lnOP_{it} + \beta_4 lnIN_{it} + \beta_5 lnEP_{it} + \beta_6 lnHC_{it} + \varepsilon_{it}$$

where i denotes the region, t denotes the year, β_0 is a constant term, β_i denotes the coefficient corresponding to the respective variable, and ε_it denotes the random error. $lnEE_{it}$ is the explanatory variable EE, and $lnGR_{it}$, $lnRT_{it}$, $lnOP_{it}$, $lnIN_{it}$, $lnEP_{it}$, $lnHC_{it}$ are the explanatory variables for green finance, resource tax policy, the openness level, industrialization, the energy price, and human capital, respectively. The descriptive statistics for each variable are shown in Table 3.

Table 3. The descriptive statistics for each variable.

Variable	Mean	Standard Deviation	Minimum	Maximum
lnEE	0.549	0.210	0.187	1.324
lnGF	0.133	0.056	0.079	0.239
lnRT	11.45	9.559	8.763	27.219
lnIN	0.316	0.098	0.123	0.664
lnOP	0.312	0.246	0.234	0.343
lnEP	0.244	0.081	0.112	0.564
lnHC	0.187	0.197	0.115	0.559

As can be seen from Table 3, the mean value of green finance after taking the logarithm is 0.133, the minimum value is 0.079, and the maximum value is 0.239, which indicates that the level of green finance in different provinces and cities in China varies greatly. The mean value of resource tax revenue after taking the logarithm is 11.45, the minimum value is 8.763, and the maximum value is 27.219, indicating that the gap of resource tax revenue in different provinces and cities in China is also more obvious, and thus it is necessary to discuss the heterogeneity of different regions.

5. Results

5.1. Regional EE Measurement Results

In this paper, we used MAX DEA's related tools to measure the EE index data for each region from 2008 to 2021 and obtain the comprehensive EE index, as shown in Table 4.

Table 4. EE measurement results.

	Region	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
Eastern	Beijing	0.998	1.097	1.104	1.132	1.135	1.146	1.157	1.162	1.187	1.219	1.226	1.250	1.269	1.324	1.172
	Tianjin	0.415	0.422	0.438	0.441	0.455	0.505	0.523	0.567	0.656	0.743	0.856	0.895	0.966	0.975	0.633
	Hebei	0.356	0.368	0.384	0.415	0.422	0.438	0.462	0.519	0.534	0.613	0.624	0.683	0.756	0.775	0.525
	Liaoning	0.337	0.343	0.356	0.383	0.423	0.448	0.533	0.578	0.585	0.631	0.658	0.677	0.742	0.749	0.532
	Shanghai	0.995	1.003	1.015	1.026	1.077	1.119	1.126	1.135	1.164	1.185	1.196	1.201	1.218	1.243	1.122
	Jiangsu	0.681	0.692	0.721	0.738	0.751	0.768	0.785	0.793	0.821	0.989	1.043	1.097	1.151	1.186	0.873
	Zhejiang	0.679	0.698	0.727	0.736	0.747	0.765	0.796	0.829	0.834	0.891	0.929	0.980	1.027	1.165	0.843
	Fujian	0.488	0.518	0.526	0.541	0.626	0.647	0.722	0.745	0.781	0.812	0.861	0.888	0.922	0.957	0.717
	Shandong	0.436	0.442	0.451	0.464	0.471	0.526	0.542	0.593	0.635	0.643	0.657	0.699	0.724	0.758	0.574
	Guangdong	0.856	0.894	0.918	0.943	0.968	1.024	1.026	1.035	1.041	1.089	1.112	1.132	1.147	1.163	1.025
	Hainan	0.289	0.311	0.328	0.341	0.368	0.405	0.428	0.457	0.466	0.483	0.516	0.549	0.582	0.621	0.439
Eastern mean		0.594	0.617	0.633	0.651	0.677	0.708	0.736	0.765	0.791	0.845	0.880	0.914	0.955	0.992	0.768

