Economic Development Efficiency Based on Tobit Model: Guided by Sustainable Development

Ming Liu
Department of Business and Accounting, Henan Open University, Zhengzhou, 450000, China

***Abstract*—At present, in resource-based regions in China, it has been seriously restricted in the harmonious growth of green economy (GE) and environment. To find and solve the problems that affect the quality of regional GE development, the study took Xinjiang, a resource-based province, as the research object. With the data of 14 prefectures and cities in Xinjiang from 2017 to 2022, an evaluation model for the efficiency of GE development based on DEA-Tobit was constructed. Data envelopment analysis (DEA) measures the spatial autocorrelation and distribution characteristics of GE development efficiency in various prefectures and cities in Xinjiang. The influencing factors were analyzed by using Tobit model. From the empirical results, there are obvious differences in the spatial distribution of GE development among various prefectures and cities in Xinjiang. The average value is 0.7289, the highest value is 1, and the lowest value is 0.3684, with a difference of 0.6316. The efficiency values of GE in the seven regions R1, R2, R4, R6, R7, R9, and R13 have reached 1, and DEA is effective. Based on the global and local Moran index, it can be seen that there is no obvious spatial correlation between the development efficiency of green economy in the cities and cities of Xinjiang, and the absolute value of its coefficient is not more than 0.5. From the results of the Tobit model, there are still areas for raising the efficiency of GE development in most regions of Xinjiang. Based on the established DEA-Tobit GE development efficiency evaluation model, this study proposes targeted development strategies for improving the efficiency of GE development in Xinjiang.**

***Keywords*—Tobit model; DEA; economic development efficiency; Moran index**

I. Introduction

The coordination and win-win situation of "economic growth" and "resources and environment" is the essence of green development. Improving the quality of economic development and enhancing the GE efficiency is the way to achieve that. [1]. Currently, green development is promising direction of development. The proposal of this concept can not only solve the relationship between humans and nature, but also apply the concept to people's daily lives. This has played a positive role in establishing a resource saving and environmental friendly society. This has achieved the harmonious development of the economy, society, and ecological environment [2]. Along with the sustained and rapid growth of economy, the ecological environment has also deteriorated. This has restricted the harmonious development of the economy and environment in countries, especially in resource-based regions. However, in the current researches, there are few systematic researches on the efficiency of GE development in specific provinces. In the northwest frontier of China is Xinjiang, a province with harsh natural environmental conditions and a low economic development. Ecological and environmental problems occur consequently. This has restricted the high-quality development of Xinjiang's economy [3,4]. Therefore, achieving green transformation and development in Xinjiang is an inevitable requirement for achieving sustainable development. Since there are few research results on green economy development efficiency in Xinjiang, taking it as the main body of research and carrying out detailed research from prefecture-prefecture level can enrich the field of green economy development efficiency in this region. Based on the double carbon background, this study applies the green related theory to the reality of green economy development in Xinjiang, which can expand the research ideas in this field. In addition, the research mainly constructs two empirical models. They are the DEA model of non-expected output and the Tobit spatial measurement model respectively; and the representative indicators of Xinjiang region are selected. This experiment not only measured the development efficiency of green economy in this region, but also innovatively conducted a further comparative analysis of its spatial distribution characteristics. The research combines measurement methods, spatial distribution rules and influencing factors to make the research results more convincing. Since the improvement of the development efficiency of green economy is a long-term development process, its input and output have a certain lag, which will also have a certain impact on the measurement results. This is what future research needs to improve as much as possible.

This study takes the green development of various states in Xinjiang as the research object, including five parts. At the beginning of the article, the first part mainly introduces the research background, significance, current situation and methods of the development efficiency of green economy. The second part describes the theoretical basis of green economy development and literature review. Respectively from the foreign and domestic two levels to comb and summarize. The third part is the method design of economic development efficiency measurement. It is mainly divided into two sections. The first section is to preliminarily screen the evaluation indicators of green economic development efficiency and establish a DEA model to calculate the corresponding green development efficiency value. The second section further extracts the effective indicators and constructs the evaluation model of green economy development efficiency based on Tobit. The fourth part is the empirical analysis of green economy development efficiency in Xinjiang from 2017 to 2019. The corresponding data were collected, and the spatial panel Tobit regression model was established to analyze the influence degree of the seven indicators on the green development efficiency in Xinjiang. The last part is based on the empirical analysis results, and puts forward specific suggestions for the green development of Xinjiang.

II. Related Works

With the economic development and living standard improvement, natural environmental pollution is also increasing. Therefore, the GE has gradually become the hot issue of many researchers at home and abroad, and has been studied in various aspects. Scholars such as Ohene Arsare have evaluated the energy efficiency of African countries and its determinants through bootstrap truncated regression. The study showed that economic development and technological progress had a positive influence on energy efficiency in African countries [5]. Researchers such as Mikhno analyzed environmental impact factors on other quality of life indicators and the main trends and issues that had emerged since the introduction of the "GE". Research has proven that with the extensive development of the economy, the per capita GDP has significantly decreased [6]. Wang et al. constructed a coupling coordination degree evaluation method with entropy weight. Quantitative analysis was conducted on the sustainable development trend and subsystem coupling of regional GE. Research has shown that the model is feasible for the development of regional GE [7]. A heterogeneous stochastic frontier model was used to measure China's GE efficiency by researchers such as Qin. The GE efficiency in China was unsatisfactory, and regional heterogeneity was significant [8]. GE efficiency and regional differences of 11 cities in Zhejiang were measured with the non-radial DEA model of the Malmquist index by Lu et al. From the research, the main factors affecting the urban GE efficiency in Zhejiang were industrial structure, environment, and urbanization degree [9].

