Research on Influencing Factors of Regional Economic Green Growth under Carbon Emissions constraint

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Abstract: Promoting the green revolution is not only an urgent need to realize the coordinated development of economy, but also a strategic choice to cope with global climate change and reduce CO2 emissions. This paper incorporates carbon emission data into the economic growth analysis model, uses the SBM-DEA model to measure the green total factor productivity of each region, and uses panel data to investigate the factors affecting regional economic growth under carbon emission constraints. The research results show that industrial agglomeration, scientific and technological progress and human resource factors have a significant role in promoting the green growth of the regional economy, and energy consumption efficiency, investment efficiency, the structure of export products have a restrictive effect on the regional green growth. Therefore, it is necessary to more closely integrate the adjustment of industrial structure with technological innovation, improve energy utilization efficiency, and at the same time promote the innovation of financial policies to provide lasting impetus for the regional green sustainable development.

1. Introduction
Climate change has significant influence on economic growth by its effect on productivity, labor, and has become an important factor restricting the high-quality growth of the regional economy. Faced with increasingly severe resource and environmental conditions, China has elevated green development of a national strategy. To speed up the transformation and upgrading and promote high-quality development, it is not only necessary to reduce the energy consumption per unit GDP and PM2.5 concentration, but also to use the carbon emission constraint mechanism to promote the transformation of development momentum. Achieving high-quality growth under the constraints of carbon emissions is not only a key focus area of scientific research, but also a practical problem that is resolved in the current response to climate change. Regarding whether economic development meets the requirements of low-carbon development, the academic community only began to focus on this issue after the Copenhagen Conference[1]. Jorgenson et al. (1987) first proposed the famous KLEM analysis model, which took...
energy consumption as an intermediate input and incorporated labor and capital into the production function to analyze the path of economic growth. Chung et al (1997) used pollution as an undesired output and used the directional distance function and the ML productivity index to measure the total factor productivity of Swedish pulp mills. For the first time, they measured the relationship between environmental pollution and economic growth and obtained the green TFP\cite{2}. Paroussos, L (2019) researched that reasonable financial policies and technological progress have a positive effect on green development. This study incorporates carbon emission factors into the analysis model, and discusses the path to sustainable development through the conversion of growth kinetic energy based on the current status and obstacles of regional economic growth under carbon emission constraints, thereby opening the theoretical door for high-quality development.

2. Research methods and data sources

2.1 Research methods

Strict emission control policies are implemented by my country to be adapted to global climate change and reduce carbon emissions, aiming to realize the transformation of economic growth mode through policy guidance. Under carbon emission constraints, traditional input-output analysis models often ignore the external effects of ecological factors on economic growth\cite{3}. Based on the Solow growth model under resource and environmental constraints, this article incorporates carbon emission factors into the most basic Solow model. The expanded model includes per capita GDP in each province, carbon emission equivalent, green capital investment, human capital, energy consumption per unit of GDP, technological progress, industrial structure, financial development, and foreign trade are nine variables. The explanatory variable is the province's total factor productivity under carbon emission constraints. In the time path under investigation, the real economic growth is correspondingly manifested as the result of the combined effect of capital, labor, energy, carbon emissions and other factors.

2.2 Data sources

To calculate total factor productivity (TFP), not only traditional factors of production must be considered, but also energy and environmental factors must be included as unpaid input into the production function to obtain green TFP in each province. However, related studies have found that environmental factors should not be regarded as inputs, because the output characteristics of pollution are negative products of expected output, so it should be estimated as undesired output. This paper draws on this idea and method, incorporates environmental pollution factors as undesired output into the production function and estimation framework, obtains green TFP in each region, and empirically tests the relationship between it and various influencing factors. Data Envelopment Analysis (DEA) is the most commonly used tool in non-parametric methods\cite{4}. This paper chooses to utilize the SBM-DEA model based on undesired output for measurement. When calculating the green TFP, the capital input, labor force, and energy consumption of each province are used as input elements, and the expected output is set as the GDP growth rate of each province, and the undesired output is the carbon dioxide emission. It needs to be pointed out that green total factor productivity is not equivalent to the level of environmental governance, but represents the potential for improving environmental quality measured under a certain data framework.

Table 1 performs descriptive statistics on sample data from 2000 to 2017. It can be seen from the analysis results that there is a big difference in the green total factor productivity index, the maximum value is 1.173, and the minimum value is only 0.224. There are large differences in technological progress, carbon emission values, and human capital among the various elements. There are differences in the endowment of green development resources in various regions, and the level of green development is uneven.
3. Model construction and empirical analysis

3.1 Model construction

Because panel data can not only control the heterogeneity of sample individuals, but also have more information and greater representativeness, the classic panel data measurement model is used to conduct the empirical analysis on the factors affecting regional economic growth under carbon emission constraints. Based on combing elements of regional economic growth under carbon emission constraints, the following panel data measurement model is constructed to consider the impact of various factors on regional economic growth. The model formula is shown below, and the representative symbols of each variable are shown in Table 1.

\[
\ln GTFP_t = C + \beta_1 \ln CE_t + \beta_2 \ln GI_t + \beta_3 \ln HC_t + \beta_4 \ln TP_t + \beta_5 \ln EE_t \\
+ \beta_6 \ln IA_t + \beta_7 \ln FD_t + \beta_8 \ln FT_t + \mu_t
\]  

(1)