Table 4. *Cont.*

	Region	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
Central	Shanxi	0.341	0.349	0.416	0.429	0.437	0.442	0.471	0.515	0.529	0.523	0.537	0.571	0.615	0.679	0.490
	Jilin	0.315	0.332	0.326	0.338	0.391	0.416	0.453	0.496	0.513	0.536	0.562	0.597	0.628	0.659	0.469
	Heilongjiang	0.341	0.355	0.363	0.408	0.413	0.426	0.437	0.453	0.462	0.476	0.499	0.521	0.535	0.538	0.445
	Anhui	0.365	0.377	0.405	0.418	0.423	0.441	0.453	0.462	0.471	0.482	0.524	0.538	0.551	0.584	0.464
	Jiangxi	0.323	0.335	0.367	0.412	0.426	0.432	0.444	0.461	0.495	0.504	0.528	0.575	0.613	0.651	0.469
	Henan	0.331	0.339	0.425	0.437	0.448	0.457	0.462	0.473	0.481	0.492	0.506	0.519	0.524	0.534	0.459
	Hubei	0.337	0.348	0.358	0.363	0.384	0.391	0.428	0.432	0.467	0.494	0.512	0.535	0.545	0.565	0.440
	Hunan	0.341	0.355	0.367	0.418	0.424	0.437	0.447	0.527	0.544	0.563	0.576	0.597	0.613	0.629	0.488
Central mean		0.337	0.349	0.378	0.403	0.418	0.430	0.449	0.477	0.495	0.509	0.531	0.557	0.578	0.605	0.465
Western	Neimenggu	0.302	0.315	0.328	0.338	0.347	0.414	0.426	0.447	0.462	0.511	0.535	0.559	0.583	0.607	0.441
	Guangxi	0.364	0.375	0.387	0.395	0.417	0.423	0.431	0.491	0.516	0.533	0.596	0.615	0.632	0.664	0.489
	Chongqing	0.299	0.321	0.333	0.341	0.353	0.367	0.405	0.423	0.436	0.457	0.463	0.472	0.481	0.499	0.404
	Sichuan	0.286	0.315	0.327	0.385	0.397	0.412	0.428	0.433	0.451	0.523	0.532	0.541	0.552	0.664	0.446
	Guizhou	0.303	0.323	0.335	0.343	0.355	0.437	0.442	0.446	0.452	0.474	0.531	0.565	0.604	0.628	0.446
	Yunnan	0.267	0.284	0.327	0.336	0.363	0.435	0.447	0.458	0.467	0.469	0.474	0.487	0.494	0.506	0.415
	Shanxi	0.302	0.313	0.332	0.343	0.352	0.368	0.423	0.434	0.441	0.448	0.532	0.565	0.614	0.562	0.431
	Gansu	0.311	0.326	0.333	0.346	0.353	0.365	0.478	0.484	0.487	0.517	0.525	0.548	0.567	0.586	0.445
	Qinghai	0.187	0.193	0.218	0.223	0.234	0.248	0.359	0.362	0.330	0.413	0.522	0.537	0.542	0.598	0.355
	Ningxia	0.267	0.282	0.297	0.219	0.226	0.237	0.244	0.357	0.365	0.422	0.458	0.535	0.559	0.579	0.361
	Xinjiang	0.217	0.218	0.226	0.231	0.253	0.266	0.281	0.287	0.322	0.352	0.361	0.432	0.478	0.512	0.317
Western mean		0.282	0.297	0.313	0.318	0.332	0.361	0.397	0.420	0.430	0.465	0.503	0.532	0.555	0.582	0.413
National mean		0.404	0.421	0.442	0.457	0.476	0.500	0.527	0.554	0.572	0.606	0.638	0.668	0.696	0.726	0.549

The average value of total energy efficiency for the Chinese industry from 2008 to 2021 is 0.549, which indicates that the wastage of resources and environmental pollution are serious and there is room for improvement. Secondly, according to the change in EE, the average EE value during the study period increased from 2008 to 2021, being 0.404 in 2008 and 0.726 in 2021, meaning that after a period of rapid development of the Chinese industry, people gradually realized that the crude way of economic growth had seriously deteriorated the resources and the environment, and the government started to put forward environmental protection policies, which led to an improvement in EE. The EE of the east, central, and west regions of China continued the development trend shown for China's overall energy efficiency, and all of them showed an increasing trend in that period. The average values of the east, central, and west regions were 0.768, 0.465, and 0.413, respectively. The highest EE values in the east, central, and west regions were indistinguishable from each other. These results are similar to the conclusions reached by Zhang [33] using the common frontier DEA model. From the above analysis, it is clear that most of the regions in China have high potential for improving their energy efficiency.

5.2. Analysis of the Impact Results for the Regional EE

5.2.1. Correlation Test

To avoid high correlations among the variables, we needed to conduct Pearson correlation tests on the six research variables first. The simple correlation coefficient matrix method was used for these tests (results shown in Table 5).

Table 5. Correlation test results.

Variable	lnGF	lnRT	lnOP	lnIN	lnEP	lnHC
lnGF	1					
lnRT	0.002 ***	1				
lnOP	0.132 ***	0.234 ***	1			
lnIN	0.112 ***	0.209 ***	0.319 ***	1		
lnEP	0.005 ***	0.192 **	0.121 ***	0.298 ***	1	
lnHC	0.021 ***	0.001 ***	0.115 **	0.213 ***	0.001 ***	1

Note: *** and ** indicate $p < 0.01$ and $p < 0.05$, respectively.