Scholars such as Zhao measured the air pollution control by adopting the proportion of air pollutant emissions to GDP. This study has effectively verified the relevance among air pollution, technology, investment, and GE development [10]. Zheng and other researchers based on the super-efficient DEA framework. It incorporated non expected output into the measurement index of regional economic development with a non-radial distance function. This study showed that the influence of financial aggregation on local GE had a non-linear threshold feature [11]. Lebedeva et al. compared existing GE assessment methods. The study found that current methods were mainly used to measure the "greening" of the economy [12]. To raise the efficiency of urban GE planning, researchers such as Liu have constructed a model based on an improved genetic algorithm. From the research results, the model has a high calculation accuracy and can be adopted in the design of urban greening planning [13]. Rutskiy and other experts have constructed a regression model based on empirical correlation. This model defined the impact of GE factors on manufacturing productivity. The research results showed that pollution control equipment and factory investment had a significant positive impact on the GE manufacturing industry [14].

To sum up, predecessors usually compare efficiency measurements based on a single structured data indicator system, while there are few researches on the major reasons influencing the efficiency of GE development. In addition, the systematic and comprehensive efficiency analysis for specific provinces is also absent. Therefore, this study is aimed at specific provinces and regions, using Tobit model and DEA to measure the reasons influencing the efficiency of GE development in the province, thereby providing practical suggestions for these factors.

III. Economic Development Efficiency Based on Tobit Model

A. Preliminary Selection of Evaluation Indicators for the Efficiency of GE Development

The term "GE" was proposed by the famous British economist Pearce. It believes that the GE is an economic development model that both human and nature can bear [15]. Moreover, this model will not cause ecological and social imbalances due to economic growth, nor will it restrict the constant growth of economy due to the depletion of natural resources. With the introduction of GE, many methods have been developed to measure the efficiency. However, there is currently no complete indicator system for the efficiency of GE development. Based on massive relevant achievements on green development, combined with the actual situation and data of various states and cities, the study screened the issues that affecting the efficiency of GE. For the establishment of an indicator system, it is first necessary to follow the principles shown in Fig. 1.

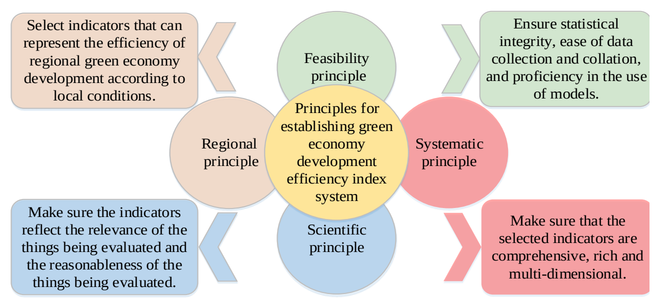


Fig. 1. Principles of establishing GE development efficiency index system.

In Fig. 1, the selection of this indicator requires four principles in order. The first is the principle of feasibility. The foundation of model implementation is data. When selecting indicators, it is necessary to consider whether the statistical data is complete, the difficulty of data collection, the proficiency in using models, and the feasibility of the results. The second is the systematic principle. The evaluation of the efficiency of the GE development involves multiple aspects such as resources, environment, and economy. Therefore, when selecting indicators, it is necessary to ensure that they are comprehensive, rich, and multidimensional. To make the calculation results more objective and reasonable, different indicators should be selected from multiple aspects to avoid interference with the evaluation results. Then there is the regional principle. When constructing an indicator system, it is needed to select GE development efficiency indicators that can represent different regions based on the economic level, cultural and geographical environment, and other conditions of different regions. Finally, there is the principle of scientificity. In constructing an indicator system, science should be taken as the basis. The selected indicators should be able to reflect the relationship between the evaluated things, while ensuring the rationality of the evaluation results of the model. With the principle of indicator selection, the research preliminarily divides the efficiency of GE development into three categories of indicators, as shown in Fig. 2.

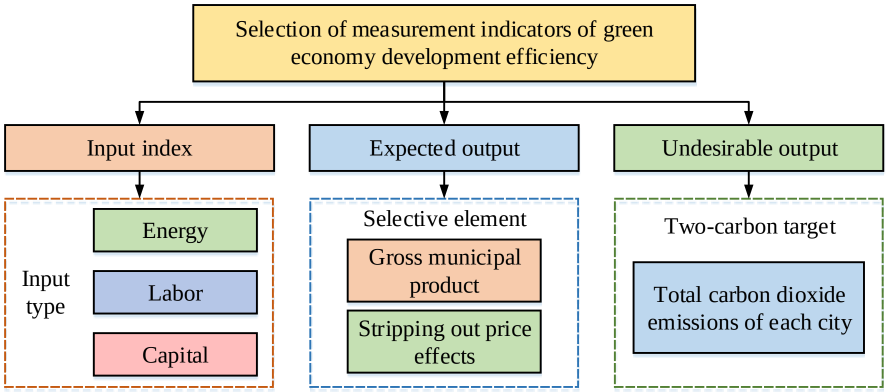


Fig. 2. Selection of measurement indicators of GE development efficiency.

In Fig. 2, the selection of investment indicators generally focuses on capital, labor, and energy inputs. Based on the availability and scientificity of data, capital investment is usually the amount of fixed assets investment of the whole society in each city. Energy input refers to the consumption of energy by enterprises or industries above designated size. Labor input is the total population of each city. In the current government work report, it is mentioned that efforts should be made to achieve the dual carbon goal and optimize the industrial and energy structure [16]. Therefore, the research takes the CO_2 emissions of each city as an unexpected output.

