The Study on the impact of clean energy development on green economy

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Abstract. Based on the data from 2010-2020 in China, the green economy development index evaluation system is constructed through three dimensions of social life, economic development situation and ecological environment, and the entropy value method is used to measure the level of green economy development, and the panel Tobit model is used for regression analysis. The study shows that clean energy has a significant promotion effect on the improvement of green economy; the per capita clean energy power generation, local financial general budget expenditure, and the value-added index of tertiary industry all show a positive promotion effect on the development of green economy; the daily treatment capacity of urban sewage, electricity consumption and the development of green economy all show an inverse relationship. Therefore, the country should accelerate the construction of energy modernization industrial system, improve people's clean energy usage, and then promote the development of green economy.

Keywords: Clean Energy, Green Economy, Tobit, TOPSIS.

1. Introduction

Currently, China has put forward the concept and goal of "carbon peaking and carbon neutral", which promotes the rapid construction of a green low-carbon cycle development economic system. In the context of the continuous promotion of ecological civilization, green economy has become the theme of economic development in the new era. Therefore, understanding the pattern of China's green economy development and exploring the factors that promote green economy development are of great practical significance for future scientific policy formulation and promotion of green economic and social transformation.

From the perspective of the evolution of energy pattern, new clean energy to replace traditional energy is the general trend, energy development trajectory and law is undoubtedly from high carbon to low carbon, from inefficient to efficient, from unclean to clean. The development and utilization of renewable and clean energy sources such as hydro, wind and biomass are in line with the trajectory of energy development and play an irreplaceable role in establishing a sustainable energy system, promoting national economic development and environmental protection. A large number of scholars have now studied the development of green economy from multiple perspectives. These include digital finance [1], digital inclusive finance [2], government innovation preferences [3], human capital [4], and population density and energy consumption [5], and it is found that all of these aspects have a facilitating effect on green economic development, and the impact of digital inclusive finance on green economic development has a "U" curve relationship [6], while population density and energy consumption and green economic development have an inverted " U" curve relationship between population density, energy consumption and green economy development. In addition, some scholars have studied the green development in Beijing [7], Beijing-Tianjin-Hebei region [8], and the middle reaches of Yangtze River [8,9], and their results show that the factors that significantly affect the efficiency of green development include the level of economic development, industrial structure, and

the level of scientific and technological development, and the cities choose a reasonable industrial agglomeration model to help green economic development, and at the same time, the cities should accelerate industrial adjustment for green development and environmental management. For the development of green economy in each province of the country, some scholars constructed the evaluation index system of big data development level system and green economy efficiency system [10], and the results show that there are differences in the level of big data development and spatial distribution among provinces, but they do not show obvious regional characteristics and spatial differences in green economy efficiency.

In summary, existing literature has explored the impact of digital finance, innovation drive and other aspects on the development of green economy, but few articles have analyzed the impact of clean energy on the development of green economy. Based on the existing research results and methods, this paper broadens the scope of research, based on the general trend that clean energy is bound to replace traditional energy, and uses Tobit model to study the impact of clean energy on green economic growth, so as to provide new ideas for the development of green economy in China.

2. Research Methodology and Data Sources

2.1. Construction of Tobit model

The dependent variable of this paper, green economic development index, is a restricted dependent variable, and if ordinary OLS is used for regression, it will bring bias to the regression results, so a panel Tobit model needs to be used for regression analysis, and the basic form of the panel Tobit model is as follows.

$$Y_{it} = \begin{cases} \partial_0 + \beta X_{it} + u_{it} \\ 0 \end{cases} \tag{1}$$

Where, $\partial_0 + \beta X_{it} + u_{it} > 0$, ∂_0 are the constant terms, y_{it} denotes the green economy of the i city in the t year, β is the regression parameter vector, and u_{it} is the error term. Combining the characteristics of the panel data of green economy development of 30 provinces in China from 2010 to 2020, the Tobit regression model is established as follows.

$$\begin{aligned} Y_{it} = {} & \partial_0 + \beta_1 PDI + \beta_2 CPI + \beta_3 ROU + \beta_4 HED + \beta_5 MTL + \beta_6 GDP \\ & + \beta_7 FT + \beta_8 \inf + \beta_9 fix + \beta_{10} TV + \beta_{11} PCP + \beta_{12} PCW + \beta_{13} WT \end{aligned} \tag{2}$$

2.2. Entropy value method

The entropy method measures the weights according to the degree of variation of indicators, which can eliminate subjective factors to a certain extent, and its formula is as follows.

Indicator selection. With r years, n provinces, and indicators m , x_{ijt} is the value of the indicator j for the i province in the t year.