Table 5 shows that the maximum coefficient is 0.319, which is the relationship between industrialization and degree of openness to the outside world, indicating that a higher degree of openness to the outside world can improve the regional industrialization level, which is in line with the actual situation of China's economic development. The smallest correlation coefficient is for the relationship between human capital and energy prices, indicating that the correlation between the two is weak, and the absolute values are all less than 0.4, so it can be considered that the model does not have the problem of multicollinearity. However, the correlation is only a preliminary analysis of the coefficients between variables and does not take into account the influences of other variables, which need to be verified in later regression analyses.

5.2.2. Smoothness Test

The unit root test is mainly used to determine the smoothness of the panel data. In time series, the standard t and F tests are invalid if a regression analysis is performed between non-stationary time series. This problem also exists for panel data. Therefore, stability tests should be performed on long-term panel data. For the above reasons, in this section, before building the model, to avoid "pseudo-regression", the data were first tested for stability. This study used the LLC test and the Fisher–ADF test to verify whether the data were smooth or not (results shown in Table 6).

Table 6. Smoothness test result.

Variables	ADF Test		LLC Test		Test Results
	ADF Test Value	*p* Value	LLC Test Value	*p* Value	
lnEE	111.56	0.0000	−8.27	0.0000	Smooth
lnGF	82.44	0.0000	−9.44	0.0000	Smooth
lnRT	86.53	0.0000	−44.78	0.0000	Smooth
lnOP	88.25	0.0001	−8.12	0.0000	Smooth
lnIN	91.37	0.0000	−16.43	0.0000	Smooth
lnEP	98.28	0.0000	−41.593	0.0000	Smooth
lnHC	84.66	0.0000	−9.88	0.0000	Smooth

In Table 6, it can be seen that all variables are homogeneous order single integers that pass the stationarity test.

5.2.3. Model Selection Results

According to the learned econometric theory, there are usually three main forms of panel data to choose from: mixed OLS regression model, fixed effects model, and random effects model. Among them, the mixed model and fixed model can be judged by observing the F-test results, the BP-LM test is used to select the mixed model or the random model, and the Hausman test determines whether the model applies to fixed or random effects. To obtain a concise report, the test results of various methods are organized in this paper in Table 7.

Table 7. Hausman test results.

Test Method	LLC Statistic	*p* Value	Results
Hausman Test	19.46	0.0000	Selecting a fixed effects model
BP-LM Test	689.04	0.0000	Selecting a random effects model
F Test	71.89	0.0000	Selecting a fixed effects model

In Table 7, the F Test shows that a fixed effects model should be used, the BP-LM test shows that the random effects model is more suitable, and the Hausman test indicates that the fixed effects model is better than the random effects model. In summary, the study chose to establish a fixed effects panel model for multiple linear regressions.

5.2.4. Results and Discussion

This study used the Tobit model for the regression estimation. In a fixed effects model, differences between units may lead to heteroskedasticity which, in turn, can affect our judgment of the parameters of the model. In the presence of heteroskedasticity, regression analysis using ordinary least squares (OLS) results in small standard errors, which makes t-values and F-values large. In this case, the OLS estimates are unreliable. Therefore, a robust standard error is needed to correct this problem. Robust standard error is a type of standard error that corrects for the effect of heteroskedasticity. It can be calculated by various methods such as White's method, Huber-White method, etc. Therefore, it was necessary to use heteroskedasticity robust standard errors, and the results are shown in Table 8 below.

Table 8. Regression results.

Variable	National	East	Central	West
lnGF	0.029 ***	0.1418 ***	0.0187	−0.064 ***
	(5.11)	(3.99)	(0.93)	(4.18)
lnRT	0.0211 ***	0.1096 ***	0.0012	0.0043
	(5.98)	(4.21)	(0.99)	(1.23)
lnOP	0.0235 *	0.1238 ***	0.0932	−0.0043
	(1.74)	(4.55)	(1.23)	(−1.46)
lnIN	−0.0443 ***	−0.1564	−0.0997 ***	−0.1123 ***
	(3.28)	(−0.88)	(−4.34)	(4.55)
lnEP	0.0046 *	0.2357 ***	0.1453 ***	0.1012
	(1.86)	(3.77)	(5.67)	(0.88)
lnHC	0.1987 ***	0.0985 **	0.3348 ***	0.0213 *
	(3.98)	(2.44)	(6.21)	(1.82)

Note: *, ** and ***, means $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively.