DEA is a relatively effective method for measuring efficiency values [17]. Measurement models consist of two broad categories, namely radial and non-radial, and angular and non-angular. Due to the fact that traditional DEA models do not take into account the slack issues caused by inputs and outputs, there may be a certain degree of calculation bias due to the existence of unexpected outputs when measuring efficiency values. Non-radial and non-angular DEA-SBM models were put forward to solve this issue [18]. The model considers the problem of relaxation variables and improves the accuracy of efficiency. The study compared various models and data collection, and ultimately selected the DEA model with unexpected outputs. The calculation expression of the DEA model for undesired outputs is shown in Equation (1).

$$\rho^* = \min \frac{1 - \frac{1}{w}\sum_{i=1}^{w}\frac{s_1^-}{x_{i0}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{s_2}\frac{s_r^b}{y_{r0}^b}\right)} \tag{1}$$

In Equation (1), ρ^* represents the efficiency value of GE development s_1, w, s_2 represents the total of elements of expected output, input, and undesired output, respectively. s^-, s^g, s^b are the relaxation variables of expected output, non-expected output, and input, respectively. x, y^g, y^b is input value, expected output value, and non-expected output value, and their respective calculation expressions are shown in Equation (2).

$$s.t. = \begin{cases} x_0 = X\lambda + s^- \\ y_0^g = Y^g\lambda - s^g \\ y_0^b = Y^b\lambda + s^g \\ s^- \geq 0, s^g \geq 0, s^b \geq 0, \lambda \geq 0 \end{cases} \tag{2}$$

In Equation (2), λ represents the weight vector. X, Y^g, Y^b represents a matrix composed of unexpected outputs, inputs, and expected outputs, respectively. The spatial autocorrelation test can reflect the overall distribution among regions. The spatial distribution characteristics of natural and ecological factors and their interrelationships can be measured by the spatial autocorrelation coefficient [19]. Moran's I coefficient and Geary's c coefficient are main indices for spatial autocorrelation analysis [20]. The global and the local Moran index are used to organise a spatial analysis of the GE development efficiency of each city, and judges whether the northern objects have a certain degree of agglomeration in space. The spatial correlation between a region and all regions can be reflected by the global Moran index. And it also can be applied to test the spatial dependence, spatial patchiness, and the degree of dispersion of gradients among all elements of the space as a whole. The calculation expression is expressed in Equation (3).

$$I = \frac{n\sum_{a=1}^{n}\sum_{b=1}^{n}\varpi_{ab}\left(x_a - \bar{x}\right)\left(x_b - \bar{x}\right)}{n\sum_{a=1}^{n}\sum_{b=1}^{n}\varpi_{ab}\left(x_a - \bar{x}\right)^2} = \frac{n\sum_{a=1}^{n}\sum_{b=1}^{n}\varpi_{ab}\left(x_a - \bar{x}\right)\left(x_b - \bar{x}\right)}{s^2 n\sum_{a=1}^{n}\sum_{b=1}^{n}\varpi_{ab}} \tag{3}$$

In Equation (3), x_a, x_b represents the observed values of a, b respectively. $\bar{x}$ represents the average value observed in all regions. The spatial weight is ϖ, and n represents the number of samples. When Moran index $I > 0$, it indicates that the development efficiency of GE has a positive spatial correlation, and the greater the I value, the stronger the correlation. When the Moran index is $I = 0$, it indicates that the efficiency value is randomly distributed in space. The significance test of its spatial autocorrelation is performed using the standardized statistic $Z(I)$, and its calculation expression is shown in Equation (4).

$$Z(I)=\frac{I-E(I)}{\sqrt{VAR(I)}} \quad (4)$$

In Equation (4), $E(I), VAR(I)$ represents the variance and expected value of the global Moran index, respectively. The local spatial autocorrelation analysis is performed using the local Moran index to reflect the relevance between a certain area and its surroundings. The calculation expression is shown in Equation (5).

$$I_i=\frac{x_a-\bar{x}}{s^2}\sum_{b=1}^{n}\omega_{ab}\left(x_b-\bar{x}\right) \quad (5)$$

The parameter meaning in Equation (5) is the same as the global Moran index, and the significance level is also tested using $Z(I)$.

B. Construction of Evaluation Model for GE Development Efficiency Based on Tobit

After preliminary screening of evaluation indicators for the efficiency of GE development, it is also necessary to focus on the actual GE development in the study area, guided by sustainable development, and conduct in-depth research on its various influencing factors. Based on the preliminary indicator selection of GE development, the study expanded it, and combined with the actual green development situation in Xinjiang, the specific indicators selected are shown in Fig. 3.

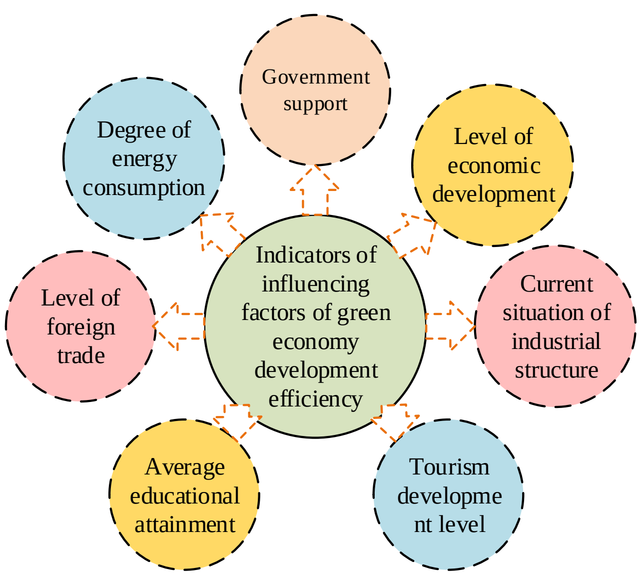


Fig. 3. Selection of influencing factors of GE development efficiency.