Positive indicators:

$$x_{ijt}' = \frac{x_{ijt} - \min(x_{1j1}, \cdots, x_{njr})}{\max(x_{1j1}, \cdots, x_{njr}) - \min(x_{1j1}, \cdots, x_{njr})} \tag{3}$$

Negative indicators:

$$x_{ijt}' = \frac{\max(x_{1j1}, \cdots, x_{njr}) - x_{ijt}}{\max(x_{1j1}, \cdots, x_{njr}) - \min(x_{1j1}, \cdots, x_{njr})} \tag{4}$$

Indicator j No. i Share of provincial values in the indicator p_{ijt} :

$$p_{ijt} = x_{ijt}^{'} / \sum_{i=1}^{r}\sum_{i=1}^{n} x_{ijt}^{'} (j = 1, 2, \cdots, m) \tag{5}$$

Calculate the entropy value of the indicator j e_j:

$$e_j = -K\sum_{i=1}^{m} p_{ijt} \ln p_{ijt} (j = 1, 2, \cdots, m) \tag{6}$$

Calculation of indicator coefficients of variation g_j and weights w_j.

$$g_j = 1 - e_j (j = 1, 2, \cdots, m) \tag{7}$$

$$w_j = g_j / \sum_{j=1}^{m} g_j (j = 1, 2, \cdots, m) \tag{8}$$

Calculating the Green Economy Ge_{it}:

$$Ge_{it} = \sum_{j=1}^{m} w_j \bullet x_{ijt}^{'} (i = 1, 2, \cdots, n) \tag{9}$$

The resulting green economy scores were measured for 30 Chinese provinces from 2010 to 2020.

2.3. Variable Description

The dependent variable of this paper is the provincial green economy index (GE). Based on the existing literature analysis and the development goals of the green economy, and drawing on the relevant evaluation system and reference indicators, it is found that the contemporary mainstream view is that the green economy model emphasizes the integrated development of economy, society, and environment. Therefore, this study measures the green economy from three aspects: economic, social, and environmental. The constituent indicators of the provincial green economy index are listed in Table Ⅰ.

Table.1. Provincial Green Economy Level Measurement Index System

Name	Primary indicators	Secondary indicators	Interpretation of indicators	Unit of measurement	Indicator Properties
Green Economic Development Evaluation Index System	Social Life	Income	Disposable income per person	Yuan	+
		Consumption	Per-person consumption expenditure	Yuan	+
		Employment	Unemployment rate	Percent	-
		Higher education	Avg. number of students in college per 100,000 population	Person	+
		Medical	The number of practicing (assistant) physicians per ten thousand people	Person	+
	Economic Development	Per person GDP	GDP of provincial units/resident population in the domain	Yuan	+
		Foreign trade	Total import and export of business unit location	Thousand dollars	+
		Inflation	Consumer Price Index	-	-
		Fixed assets	Investments in fixed assets (excluding farm households) grew over the previous year	Percent	+
		Goods transport	Cargo volume	Ten thousand tons	+
	Ecological Environment	Green space situation	Green space per person	Square meter per person	+
		Water resources	Water resources per person	Cubic meter per person	+
		Wastewater treatment	Operational costs for industrial wastewater treatment facilities put in a year	Ten thousand yuans	+

The independent variable is the provincial clean energy generation (CE).

The control variables are daily municipal wastewater treatment capacity (DT), local general budget expenditure (GB), electricity consumption (PC), and tertiary industry value-added index (AD).

2.4. Data sources

Thirty provincial administrative units in mainland China, excluding the Tibet Autonomous Region, were selected as samples, and a panel database was established to measure the provincial green economy index in China using the entropy method. The original data in this study are the relevant data of 30 provincial administrative units from 2010-2020, which are obtained from the China Energy Statistical Yearbook, National Bureau of Statistics, and China Stock Market & Accounting Research Database database, in which individual missing data have been made up using the mean value method.

3. Analysis of empirical results

3.1. Base regression results

The data for the independent, dependent, and control variables were analyzed using the Tobit model and the results are shown in Table Ⅱ.

Table.2. Tobit regression results

GE	Tobit	
	(1)	(2)
CE	0.2368***	0.1309***
	(0.0382)	(0.0487)
DT		-0.3916***
		(0.1441)
GB		0.0775***
		(0.0133)
PC		-0.1210***
		(0.0412)
AD		0.0001
		(0.0004)
sigma2_u	0.1253***	0.1358***
	(0.0162)	(0.0181)
sigma2_e	0.0182***	0.0171***
	(0.0007)	(0.0007)
LR	1083.02***	852.66***

***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively.

The provincial clean energy generation is positively correlated with the green economy index and is significant at the 1% level, indicating that the increase in clean energy generation is beneficial to the green economy growth of the province. This is mainly because electricity is an important energy source applied in our daily production and life, and clean energy generation is more friendly to the environment compared with traditional thermal power generation. Not only that, but clean energy generation also has a positive effect on cost saving and structure optimization.