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

The regression coefficient of the resource tax revenue is 0.0211, which is positive at the 1% significance level. Resource tax plays a role in promoting a reduction in energy consumption and improving the energy efficiency. As part of the cost of energy-consuming enterprises, an increase in the resource tax burden will cause the profit margin of enterprises to narrow. In order to alleviate the pressure of reduced profits, enterprises will reduce the wastage or use of energy resources and improve equipment or production technology to increase the level of utilization of resources in order to reduce their own costs. Therefore, to improve the utilization of energy and promote the comprehensive development of resource utilization, China should increase the implementation of resource tax to promote the sustainable utilization of energy resources in China. This shows that an increase in resource tax will reduce energy consumption and thus improve the EE and mineral resource utilization, which is in line with our expectations. This verifies theoretical hypothesis 3. Additionally, most scholars have reached consistent conclusions; for example, domestic scholars Jin et al. [49] focused on the specific research and analysis of oil and gas resource tax ad valorem reform and the link between resource tax ad valorem and the mineral resource utilization rate and other indicators by means of double difference empirical research. They concluded that the reform of the oil and gas resource taxation method can be improved. The foreign scholar Allcott et al. [29] conducted a study on the positive and negative externalities of resources on social welfare and found that resource tax can improve investment incentives in resource utilization and reduce the negative externalities of resource extraction and utilization, thus enhancing social welfare and promoting economic development.

Looking at different regions, the inverse suppression effect of resource tax revenue on energy consumption varies across regions. There is a significant gap between different regions. In eastern regions, the resource tax coefficient is 0.1096 and passes the test at the 1% significance level. For example, in Jiangsu and Guangdong, economic development does not depend too much on energy consumption, and these provinces have a more advanced concept of energy conservation and attach more importance to comprehensive EE; thus, the resource tax revenue policy can improve EE. On the contrary, in central and western regions, the resource tax coefficients are all positive but do not pass the significance test. For example, Shanxi has coal mine regions with very abundant resources and developed heavy industries with higher requirements for energy extraction and use, where economic growth relies on energy drive. Thus, the impact of resource tax revenue on the reduction in the unit energy consumption is not significant, further indicating the necessity of setting differential tax rates for resource tax. This result verifies hypothesis 4 and shows a strong regional heterogeneity. Existing scholars have conducted less research on regional heterogeneity, and many researchers have focused on the heterogeneity of different types of energy.

Regional green financial development can significantly improve the EE at the 1% confidence level, which is expressed by the specific value showing that, when keeping the relevant control variables unchanged, every one-unit increase in the green financial level makes the corresponding EE increase by 0.029 units, and the effect is relatively obvious. Green finance is important in the field of energy conservation and can also place a certain degree of restraint on high-pollution industries, which can accelerate the green transformation of the economic structure, achieving a series of ecological goals, such as resource conservation and environmental improvement, and realizing the mutual benefit of economic development and ecological protection. The findings of this study verify hypothesis 1 and are consistent with the findings of a large number of domestic and foreign scholars, including An [20], Su and Lian [50], and Wang et al. [51], who argue that the mechanism of green finance will increase the financing pressure of the "three high" enterprises, control the scale of investment of these enterprises, and promote the upgrading and optimization of the regional industrial structure. Palencia et al. [52] argued that green finance promotes the upgrade of the industrial structure through a variety of green financial products, thus achieving the sustainable development of the environmental protection and energy conservation industry.

The different development bases and industrial structures in the eastern, central and western regions may lead to differences in the role of green finance in terms of its influence on the EE. In the eastern region, this effect is also positive and very significant with an elasticity coefficient of 0.1418, mainly because the eastern region is more economically developed, and the financial system and the level of financial development are much higher than those of the central and western regions. Green finance plays a very important role in guiding the ecological environment; for example, by guiding the investment of funds in green industries and low-emission industries, the ecological environment can be effectively improved, and in addition, green finance can guide the use of funds to improve traditional equipment and technology so as to improve the efficiency of energy utilization and achieve green development. However, green finance in the western region does not significantly promote an improvement in the EE, but rather, inhibits the improvement of the regional EE, mainly because the current economic development in the west still relies on regional resource development, and the development of green finance requires a large amount of capital while it aggravates resource development and causes a decline in the EE. The western region should change the current development mode, strengthen the support for green industries, promote technological innovation, guide green investment, promote green financial innovation and development, and practice ecological civilization construction. In the central region, green finance plays a role in promoting EE, but the role is not significant and the impact is weaker, mainly because the similar slow development of green finance in the central region and the western region is not enough to promote EE, but the negative effect in the central region is not significant, indicating that the promotion effect of green finance in the central region is gradually emerging and is expected to appear in the next few years with a significant promotion effect. From the above results, it can be seen that there is a significant difference between green finance on energy efficiency in east, central and west in China. The findings of this study verify the hypothesis 2 proposed, that existing studies mainly focus on the relationship between financial development and EE [53–55] and the relationship between green finance and energy efficiency in different regions has not yet been studied. Thus, this is the main innovation of this paper, which is a supplement and improvement to existing studies.