In Fig. 3, the study selected seven representative indicators as specific evaluation indicators for the standard of green development in Xinjiang. These include government support, economic development level, current industrial structure, tourism development level, average education level, foreign trade level, and energy consumption level that play an important role in Xinjiang's development. Tobit model is a generalization of Probit regression model proposed by economist James Tobin. It refers to an econometric model with hidden variables, although continuously distributed at positive values, still contain a portion of observations with a positive value of 0 [21]. The model uses the maximum likelihood method for estimation. In parameter estimation, this can better avoid bias or inconsistency issues. The model expression is shown in Equation (6).

$$r_i=\begin{cases} r_i\cdot=v_i\beta+\varepsilon, r_i\cdot>0 \\ 0, \qquad r_i\cdot\le 0 \end{cases} \quad (6)$$

In Equation (6), v_i represents the explanatory variable. $r_i\cdot$ is the interpreted variable. β represents a regression parameter. ε represents a random perturbation term. Before figuring out the issues influencing the efficiency of GE development in various cities in Xinjiang, it was clear that the explained variable value was in the range of 0-1, so the Tobit model was used as the analysis method in the study. The efficiency of GE development is used as the explanatory variable, and the statistical yearbooks or bulletins of different cities in Xinjiang are used as the data source for studying the explanatory variable. According to the Tobit model, the resulting regression equation is constructed as shown in Equation (7).

$$Y_{gh}=\beta_1X_{1gh}+\beta_2X_{2gh}+\beta_3X_{3gh}+\beta_4X_{4gh}+\beta_5X_{5gh}+\beta_6X_{6gh}+\beta_7X_{7gh}+\varepsilon \quad (7)$$

In Equation (7), $\beta_1,\beta_2,\beta_3,\beta_4,\beta_5,\beta_6,\beta_7$ represents the parameter to be evaluated. g represents the city of Xinjiang, and h represents the year. The explanatory variables and the interpreted variables are expressed in Table I.

TABLE I. EXPLAINED VARIABLE VERSUS INTERPRETED VARIABLE

Statistical variable	Index name	Variable	Meaning
Explained variable	Efficiency of GE development	Y	Efficiency of GE development
Interpreted variable	Government support	X_1	Share of General Public Budget expenditure in GDP (%)
	Level of economic development	X_2	Per capita gross regional product (yuan)
	Current situation of industrial structure	X_3	Proportion of output value of secondary industry in GDP (%)
	Tourism development level	X_4	Share of tourism revenue in GDP (%)
	Average educational attainment	X_5	Proportion of the total number of students in school to the total population of the District (%)
	Level of foreign trade	X_6	Total imports and exports as a percentage of GDP
	Degree of energy consumption	X_7	Energy consumption per unit of GDP (10,000 tons of standard coal / 10,000 yuan)

There are contradictions and incompatibilities among various factors in the indicator system, so the study conducts dimensionless quantitative processing on the values of the original indicators. Since most of the indicators are benefit based, the linear standardization method is used for processing. Equation is the standardized calculation of positive indicators (8).

$$X_{ij} = \frac{x_{ij} - m_j}{M_j - m_j} \tag{8}$$

In Equation (8), j represents the selected indicators. i represents each city. X_{ij} is the value of the j indicator i region after standardization. x_{ij} represents the original value. M_j, m_j represents the maximum and minimum values of the j index during the sample period. The standardized calculation of inverse indicators is expressed in Equation (9).

$$X_{ij}^{'} = \frac{M_j - x_{ij}}{M_j - m_j} \tag{9}$$

Then, each indicator is weighted. Entropy method can avoid the interference of subjective factors and the importance of indicators is taken as the basis for weighting. Therefore, the research mainly uses entropy method to work out the proportion of specific indicators in the indicator system. It assumes that there is an indicator data matrix composed of m evaluation objects and n evaluation indicators. The higher the degree of dispersion of data, the lower the value of information entropy, and the greater the corresponding weight. Due to the standardization of some indicator values, the data may be small or even negative. Therefore, to ensure convenient and uniform calculation, its standardized values will be translated. The calculation expression is shown in Equation (10).

$$x_{ij}^{'} = H + x_{ij}^{'} \tag{10}$$

In Equation (10), H represents the magnitude of the indicator shift, typically taking a value of 1. The weight of an indicator can be determined with entropy method. It represents a measure of uncertainty, and a smaller value indicates a higher degree of variation. The more information offered by that, the more the weight it occupies. The calculation expression of the ratio of the market value of the i land under the j th indicator in this indicator is shown in Equation (11).

$$p_{ij} = x_{ij}^{'} / \sum_{i=1}^{n} x_{ij}^{'} \tag{11}$$

In Equation (11), p_{ij} represents the proportion of $x_{ij}^{'}$. However, after the indicator is standardized, a value of 0 may appear during processing. Therefore, the study shifted the entire processed data to the right by 0.0001 units to make the 0 value after standardization meaningful. Then determine the information entropy value of the j index, as shown in Equation (12).

$$a_j = -k \sum_{i=1}^{n} y_{ij} \ln p_{ij} \tag{12}$$

In Equation (12), a_j represents the information entropy value of each indicator. n represents the sample number of each indicator. k represents a constant, which is related to the number of samples n, as shown in Equation (13).

$$k = 1 / \ln n \tag{13}$$

Information entropy a_j can be used to measure the information utility value of the j th indicator. When the information is completely out of order, $a_j = 1$. At this time, the utility value d_j of the indicator of a_j for comprehensive evaluation is 0. The relationship between the information usage value a_j of the indicator and the information entropy d_j of the indicator is expressed in Equation (14).

$$d_j = 1 - a_j \tag{14}$$

In Equation (14), $j = 1, 2, \cdots\cdots p$. When using the entropy to calculate the weight of each evaluation index, the higher the coefficient in the evaluation, the greater the importance of the evaluation. On the contrary, the importance of evaluation will be smaller. The weight expression of the j index is obtained in Equation (15).

$$\omega_j = d_j / \sum_{j=1}^{n} d_j \tag{15}$$

According to the weights of various indicators, it needs to build corresponding for the standardized values of various indicators of data, and then the linear weighting method is used to calculate the sum of efficiency values.

