HK.NCCP

International Journal of Applied Mathematics and Soft Computing
Volume 4, Issue 3, June, 2018

Analysis of Carbon Emission Trends and Emission Reduction Strategies in Liaoning Province

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Abstract: As an old industrial base in northeastern China, Liaoning Province has more energy consumption, resulting in a larger carbon emissions from energy consumption. Therefore, whether Liaoning Province can achieve peak carbon emissions will achieve China's overall carbon emission peak. The goal of beautiful China is of great significance. Based on the current research status, this paper analyzes and analyzes the factors affecting carbon emission in Liaoning Province, and calculates the energy saving and emission reduction efficiency in Liaoning. Through the analysis of the dynamic changes of energy saving and emission reduction efficiency, the city provides energy saving and emission reduction and policy reference.

Keywords: STIRPAT model; Ridge regression; EKC curve; Carbon emission inflection point; Energy saving and emission reduction efficiency

1. Introduction

The Chinese government has made a commitment in the Joint Statement on Climate Change jointly issued by the US government: "China plans to reach a peak in carbon dioxide emissions around 2030 and will strive to reach an early peak and plan to increase the proportion of non-fossil energy in primary energy consumption by 2030. Up to 20%." As an old industrial base in northeast China, Liaoning Province has more energy consumption, resulting in a larger amount of CO2 emissions from energy consumption. Therefore, whether Liaoning Province can achieve carbon emissions peaks can achieve China's overall It is important to increase the efficiency of energy conservation and emission reduction at the peak of carbon emissions.

2. Research Status and Problems

Under the current trend of low carbon development, the research results of carbon emission influencing factors in relevant regions or industries at home and abroad are gradually enriched. Among them, the index decomposition method, Kaya identities, LMDI decomposition method and STIRPAT model are the most effective factors for studying carbon emission influencing factors. Several methods have been widely used by scholars at home and abroad. Ang and Pandiya used the factor decomposition method to study the carbon intensity of manufacturing sectors in China, Taiwan, and South Korea, and pointed out that the factors that have the greatest impact on the carbon intensity of the manufacturing sector in terms of product structure, fuel share, and sectoral energy intensity are sectors. Energy intensity. There are also many decomposition studies on the factors affecting carbon emissions in China. Yuan Peng and Cheng Shi used the logarithmic average Divisia index decomposition method to analyze the driving factors of carbon emission increase in Liaoning Province. The expansion of economic scale is the decisive factor for the increase of carbon emissions in Liaoning. The heavy industrialization has also played a certain role in increasing emissions. In general, the existing research has greatly promoted the factors affecting carbon emissions and the research of Dafeng, which laid the foundation for the follow-up research in this field. However, the current research has the following three shortcomings:

On the research object, there is a lack of research on regional carbon emission peaks. At present, most of the literature only analyzes the carbon emission influencing factors or peak forecast of China's overall industry or industry, and the research on carbon emissions in China's specific provinces and regions needs to be deepened, especially in provinces with more carbon emissions.

It is not comprehensive enough to choose the factors affecting carbon emissions. Most scholars only consider the recognized factors such as GDP per capita, industrial structure, and other factors that may affect carbon emissions. The conclusions drawn may be biased.

In terms of research methods, the prediction model for carbon emissions needs to be improved.

3. Model Assumptions

Hypothesis 1: The ratio of the total output value of the secondary industry to the total output value of Liaoning Province can represent the adjustment of the industrial structure of the region.
Hypothesis 2: The consumption of coal in the quantitative calculation of energy structure accounts for the total attribute of all primary energy consumption, which can represent the specific characteristics of carbon emissions in Liaoning Province.
Hypothesis 3: The impact of carbon emissions does not take into account the adverse effects of small and micro enterprises' output values

4. The Establishment of the Model

4.1. Carbon emission prediction based on STIRPAT model

This paper divides Liaoning's carbon emissions into two parts: one is direct carbon emissions from fossil fuel combustion, and the other is indirect carbon emissions from electricity consumption. The calculation of direct carbon emissions uses the benchmark method described in the IPCC, which measures the carbon emissions of Liaoning Province from the perspective of various fossil fuel consumption. Therefore, the calculation formula for carbon emissions in Liaoning Province is:

$$C = C_1 + C_2 \tag{1}$$

$$C_1 = \sum_{j}^{m} (E_j \times NCV_j \times CC_j \times COF_j \times \frac{44}{12}) \tag{2}$$