(2) Regression results for the control variables

It is generally believed that the more open a country is to the outside world, the more absorbance of advanced foreign production technology and management experience there is, and thus, the greater the energy efficiency. However, openness to the outside world may have two effects on the EE that operate in opposite directions. First, as mentioned earlier, provinces learn advanced technologies and experiences from foreign trade and foreign investment, which subsequently generate external spillover effects that improve the production technology of the province as a whole, thus improving the EE. Second, areas with a higher degree of openness to the outside world are generally concentrated in the eastern regions, and the benefits from foreign trade and foreign investment in the eastern regions are much greater than those in the central and western regions, so the external spillover effects from openness to the outside world are also much greater in the east than in the central and western regions. In this context, the improvement in the EE in the eastern region by degree of openness to the outside world is very significant, while the effect on the central and western regions is not significant.

The level of industrialization is negatively correlated with the national EE and passes the test, which is consistent with the results of Wang and Zhou [56]. However, although industrialization in the eastern region is negatively correlated with EE, it is not significant, probably because the eastern region is technologically developed and has a high level of industrialization, and EE is significantly higher than that in the central and western regions. Industrialization in the central and western regions inhibits EE, and it passes the test. It is possible that these two big regions are less industrialized and less technologically advanced, and their use of energy is still crude, so they show a significant negative correlation.

The impact of the energy price on the EE is positive, but the effect is small, which is consistent with the results of Li and Huo [57]; that is, a higher energy price level will improve EE. The impact of the energy price level impact on the EE in the eastern region and the central region is positive, i.e., the higher the energy price level, the higher the EE in China to some extent, which is consistent with the results of Qu [11]. Although the effect of the energy price level on the EE in the western region is positive, it is not significant, mainly because economic development in the western region is overly dependent on resource development, so it does not significantly promote EE.

Through the regression results, it can be found that human capital plays a role in promoting energy efficiency in all regions, mainly because human capital is the source of labor input and innovation, and high-quality labor input can promote the innovation ability of the technical level which, in turn, can improve the energy efficiency. However, the central region has the highest elasticity coefficient, which indicates that its human and capital cooperation is higher, and it can play the role of human capital more efficiently, thus significantly improving the energy efficiency. The eastern and western regions have the highest and lowest human capital, respectively, and the effects are lower than that of the central region, probably because the cooperation of human and capital equipment is not coordinated, thus affecting the efficiency of the human capital's role.

5.3. Robustness Test

There are usually three types of robustness tests: first, changing the proxies for the variables (changing the independent variables, changing the construction method of the dependent variable); second, changing the estimation method, such as considering endogeneity (instrumental variable method, 2sls estimation, GMM estimation, DID estimation); and third, changing the model setting by adding or subtracting variables. In order to further prove the robustness of the model, this paper adopts the replacement model method to carry out the robustness test. In this paper, the Tobit regression model is chosen to analyze the role of each influencing factor on the regional energy efficiency in the regression analysis for the unrestricted dependent variable, and it is found that there are three kinds of dynamic panel model estimation: the mixed OLS estimation, the fixed effect estimation, and GMM through the combining of the literature. Among them, the mixed OLS estimation does not take into account the influence of individual differences, and the fixed effects estimation takes into account individual differences, both of which are estimation methods under the exogenous perspective. Generalized moments estimation GMM is an estimation method for dynamic panels from the endogenous perspective, and there are mainly two estimation methods: differential-GMM and system-GMM. Compared with the differential-GMM method, the system-GMM method combines the results of differential equations and level equations, which is able to overcome the problem of weak instrumental variables on the one hand, and solve the problem of parameter bias and non-consistency in the OLS and FE estimation on the other hand. It not only solves the endogeneity in the model, but also overcomes the problem of weak instrumental variables appearing in the difference equations, and improves the estimation efficiency of the GMM method. Therefore, in order to verify the robustness, the estimated results using the system-GMM model are shown in Table 9 below.

Table 9. Robustness test results.

Variable	National	East	Central	West
lnGR	0.031 ***	0.1632 ***	0.0342	−0.049 *
lnRT	0.0313 ***	0.1214 ***	0.0096	0.0077
lnOP	0.0317 **	0.1095 ***	0.0765	−0.0123
lnIN	−0.0677 ***	−0.1902	−0.0821 ***	−0.1316 ***
lnEP	0.0071 *	0.1998 ***	0.1124 ***	0.0925
lnHC	0.1567 ***	0.0910 ***	0.2988 ***	0.0316 **
AR (1)	0.005	0.012	0.033	0.023
AR (2)	0.177	0.232	0.261	0.221
Sargan test	0.210	0.343	0.183	0.229

Note: *, ** and ***, means $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively.