IV. An Empirical Analysis of the Efficiency of GE Development

After preprocessing the collected data, based on the non-expected output DEA model proposed in the study, the GE development efficiency of four prefecture-level cities, five regions, and five autonomous prefectures in Xinjiang were measured by MATLAB R2017b software. In the experiment, these 14 prefectures and cities in Xinjiang were named R1-R14. Their calculation results are shown in Fig. 4.

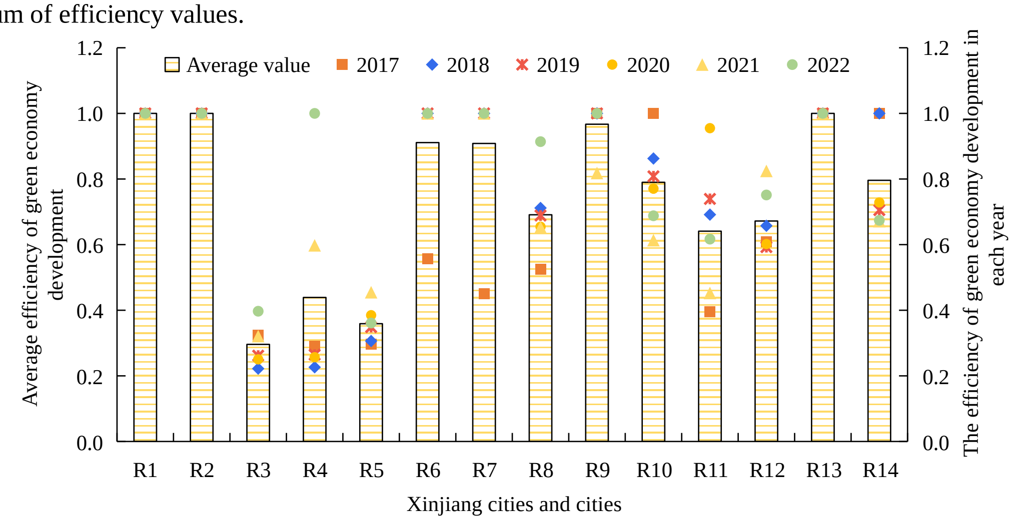


Fig. 4. GE development efficiency of 14 prefectures and cities in Xinjiang from 2017-2022.

From Fig. 4 it is clear that the spatial distribution of GE development in various prefectures and cities in Xinjiang varied greatly. The average value was 0.7289; the highest and the lowest value was 1 and 0.3684, respectively, with a difference of 0.6316. From the measurement results, the GE efficiency values of the seven regions R1, R2, R4, R6, R7, R9, and R13 had reached 1, and their DEAs were effective. In 2017-2019, only four regions, R1, R2, R9, and R13, achieved an average value of GE development above 0.9. The average value of GE development efficiency in northern, southern, eastern, and entire Xinjiang based on the measured GE development efficiency of each prefecture and city in Xinjiang are calculated and expressed in Fig. 5.

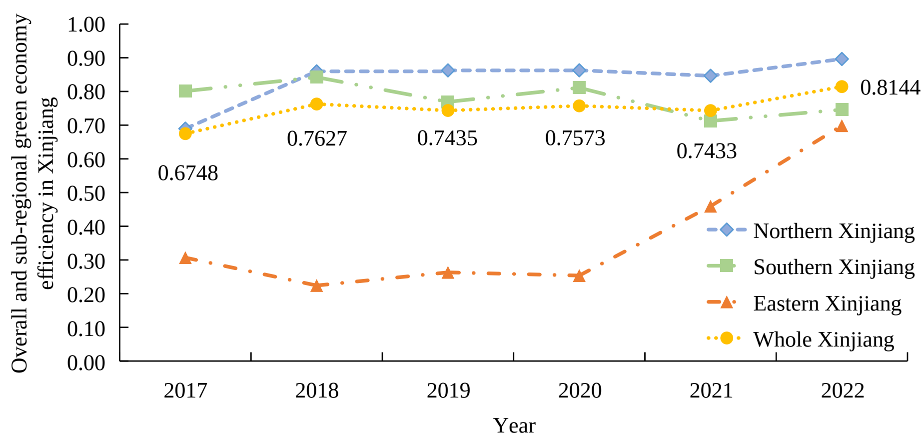


Fig. 5. Change trend of GE efficiency in Xinjiang as a whole and sub-region during 2017-2022.

From Fig. 5 it is clear that the overall efficiency of GE development in Northern Xinjiang was on the rise, with an average value of about 0.7796. The fluctuation trend of the efficiency of GE development in Southern Xinjiang was obvious, with an average value of about 0.7783, which was at a relatively stable medium to high stage. The efficiency of GE development in Eastern Xinjiang continued to rise after 2020, with an average value of 0.4272. From 2019 to 2022, the efficiency of GE development in the entire Xinjiang region had a relatively stable trend of change, with a slow upward trend. This indicates that optimization has been done in industrial organization and the transformation of its development mode has been effective. In the experiment, Eviews software was used to obtain the GE development efficiency values of 14 prefectures and cities in Xinjiang in 2022, and a broken line chart reflecting their fluctuation trend was obtained, as shown in Fig. 6.