$$C_2 = QE \times DE \times EE \tag{3}$$

In formula (2), j represents the jth energy type. In this paper, eight energy types are selected according to the energy division of IPCC, namely raw coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil and natural gas; Ej means j The energy consumption is derived from the 2007-2016 China Energy Statistical Yearbook; NCVj represents the low calorific value of the jth energy; CCj represents the carbon content of the jth energy; COFj represents the carbon of the jth energy The oxidation factor, which is usually 100% according to the IPCC Guidelines, means complete oxidation; 44/12 represents the ratio of the molecular weight of CO2 to carbon, ie the conversion coefficient of carbon to CO2. In formula (3), QE represents the total power consumption, the data comes from the 2007-2016 China Energy Statistical Yearbook; DE represents the power carbon emission coefficient, this paper takes the average of 0.7173t/tce calculated by different studies; EE means power supply Coal consumption, the specific value of each year is taken from the news data released by the State Grid.
In this paper, ridge regression method is adopted to reanalyze the model. Ridge regression analysis is an improved statistical method based on least square method, which can eliminate the interference of multicollinearity on analysis results by adding non-negative factors to the principal diagonal of standardized matrix of independent variables, so as to significantly improve the results of regression inference.In the changing process of ridge parameter k from 0 to 1, the urbanization rate and energy efficiency variable standardization of ridge regression coefficient absolute value is small and has been very stable, from the perspective of the variable test results of ridge regression analysis, the two variables in a business and the scale of the p value is greater than the significance level of 0.05, no significant impact on carbon emissions in liaoning province shows three, should remove these three variables again for ridge regression analysis. Finally, the ridge regression results of economic level, energy structure, industrial structure, openness, and carbon emission intensity were taken as independent variables, and the carbon emission of liaoning province as dependent variables were shown as follows:

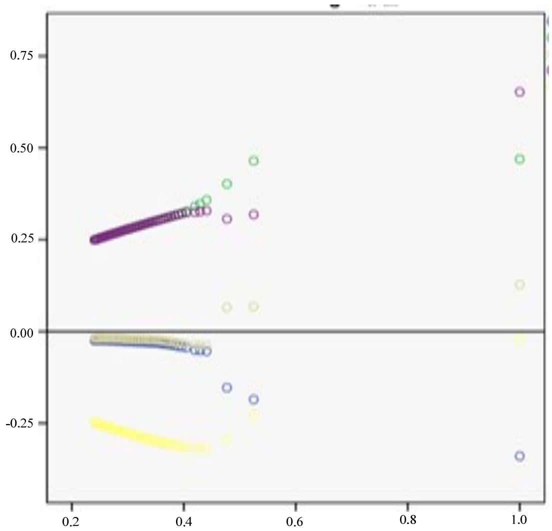

Figure 1. Result of ridge regression method

4.2. Kuznets curve of liaoning province carbon emission environment

From the above results, it can be seen that the economic level has a great impact on carbon emissions, and the regression coefficient is as high as 0.941. Therefore, we conducted an in-depth study on the factors of economic level. By establishing the environmental kuznets curve of carbon dioxide emissions, we conducted an empirical study on the relationship between liaoning province's carbon emissions and economic growth from 2007 to 2016, and calculated the inflection point and time path of carbon emissions.
The kuznets curve describes the relationship between per capita carbon dioxide emissions and per capita income. PC represents per capita carbon dioxide emissions, while PY represents per capita income. The logarithmic model

of kuznets curve for carbon dioxide emission is as follows:

$$\ln PC = \alpha + \beta_1 \ln PY + \beta_2 (\ln PY)^2 \quad (4)$$

Where:αis the intercept term, β1 andβ2 are the estimated coefficients of lnPY and (lnPY)2respectively. Economic growth mainly affects the environment through scale effect, structure effect and technology effect. In the primary stage of economic development, the scale effect is positive. With economic growth, the structure effect and technology effect will gradually take a dominant position. The environmental condition can be improved through the reduction of structural and technological emissions. In the model, when the primary term coefficient is positive and the secondary term coefficient is negative, it indicates that there is an inflection point in the co2 kuznets curve, which has the characteristic of "inverted U" curve. On this basis, we can calculate the inflection point path of carbon dioxide kuznets curve.

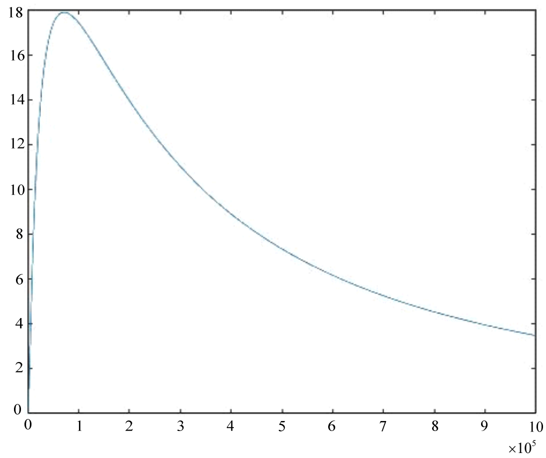

Figure 2. Kuznets curve for carbon dioxide

4.3. Definition and calculation of energy saving and emission reduction efficiency

For each province, set three input elements x = (L, K, E) for R. L, K and E are respectively labor force, capital and energy, producing the desired output region GRP for R, and releasing the undesired output carbon dioxide for R. Defined by the production feasibility set, it can be denoted as: P(x) = {(GRP, C).Further, we introduce the directional distance function. The core idea of the directional distance function is to reduce the non-consensual output while the desired output increases, and its measurement value specifically measures the possibility of the expansion of the acceptable output and the reduction of the undesirable output under a given direction, input and environmental technology structure.