The results of the robustness test are shown in Table 9. The results show that the size of the coefficient of the impact of green finance and resource tax variables on energy efficiency changes slightly, and the level of significance does not change significantly, and some of the other variables have a change in the level of significance, but there is no change in whether it is significant or not, and the positive and negative coefficients do not change significantly either. The results of the autocorrelation test of the perturbation term showed the existence of first-order autocorrelation, but no second-order autocorrelation; the results of the over-identification test showed that there was no over-identification. Therefore, after replacing the model, the results are consistent with the Tobit estimation and pass the robustness test of the model.

6. Conclusions and Implications

6.1. Conclusions

Based on measuring the EE, this study investigated the impacts of resource tax policies and green finance on the EE, expecting to provide a basis for local governments to make decisions to improve the EE. We drew the following conclusions:

The average EE value is about 0.549, and there is high regional heterogeneity, that is, high in the east and low in the west.

Green financial development can promote EE in China, and green finance can play important roles in energy conservation, environmental protection, cleanliness, and greenness, realizing the mutual benefit of economic development and energy conservation. In the eastern region, this effect is also positive and very significant; however, green finance in the western region does not significantly promote an improvement in EE, but rather, inhibits an improvement in the regional EE. In the central region, green finance plays a role in promoting EE, but the role is not significant, and the impact is weaker.

Resource tax revenue policy can significantly improve EE. An increase in resource tax will improve EE. There is a significant gap between regions. The resource tax revenue policy can improve the EE in the east. On the contrary, the resource tax revenue does not significantly reduce energy consumption in the central and western regions because of the high demand for energy extraction and use by developed heavy industries and the need for energy-driven economic growth, further illustrating the necessity of setting differential tax rates for resource tax.

Openness to the outside world can improve the EE at the national level and in the eastern region very significantly, but the effect is not significant in the central and western regions. The effect of the industrialization level on the EE at the national level and central and western regions is significant and negative, while the effect of the industrialization level on the EE in the eastern region is negative but does not pass the significance test; the effect of the energy price level on the EE at the national level and central and eastern regions is positive, while it is insignificant in the western region. Human capital has a facilitating effect on EE in all regions, and the central region has a higher elasticity coefficient than the other two big regions.

6.2. Directions for Further Research and Limitations

First, there are certain difficulties in the collection of authoritative data and information such as the tax situation and data summarization and analysis, and the acquired data related to the resource tax on energy and mineral resources are relatively short, and some of the data cannot be obtained or updated in time and are missing. The data will be continuously updated in the future research, expecting to draw richer conclusions.

Second, this paper has studied regional heterogeneity and analyzed regional differences, but it has not analyzed the spatial spillover effect between regions, and in the future research, spatial econometric models can be constructed to verify the spatial spillover effect between variables, expecting to draw more valuable conclusions.

Funding: This research was not funded by any funding.

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 author declares no conflict of interest.

References

1. Cortios, N.D.; Duarte, C.C. Energy efficiency in large office buildings post-COVID-19 in Europe's top five economies. *Energy Sustain. Dev.* **2022**, *68*, 410–424. [CrossRef] [PubMed]
2. Soytas, U.; Sari, R.; Ewing, B.T. Energy consumption, income, and carbon emissions in the United State. *Ecol. Econ.* **2007**, *62*, 482–489. [CrossRef]
3. Wang, L.; Yang, C.; Chen, R.H. Study on the impact of FDI on total factor energy efficiency in China: Reflections on the 14th Five-Year Energy Plan. *Foreign Econ. Trade Pract.* **2023**, *1*, 88–96.
4. Tajudeen, I.A. The underlying drivers of economy-wide energy efficiency and asymmetric energy price responses. *Energy Econ.* **2021**, *98*, 105222. [CrossRef]
5. Diaz-Rainey, I.; Corfee-Morlot, J.; Volz, U.; Caldecott, B. Green finance in Asia: Challenges, policies and avenues for research. *Clim. Policy* **2023**, *23*, 1–10. [CrossRef]