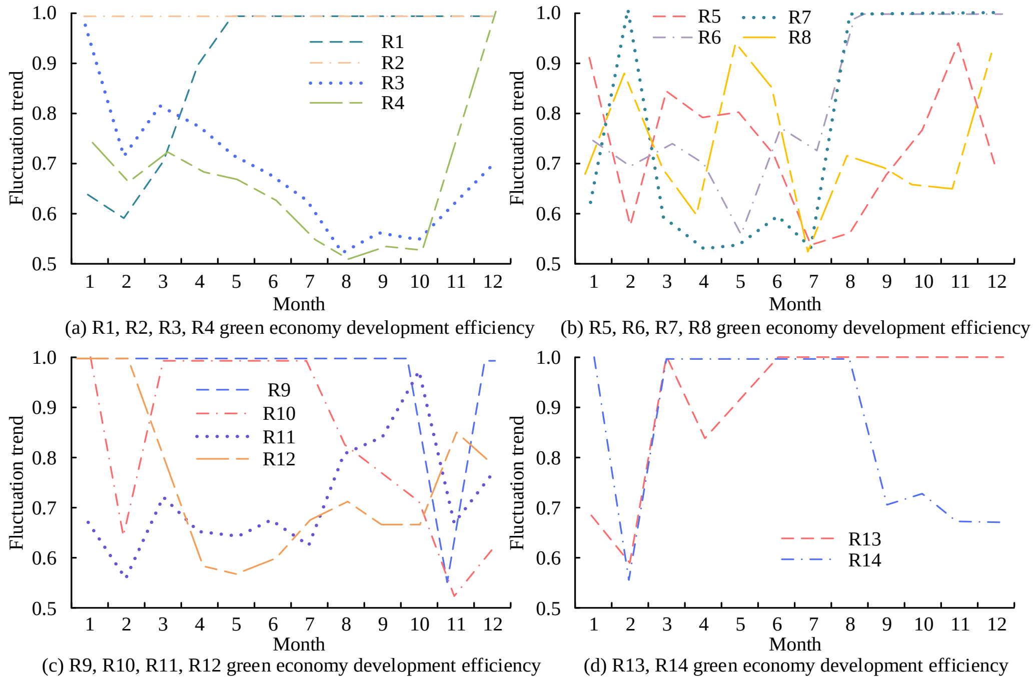


Fig. 6. Trend types of GE development efficiency in Xinjiang cities and cities in 2022.

From Fig. 6(a), GE development efficiency of R1 was of a fluctuating and rising type. That of R2 was stable. That of R3 and R4 was continuously fluctuating. From Fig. 6(b), GE development efficiency of R5, R6, R7, and R8 were the type of first decreasing and then increasing, fluctuating and rising, continuously fluctuating, and first decreasing and then increasing, respectively. From Fig. 6(c), GE development efficiency of R9, R10, R11, and R12 were respectively stable, fluctuating, decreasing first, then rising, and continuously fluctuating. From Fig. 6(c), GE development efficiency of R13 and R14 were respectively fluctuating upward type and fluctuating downward type. Among them, the development of resources, economy, and environment in stable regions was relatively balanced. However, fluctuating and declining regions were due to excessive urging of economic development, leading to resource waste and environmental pollution. This has led to a slide in the overall efficiency of the region's GE. The experiment used Stata15 software and combined with calculations to obtain the global Moran index measurement results of GE development efficiency in various states and cities in Xinjiang, see Table II.

TABLE II. MORAN INDEX AND TTS TEST IN XINJIANG FROM 2017 TO 2022

Year	I	$sd(I)$	z	$p-value*$
2017	-0.113	0.181	-0.199	0.421
2018	0.320	0.174	2.287	0.011
2019	0.294	0.175	2.115	0.017
2020	0.319	0.175	2.264	0.012
2021	0.089	0.178	0.932	0.176
2022	-0.044	0.173	0.187	0.426

From Table II, in 2018, 2019, and 2020, the GE development efficiency of various prefectures and cities in Xinjiang showed a relatively strong positive correlation. The correlation I was 0.320, 0.294, and 0.319, respectively. The spatial correlation in other years was significant. Through calculation, the local Moran index of GE development efficiency in various prefectures and cities in Xinjiang can be obtained. As shown in Fig. 7, the local Moran index test results and scatter plot for 2022 are shown.

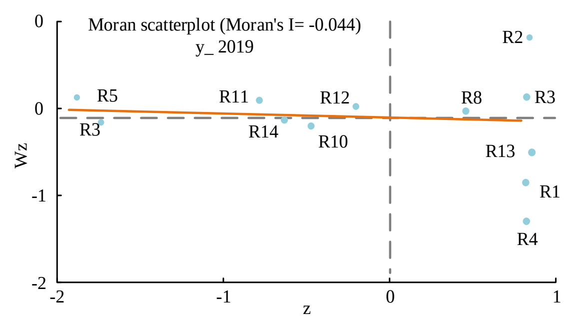
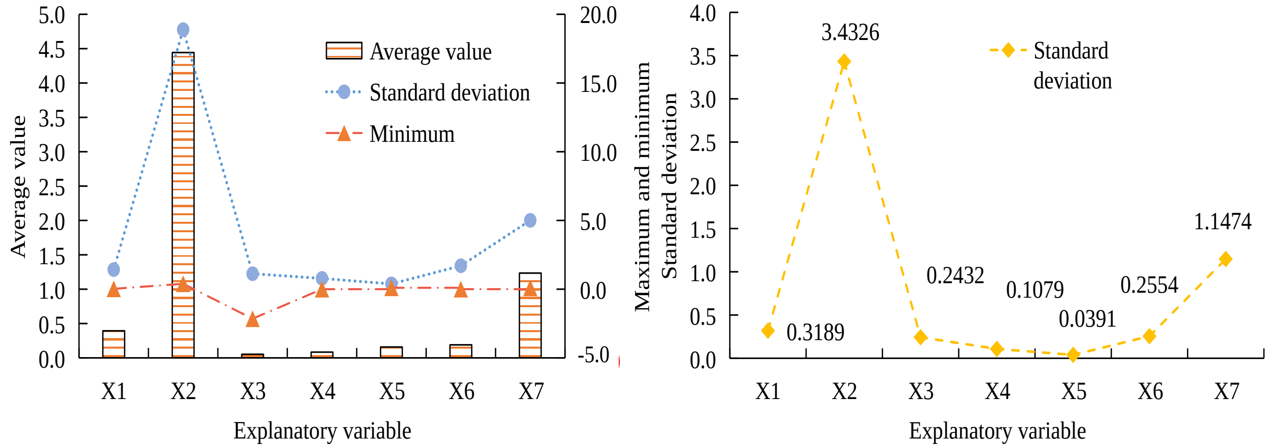


Fig. 7. Scatter plot of local Moran index in 2022.