3.2 Unit root tests

In order to avoid false regression, the seasonality of each variable is tested before the empirical test. An important tool for seasonality test is a unit root test. According to the conclusion of Monte Carlo test simulation, if the lag order of the individual ADF test is large enough, the IPS test has better properties than other test methods. Therefore, two inspection methods of LLC and IPS are used to perform unit root test on sample data. Table 3 shows the unit root test results.
3.3 Analysis of Empirical Results

The form of the panel data model is determined by the following tests: First, construct the F statistic to determine whether the individual effect is zero, perform fixed effects and parameter screening; use the BP Lagrangian multiplier test (Breusch-Pagan LM test) to perform random effects and homogeneity Parametric test; Finally, Hausman test is used to compare fixed effects and random effects. In addition, because panel data is prone to cross-sectional correlation, heteroscedasticity, and the serial correlation, the Friedman test, Modified Wald test and Wooldridge test are further carried out. According to the results of the panel unit root test, the test results of the first-order difference statistical value of all variables are at the 5% significance level and the next-order single integer can be regression estimated. The distinct effects test results show that the fixed effects model is better than the mixed OLS model. The LM test results show that the random effects are better than the mixed OLS model. Therefore, generalized least squares (FGLS) are used for estimation. The results of FGLS estimation are shown in Table 4. The regression coefficients of all variables have passed the significance level test, and the estimation results have good explanatory properties.

Table 3. Model estimation results

| variable             | Pooled estimate | FE model | RE model | FGLS    |
|----------------------|-----------------|----------|----------|---------|
| Constant             | 0.692***        | 0.253*** | 0.119*** | 0.511***|
| (0.000)              | (0.000)         | (0.001)  | (0.003)  |         |
| Carbon emission data | -0.052***       | -0.006   | -0.002   | -0.023***|
| (0.606)              | (0.571)         |          | (0.035)  |         |
| Environmental        | -0.049***       | -0.010   | -0.008*  | -0.027**|
| investment           | (0.189)         | (0.108)  |          | (0.021) |
| Human capital        | 0.017***        | -0.025***| -0.012***| 0.010   |
| (0.006)              | (0.004)         |          | (0.597)  |         |
| Technology progress  | 0.014***        | 0.014*** | 0.013*** | 0.003   |
| (0.000)              | (0.000)         | (0.000)  | (0.450)  |         |
| Energy efficiency    | -0.061**        | -0.065***| -0.056***| -0.050**|
| (0.048)              | (0.022)         |          | (0.041)  |         |
| Industrial Cluster   | 0.30***         | 0.023    | 0.069    | 0.200   |
| (0.000)              | (0.635)         |          | (0.174)  |         |
| Financial development| -0.203***       | -0.003   | -0.028*  | -0.292***|
| (0.588)              | (0.027)         |          | (0.985)  |         |
| Financial development| -0.047          | 0.145*   | 0.155*   | -0.002  |
| (0.951)              | (0.493)         |          | (0.001)  |         |

Note: I(n) means that the sequence is stable after n-th order difference. The numbers in parentheses are the corresponding P values. *** , ** , * indicate rejection at the significance level of 1%, 5%, and 10%, respectively.
R²  0.280  0.0627  0.076  —

Note: The numbers in parentheses are the corresponding P values, and ***, **, and * indicate significance levels of 1%, 5%, and 10% respectively.

In order to test the stability of the estimation results, pooled, fixed effect estimation and random effect estimation methods were used to test the data. The results are shown in Table 3.

It can be seen from the test results that technological progress, industrial agglomeration, and human capital have a significant positive effect on green development. Industrial agglomeration has a greater impact on green development. In fact, the level of green development is closely related to the industrial structure or industrial structure of each region. It shows that the adjustment of industrial structure and the realization of industrial agglomeration will help improve the efficiency of green development. At the same time, the level of human capital and technological progress has a significant positive effect on the improvement of the quality of green development. Human capital is related to high-tech industries, so the improvement of human capital level helps to indirectly improve the level of green development. Technological progress can effectively replace energy and develop high-end industries, and contribute to energy conservation and emission reduction.

According to the estimation results, the regression coefficients of carbon emissions, green investment, energy efficiency, financial development, and the four factors are negative. According to the GLS regression results, the carbon emission regression coefficient is -0.02. This shows that carbon emissions are an important factor restricting green growth, and effective control of carbon emissions levels is conducive to increasing the quality of regional green development. At the same time, green investment and financial development have not significantly increased the level of regional green development. Because most of the green investment is used for environmental governance other than carbon emissions or the end-of-pipe governance model is adopted. Financial development increases industrial investment and increase polluting enterprise emissions.

4. Suggestions
Firstly, to promote the agglomeration of high-energy elements to promote the development of industrial clusters. Through cross-regional integration of upstream and downstream resources of the industry, promote the concentration of industrial development factors, promote the upgrading of the industrial chain, and gradually change the small and scattered development situation. Secondly, to improve the efficiency of green finance[5]. Combining green bonds, green funds and other methods to provide targeted financial support for energy conservation, sustainable growth. Thirdly, to promote green technological innovation. Strengthen the research and development of green technology and the application and transformation of technological achievements, establish new regional competitive advantages. Lastly, Gradually change the previous end-of-pipe governance methods, explore market-based means such as carbon emission taxes and carbon emission rights trading to build a long-term mechanism, and improve the market-oriented green development mechanism.

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