6. Zhang, Z.Y.; Hao, L.; Linghu, Y.T.; Yi, H. Research on the energy poverty reduction effects of green finance in the context of economic policy uncertainty. *J. Clean. Prod.* **2023**, *410*, 137287. [CrossRef]
7. Akbari, F.; Salehi, M.; Vlashani, M.A.B. The relationship between tax avoidance and firm value with income smoothing: A comparison between classical and Bayesian econometric in multilevel models. *Int. J. Organ. Anal.* **2018**, *27*, 125–148. [CrossRef]
8. Salehi, M.; Salami, S. Corporate tax aggression and debt in Iran. *J. Islam. Account. Bus. Res.* **2020**, *11*, 257–271. [CrossRef]
9. Akbari, F.; Salehi, M.; Vlashani, M.A.B. The effect of Managerial ability on tax avoidance by Classical and Bayesian Econometrics in Multilevel Models: Evidence of Iran. *Int. J. Emerg. Mark.* **2018**, *13*, 1656–1678. [CrossRef]
10. Patterson, M.G. What is energy efficiency? *Energy Policy* **1996**, *24*, 377–390. [CrossRef]
11. Qu, S.E. Decomposition of inter-provincial total factor energy efficiency changes in China: An empirical study based on Malmquist index. *Quant. Econ. Tech. Econ. Res.* **2009**, *8*, 29–43.
12. Chen, Y.Y.; Li, K.W. The impact of FDI on inter-provincial industrial energy efficiency. *China Popul. Resour. Environ.* **2010**, *20*, 28–33.
13. Duro, J.A. The international distribution of energy intensities: Some synthetic results. *Energy Policy* **2015**, *83*, 257–266. [CrossRef]
14. Yang, L.L.; Shao, S.; Cao, J.H. Decomposition of industrial total factor energy efficiency changes and influencing factors in the Yangtze River Delta city cluster—An empirical study based on stochastic frontier production function. *J. Shanghai Univ. Financ. Econ. Philos. Soc. Sci. Ed.* **2014**, *16*, 95–104.
15. Zhao, J.L.; Li, G.; Su, Y. Regional differences and convergence analysis of energy efficiency in China—An empirical study based on stochastic frontier analysis and panel unit root. *China Manag. Sci.* **2013**, *21*, 175–184.
16. Chen, L.; Li, J.C.; Cheng, K.M. Energy efficiency measurement in Chinese cities. *Bus. Econ. Manag.* **2016**, *7*, 83–96.
17. Wang, X.; Huang, J.; Xiang, Z. Nexus Between Green Finance, Energy Efficiency, and Carbon Emission: COVID-19 Implications From BRICS Countries. *Front. Energy Res.* **2021**, *9*, 786659. [CrossRef]
18. Luo, S.; Wang, D. The effect of carbon trading policy on total factor energy efficiency in provincial areas. *Econ. Geogr.* **2022**, *42*, 53–61.
19. Mo, G.W.; Li, M.; Zhang, W. The impact of industrial structure upgrading, energy efficiency and green development. *Sci. Ind.* **2023**, *23*, 199–205.
20. An, W. A preliminary study on the connotation, mechanism and practice of green finance. *Econ. Econ.* **2008**, *5*, 156–158.
21. Luo, Y.Q. Does green finance improve environmental pollution?—Based on the mediated path analysis of regulated energy efficiency. *Brand Res.* **2021**, *30*, 285–289.
22. Du, L.; Ma, Y.Y. Green development and its performance assessment in countries along the "Belt and Road". *J. Soc. Sci. Jilin Univ.* **2019**, *5*, 135–149+222.
23. Yuan, Y. Research on the Dynamic Relationship between Regional Financial Development and Energy Efficiency. Master's Thesis, Shanxi University of Finance and Economics, Taiyuan, China, 2018.
24. Li, C.X.; Wang, X.Y. Research on the policy effect of green finance on environmental pollution. *J. Hebei Inst. Environ. Eng.* **2021**, *31*, 1–5.
25. Zhang, D.; Li, J.; Ji, Q. Does better access to credit help reduce energy intensity in China? Evidence from manufacturing firms. *Energy Policy* **2020**, *145*, 111710. [CrossRef]
26. Long, S.; Zhang, L.E.; Zhang, S.H. Study on the impact of green finance development on total factor energy efficiency in China. *J. Suihua Coll.* **2021**, *41*, 8–12.
27. Conrad, K. Energy Tax and Competition in Energy Efficiency: The Cases of Consumer Durables. *Environ. Resour. Econ.* **2000**, *15*, 159–177. [CrossRef]
28. Giljum, S.; Behrens, A.; Hinterberger, F.; Lutz, C.; Meyer, B. Modelling scenarios towards a sustainable use of natural resources in Europe. *Environ. Sci. Policy* **2008**, *11*, 204–216. [CrossRef]
29. Allcott, H.; Mullainathan, S.; Taubinsky, D. Energy Policy with Externalities and Internalities. *J. Public Econ.* **2014**, *112*, 72–88. [CrossRef]
30. Mitch, K.; Shelby, G.; William, M.; Ryan, M. State Taxation, Exploration, and Production in the U.S. Oil Industry. *J. Reg. Sci.* **2003**, *4*, 749–770.
31. Xu, M.; Zhang, Y. Analysis of the impact of resource tax reform on the economic development of Heilongjiang Province. *Bus. Manag.* **2019**, *2*, 83–88.
32. Zhang, B.L. The effect of resource tax on the utilization of energy and mineral resources: Institutional orientation and trend judgment. *Res. Financ. Econ.* **2017**, *7*, 73–80.
33. Yu, J.X.; Song, S.S. An empirical analysis of the impact of resource tax on resource utilization efficiency. *Tax Res.* **2021**, *2*, 42–48.
34. Yu, X.; Wang, P. Government Control and the Value of Cash: Evidence from Listed Firms in China. *Rev. Quant. Financ. Account.* **2020**, *55*, 1341–1369. [CrossRef]
35. Tian, Y. National resource tax reform expansion and upgrade. *China Pet. Enterp.* **2014**, *12*, 62.
36. Zeng, X.Q. Consultation on Energy Law and Enforcement of Resource Tax Law: Improving the Legal System for Green Development. *Int. Pet. Econ.* **2021**, *1*, 60–63.
37. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the efficiency of decision making units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444. [CrossRef]