From Fig. 7, in 2022, most of the autocorrelations of the 14 prefectures and cities in Xinjiang did not pass the assist test, and only a few regions had significant local spatial correlations. Based on the overall and local Moran indexes, there is no significant spatial correlation between the efficiency of GE development in various prefectures and cities in Xinjiang. The experiment conducted statistical processing on seven specific evaluation index data of GE development efficiency in Xinjiang from 2017 to 2022, and the results are shown in Figure 8.



(a) Extreme values and average values of influencing factor indicators during 2017-2022

(b) Standard deviation of influencing factor indicators in 2017-2022

Fig. 8. Statistics of influencing factors of Xinjiang GE development efficiency from 2017-2022.

From Fig. 8 (a), among the seven GE development efficiency evaluation indicators, the average value of X_2 was the largest. This indicates that the contribution rate of GDP per capita is the highest, at 4.44. The average value of X_3 was the smallest, 0.0527, and its minimum value was negative. From Fig. 8(b), X_2 had the largest standard deviation of 3.4326. The standard deviation of DD was the smallest, 0.0391. Before conducting regression analysis on the data of the above indicators, correlation analysis and correlation significance test shall be conducted for each explanatory variable. This can avoid multiple collinearity problems between variables, as shown in Table III.

TABLE III. CORRELATION COEFFICIENTS OF EACH VARIABLE

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1.000	0.186*	0.002	0.011*	0.220*	-0.012	-0.459*
X_2	0.186*	1.000	-0.010**	-0.058**	0.162*	0.025**	-0.195*
X_3	0.002	-0.010**	1.000	-0.098**	0.024	0.074*	0.103
X_4	0.011*	-0.058**	-0.098**	1.000	-0.101	0.013*	-0.036**
X_5	0.220*	0.162*	0.024	-0.101	1.000	-0.140*	0.096
X_6	-0.012	0.025**	0.074*	0.013*	-0.140*	1.000	-0.050*
X_7	-0.459*	-0.195*	0.103	-0.036**	0.096	-0.050*	1.000

Note: * and * * mean a significance level of 5% and 10%, respectively.

From Table III, even though the correlation between the two variables was significant, the correlation coefficient between each explanatory variable was small, and the absolute value of the coefficient was below 0.5. This implies that the probability of causing multicollinearity problems among various explanatory variables is low. The experiment used Eviews 8.0 software to establish a Tobit model based on the relevant data of GE development efficiency indicators in Xinjiang and various regions from 2017 to 2022. Table IV is the regression results.

TABLE IV. REGRESSION RESULTS OF TOBIT MODEL

Explanatory variable	Northern Xinjiang	Southern Xinjiang	Eastern Xinjiang	Whole Xinjiang
ε	0.6993*	0.8480*	0.9368*	0.7741*
X_1	-0.3992	-0.1383**	-1.7892*	-0.1283**
X_2	-0.0108	0.0035	0.5073*	-0.0032
X_3	-0.3552	0.1578*	0.0376	0.0054
X_4	0.0913	1.2268	0.0239	-0.2882**
X_5	2.3485*	0.0184	-0.3553	0.8976**
X_6	0.0192	0.2973	-2.9941*	0.1227**
X_7	-0.0864*	-0.1238*	-0.0463	-0.0987*

Note: * and * * mean a significance level of 5% and 10%, respectively.

In Table IV, based on the analysis of the entire Xinjiang region, there was a significant correlation between the GE development efficiency and X_1, X_4, X_5, X_6, X_7. The correlation values were -0.1283 * *, -0.2882 * *, 0.8976 * *, 0.1227 * *, -0.0987 *. Among them, there was a negative correlation with X_1, X_4, and X_7. This indicates that government support, tourism development level, and energy consumption level have restrained the efficiency of Xinjiang's GE development. Average education level and foreign trade level promote the efficiency of GE development. From a regional perspective, the value of GE development in northern Xinjiang was significantly positively correlated with X_5, and significantly negatively correlated with X_7. The value of GE development in South Xinjiang was significantly positively correlated with X_3, and negatively correlated with X_1 and X_7. The value of GE development in Eastern Xinjiang was significantly positively correlated with X_2, and significantly negatively correlated with X_1 and X_6. Overall, there is significant room for improving the efficiency of GE development in most regions of Xinjiang.