The daily municipal wastewater treatment capacity is negatively correlated with the green economy index and is significant at the 1% level, indicating that an increase in the daily municipal wastewater treatment capacity in the current condition will be detrimental to the growth of the green economy. This may be due to the fact that the current wastewater treatment technology is not mature and requires more energy consumption or generates other wastes in the process of treating wastewater.

The general budget expenditure of local finance is positively correlated with the green economy index and significant at the 1% level, indicating that the growth of general budget expenditure of local finance will be beneficial to the development of the green economy. With the continuous development

of China's ecological civilization construction, local governments actively invest financial resources to support green development, and the proportion of this investment in finance is increasing.

Electricity consumption is negatively correlated with the green economy index and is significant at the 1% level, indicating that the increase in electricity consumption is not conducive to the development of the green economy. Thermal power generation still accounts for a large proportion of electricity production, and the increase in electricity consumption also means an increase in electricity generation, which is bound to have a bad impact on the environment and other aspects.

The value-added index of the tertiary industry is positively correlated with the green economy index, but the results are not significant. This indicate that the development of tertiary industry in Chinese provinces does not support the growth of a green economy, which means that the development of tertiary industry needs to be further improved.

3.2. Robustness tests

To ensure the stability and accuracy of the results, the model was tested for robustness. The independent variable of clean energy generation is supplemented and enriched by adding this variable to the production of natural gas and converting it to electricity generation in the corresponding proportion: according to the Energy Statistics Yearbook, the average heat of natural gas is equal to 32,238-38,931 kJ per cubic meter, and the average heat of electricity is 3600 kJ per kWh, taking its middle value, the natural gas The average heat generation is 36000 kJ per kWh, which means that the energy value of each cubic meter of natural gas is 10 kWh of electricity. The clean energy generation from the original model is summed to obtain the clean energy equivalent generation. Other than this, the other data in the original model are kept constant and the calculation results are shown in Table Ⅲ.

Table.3. Robustness test results

RE	Tobit	
	(3)	(4)
CE	0.1358***	0.0767***
	(0.0239)	(0.0288)
DT		-0.4198***
		(0.1439)
GB		0.0809***
		(0.0130)
PC		-0.1208***
		(0.0412)
AD		0.0001
		(0.0004)
sigma2_u	0.1266***	0.1370***
	(0.0164)	(0.0183)
sigma2_e	0.0184***	0.0171***
	(0.0008)	(0.0007)
LR	1075.77***	860.88***

4. Conclusions and Recommendations

4.1. Conclusion

This paper constructs an evaluation system of green economy development indexes from three dimensions: social life, economic development situation and ecological environment, uses entropy value method to measure the level of green economy development, analyzes the impact of clean energy on green economy in 30 Chinese provinces from 2010 to 2020, and concludes that the research is as follows.

First, clean energy has a significant promotion effect on the improvement of green economy. Through panel data model, regression analysis and robustness test, it is found that clean energy has a significant promoting effect on green economy.

Second, the per capital clean energy generation, local general budget expenditure, and tertiary industry value added index all show positive promotion effects on the development of green economy. Increasing the use of clean energy and the proportion of government expenditure on clean energy will contribute to the development of green economy, while increasing the proportion of tertiary industry development can effectively reduce pollution emissions and resource consumption.

Third, the daily treatment capacity of urban sewage, electricity consumption and green economy development all show an inverse relationship. It indicates that the use of traditional energy will be detrimental to the development of green economy, and the use of traditional energy should be reduced and the efficient use and reasonable transformation of traditional energy should be increased, which will help the use of clean energy and promote the development of green economy.

4.2. Recommendations

According to the above research findings, this paper puts forward the following policy recommendations.

First, accelerate the energy modernization industrial system, clean energy fully meets the needs of sustainable development and can effectively promote the development of green economy. In order to cultivate clean energy enterprises with global competitiveness, the country needs to increase the publicity of clean energy, from top to bottom, to deepen people's awareness of clean energy. The organic integration of traditional energy elements and new clean energy elements.

Second, promote the use of clean energy and increase policy guidance. Increasing central and local spending on clean energy and providing economic subsidies to enterprises and households that use clean energy, along with the introduction of technical talents by the state, will help to further promote the construction of a national new energy industry innovation demonstration zone and accelerate the construction of a clean, low-carbon, safe and efficient energy system.

Third, gradually reduce the use of traditional energy floating on the sea surface to make its efficient use, while guiding the transformation of traditional energy to find a balance between traditional and clean energy. For example, Ningbo City in Zhejiang Province has built a photovoltaic carbon reduction "basket", with complementary light fishing and complementary light agriculture, ground support and full control.

Setting reasonable targets for clean energy development and building clean energy industries will promote high-quality development of the green economy. As the cost of clean energy decreases and the proportion of clean energy in energy production and energy consumption increases, the carbon neutrality target may be achieved ahead of schedule, and people's quality of life will improve steadily.

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