38. Tone, K. Dealing with undesirable outputs in DEA: A slacks-based measure (SBM) approach. *Oper. Res. Soc. Jpn.* **2004**, *2004*, 44–45.
39. Li, G. A study of regional differences in energy eco-efficiency of manufacturing industry considering non-desired output—A two-stage analysis based on SBM and Tobit models. *China Manag. Sci.* **2019**, *11*, 76–87.
40. Shan, H.J. Re-estimation of capital stock K in China: 1952 to 2006. *Quant. Econ. Tech. Econ. Res.* **2008**, *25*, 17–31.
41. Shan, H.J.; Shi, B. Return to capital in China's industrial sector: 1978–2006. *Ind. Econ. Res.* **2008**, *6*, 1–9.
42. Zhang, J.; Wu, G.Y.; Zhang, J.P. Estimation of interprovincial physical capital stock in China: 1952–2000. *Econ. Res.* **2004**, *10*, 35–44.
43. Tobin, J. Estimation of Relationships for Limited Dependent Variables. *Econometrica* **1958**, *26*, 24–36. [CrossRef]
44. Yang, Y.; Wang, G.S. Measuring the level of green financial development—Shanghai as an example. *Hainan Financ.* **2017**, *4*, 20–26.
45. Li, W.W. External openness and energy efficiency: An empirical study based on 35 industrial sectors. *Int. Trade Issues* **2008**, *6*, 7–15.
46. Gao, P.; Sun, Q.L. The impact of industrialization process on regional economic growth in China. *Stat. Res.* **2008**, *25*, 40–44.
47. Jiang, H.; Chen, L. Spatial heterogeneity of energy prices on energy efficiency pushback mechanism-an empirical analysis based on panel threshold model. *Price Theory Pract.* **2017**, *2*, 96–99.
48. Fu, X.X.; Wu, L.X. The development of stochastic production frontier method and its application in China. *Nankai Econ. Res.* **2006**, *2*, 130–141.
49. Jin, C.X.; Zhang, D.M.; Wang, J.M. The policy effect of changing China's oil and gas resource tax from quantitative to ad valorem—An econometric analysis based on double difference method. *Financ. Theory Pract.* **2015**, *36*, 90–96.
50. Su, D.W.; Lian, L.L. Does green credit affect the investment and financing behavior of heavy polluters? *Financ. Res.* **2018**, *12*, 123–137.
51. Wang, K.S.; Sun, X.R.; Wang, F.R. Green finance, financing constraints and polluters' investment. *Contemp. Econ. Manag.* **2019**, *41*, 83–96.
52. Palencia, J.C.G.; Furubayashi, T.; Nakata, T. Analysis of CO_2 emissions reduction potential in secondary production and semi-fabrication of non-ferrous metals. *Energy Policy* **2013**, *2*, 328–341. [CrossRef]
53. Jiang, B.Z.; Tong, Y.; Lu, Z. A study on the influencing factors of financial development and energy efficiency in China. *Financ. Educ. Res.* **2020**, *33*, 22–32.
54. Yang, Y.; Cheng, L.W. Stages of regional financial development affecting energy efficiency. *Sci. Res. Manag.* **2019**, *4*, 125–134.
55. Xu, X.H.; Xie, Z.Z.; Xu, Y. An empirical study on the impact of financial development on energy efficiency changes in China—Analysis based on inter-provincial panel data. *Southeast Acad.* **2018**, *6*, 127–136.
56. Wang, M.; Zhou, F.Q.; Zhao, X.D. Regional energy efficiency analysis based on virtual energy intensity method. *China Foreign Energy* **2012**, *10*, 18–22.
57. Li, G.Z.; Huo, Z.J. Total factor energy efficiency in China, convergence and its influencing factors: An empirical analysis based on inter-provincial panel data from 1995–2006. *Econ. Rev.* **2009**, *6*, 101–109.