V. CONCLUSION

This study took Xinjiang, a typical resource rich province, as the research object, and built a GE development efficiency evaluation index model based on DEA-Tobit to achieve sustainable green development of economy, resources and environment. The study used this model to calculate the efficiency of GE development in 14 prefectures and cities in Xinjiang from 2017 to 2020. At the same time, the autocorrelation relationship and spatial distribution characteristics were analyzed in depth. The research showed that there were obvious differences in the spatial distribution of GE development among various prefectures and cities in Xinjiang. The average value was 0.7289; the highest value was 1; the lowest value is 0.3684, with a difference of 0.6316. The GE efficiency value of the seven regions R1, R2, R4, R6, R7, R9, and R13 has reached 1, and their DEA were effective. Based on the overall and local Moran indexes, there was no obvious spatial correlation between the efficiency of GE development in various prefectures and cities in Xinjiang. The absolute values of their coefficients did not exceed 0.5. According to the regression results obtained from the Tobit model, X_5 and X_6 had a great promoting effect on the efficiency of GE development in Xinjiang. X_1 has not played a positive role in the efficiency of Xinjiang's GE development, indicating that the relevant policies of the government were lagging behind. X_4 had an inhibitory influence on the efficiency of Xinjiang's GE development. This indicates that during its development, it has caused a certain degree of ecological damage. X_7 would inhibit the rise of the efficiency of GE development. Based on the results of the study, it is recommended to first increase the support of the local government in Xinjiang, optimize the industrial structure of Xinjiang as soon as possible, and promote energy development efficiency. In addition, it is necessary to strengthen investment in education in Xinjiang, do a good job in energy saving and emission reduction, and promote the overall efficiency of GE development in Xinjiang according to local conditions.

REFERENCES

[1] A. V. Agbedahin, "Sustainable development, education for sustainable development, and the 2030 agenda for sustainable development: emergence, efficacy, eminence, and future," Sustainable Development, vol. 27, no. 4, pp. 669-680, 2019.

[2] C. Qiqi, W. Jinghua, and S. Yufeng, "Theoretical basis and level evaluation of Tobacco planting and green agriculture: a Case Study in Henan Province, China," Tobacco Regulatory Science, vol. 7, no. 5, pp. 2777-2793, 2021.

[3] J. S. Finley, "Tabula rasa: Han settler colonialism and frontier genocide in "re-educated" Xinjiang," HAU: Journal of Ethnographic Theory, vol. 12, no. 2, pp. 341-356, 2022.

[4] Z. Zhang, and K. P. Paudel, "Small-Scale forest cooperative management of the grain for green program in Xinjiang, China: A SWOT-ANP Analysis," Small-Scale Forestry, vol. 20, no. 2, pp. 221-233, 2021.

[5] K. Ohene-Asare, E. N. Tetteh, and E. L. Asuah, "Total factor energy efficiency and economic development in Africa," Energy Efficiency, vol. 13, no. 6, pp. 1177-1194, 2020.

[6] I. Mikhno, V. Koval, G. Shvets, and O. Garmatiuk, "Green economy in sustainable development and improvement of resource efficiency," Central European Business Review, vol. 1, pp. 99-113, 2022.

[7] M. Wang, X. Zhao, Q. Gong, and Z. Ji, "Measurement of regional green economy sustainable development ability based on entropy weight-topsis-coupling coordination degree—a case study in Shandong Province, China," Sustainability, vol. 11, no. 1, pp. 2-18, 2019.

[8] X. Qin, J. Wang, Y. Liu, "Efficiency measurement and inefficiency environmental factors of China's green economy," Prague Economic Papers, vol. 1, pp. 25-57, 2022.

[9] Y. Lu, B. Cao, Y. Hua, et al., "Efficiency measurement of green regional development and its influencing factors: an improved data envelopment analysis framework," Sustainability, vol. 12, no. 11, pp. 3-23, 2020.

[10] M. Zhao, F. Liu, Y. Song, G. Jiangbo, "Impact of air pollution regulation and technological investment on sustainable development of green economy in eastern China: empirical analysis with panel data approach," Sustainability, vol. 12, no. 8, pp. 2-18, 2020.

[11] Y. Zheng, S. Chen, N. Wang, "Does financial agglomeration enhance regional green economy development? Evidence from China," Green Finance, vol. 2, no. 2, pp. 173-196, 2020.

[12] M. Lebedeva, "Comparative analysis of methods for assessing the transition to a green economy," Vestnik Volgogradskogo Gosudarstvennogo Universiteta Ekonomika, vol. 3, pp. 109-122, 2020.

[13] T. Liu, B. Xin, F. Wu, "Urban green economic planning based on improved genetic algorithm and machine learning," Journal of Intelligent and Fuzzy Systems, vol. 40, no. 4, pp. 7309-7322, 2021.

[14] V. N. Rutskiy, M. V. Osipenko, "Green economy as a labor productivity factor in the manufacturing industry of European Union Countries," Finansovyj žhurnal-Financial Journal, vol. 4, pp. 69-84, 2020.

[15] K. Sakai, M. A. Hassan, C. S. Vairappan, Y. Shirai, "Promotion of a green economy with the palm oil industry for biodiversity conservation: A touchstone toward a sustainable bioindustry," Journal of Bioscience and Bioengineering, vol. 133, no. 5, pp. 414-424, 2022.

[16] T. Jiang, Y. Yu, A. Jahanger, D. Balsalobre-Lorente, "Structural emissions reduction of China's power and heating industry under the goal of" double carbon": A perspective from input-output analysis," Sustainable Production and Consumption, vol. 31, pp. 346-356, 2022.

[17] J. Lozić, "Application of data envelopment analysis in information and communication technologies," Tehnički glasnik, vol. 16, no. 1, pp. 129-134, 2022.

[18] H. Jung, K. Lee, "Efficiency analysis of security management system of affiliates of conglomerate using DEA-SBM model," Journal of the Korea Institute of Information Security & Cryptology, vol. 32, no. 2, pp. 341-353, 2022.

[19] J. Mur, "A simple test of spatial autocorrelation for centered variables," Revista Economía, vol. 44, pp. 41-55, 2021.

[20] G. Tepanosyan, L. Sahakyan, C. Zhang, A. Saghatelyan, "The application of Local Moran's I to identify spatial clusters and hot spots of Pb, Mo and Ti in urban soils of Yerevan," Applied Geochemistry, vol. 104, pp. 116-123, 2019.

[21] M. D. Amore, S. Murtinu, "Tobit models in strategy research: Critical issues and applications," Global Strategy Journal, vol. 11, no. 3, pp. 331-355, 2021.