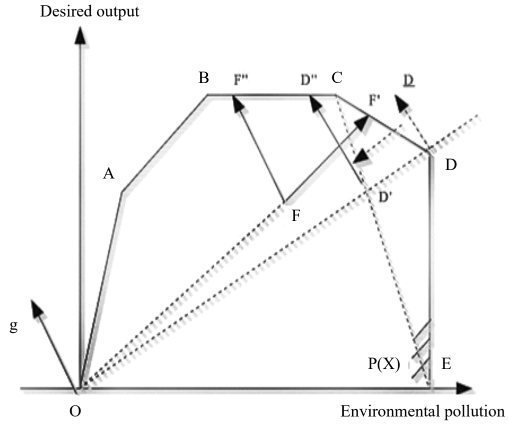

Figure 3. Schematic diagram of efficiency measurement method for energy conservation and emission reduction

According to the idea of Figure 3, this paper uses the super-efficiency DEA method to solve the directional distance function, then the k-th production decision-making unit satisfies the above-mentioned production feasibility set condition, and the output-oriented linear return of the directional distance function model with the same scale return The problem can be expressed as:

$$D_0 = (x_k^t, GRP_k^t, C_k^t; g_{GRP,k}^t, g_{C,k}^t) = [\beta : (GRP_k^t + \beta g_{GRP,k}^t, C_k^t - \beta g_{c,k}^t) \in P(x_k^t)] \quad (5)$$

$$\begin{cases} \sum_{j=1, j\neq k}^{30} z_j^t \cdot GRP_j^t \geq (1+\beta) \cdot GRP_k^t \\ \sum_{j=1, j\neq k}^{30} z_j^t \cdot C_j^t = (1-\beta) \cdot C_k^t \\ \sum_{j=1, j\neq k}^{30} z_j^t \cdot x_j^t \leq x_k^t, x = (L, K, E) \in R^+ 3 \\ z_j^t \geq 0, \forall j \end{cases} \quad (6)$$

In the above model, ztj represents the weight of each production decision unit, and non-negative weight variables indicate that the production technology is the same size. According to the directional distance function value obtained by the model (2), the total factor energy efficiency (abbreviated as TFCE) of the undesired production considering carbon dioxide emissions can be calculated :

$$TFCE_k^t = 1/[1 + D_0(x_k^t, GRP_k^t, C_k^t; g_{GRP,k}^t, -g_{C,k}^t)] \quad (7)$$

Because TFCE considers both energy consumption and environmental losses caused by it, this paper uses it as a measure of energy saving and emission reduction efficiency, and serves as the focus of analysis and research.

4.4. Dynamic changes in efficiency of energy conservation and emission reduction

The TFCE estimates show that the average score of TFCE in our province has risen from 0.6653 to 0.731, which is slightly higher than the average score of TFEE. The economic implication of this conclusion is that when considering carbon emission constraints, the growth potential of its output potential under the existing technology structure is smaller than when carbon emission constraints are not considered. This is because when considering carbon emission constraints, the contribution to environmental improvement in the production process is also considered to be the contribution of total factor energy efficiency, so that the total factor energy efficiency score considering carbon emission constraints is higher than the case without considering carbon emission constraints. In addition, the average value of TFCE in our province is 0.7020. This means that under the established resource input and technical conditions, the province can save energy, reduce carbon emissions and increase output by 29.80% per year. Obviously, from the historical data, our province has a lot of space and potential for energy conservation and emission reduction.

From the municipal level, the annual average TFCE rankings increased in Shenyang, Chaoyang and Yingkou; Dandong and Benxi remained unchanged in the second place, while the remaining provinces ranked lower. Consistent with the previous analysis, the rapid economic growth of most provinces and municipalities in our province is at the expense of the environment (this article refers to excess carbon emissions). This result indicates that the pressure of China's carbon emission reduction work is greater than the pressure of energy conservation work.

5. Summary

The promotion of technological progress to energy conservation and emission reduction is slow. At the same time, efficiency improvement has a limited effect on energy saving and emission reduction efficiency. Since efficiency improvement mainly depends on the efficiency of the allocation of elements, the latter is affected by the structural adjustment caused by the flow of production factors. Therefore, this conclusion means that at this stage, the effect of structural adjustment on China's energy conservation and emission reduction is not very obvious, and technological progress, especially energy-saving technologies and low-carbon technology innovation are the main forces driving energy conservation and emission reduction. China's current technological progress is manifested in a large number of technological advances in capital. Therefore, the above findings mean that in the future economic growth, special attention should be paid to the development and utilization of energy-saving and low-carbon technologies in equipment investment and infrastructure construction.Relatively small carbon emissions in lower-economy cities have improved their environmental performance, but in the face of relatively backward technological and economic development levels, they tend to accept high-energy, high-emission companies when undertaking industrial transfers, which will Damage to its energy saving and emission reduction efficiency. Therefore, the central government should increase policy guidance on energy conservation and emission reduction in the western region, improve the energy conservation and emission reduction restraint policy and support for the western provinces, so as to promote the transformation opportunities of the western provinces to grasp the low carbon economy and promote national energy conservation more effectively. Increased efficiency of emission reduction.

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