Environmental Regulation, FDI and Peak Prediction of Carbon Emissions from Energy Consumption: A Case Study of Five Northwestern Provinces Postprint Based on the STIRPAT model, this study predicts the peak of carbon emissions from energy consumption in the five northwestern provinces under the co...

Authors: Dong Bangbang, Li Li, Tang Hongsong, Su Yang, Li Li

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Abstract

Based on the STIRPAT model, this study employs scenario analysis to forecast carbon emissions from energy consumption in Northwest China from 2017 to 2030. Nine development models are established under three environmental regulation intensities (high, medium, and low) to analyze the impact of environmental regulation and FDI on energy carbon emission peaks. The research indicates: (1) Under the initial development scenario, the total carbon emissions in Northwest China in 2030 will be 70 273.07$×104t, failingtoachievethecarbonemissionpeaktarget.(2)Underthelowenvironmentalregulationbackg
medium, andhigh−lowhaveenergyconsumptioncarbonemissionamountsof73550.53×104t, 64881.98×104t, an
lowandlowdevelopmentmodelsreachtheircarbonemissionpeaksin2025and2020respectively, withpeakamounts
t. The corresponding energy carbon emission intensities are 0.86 t・(104 元) -1 and 0.68 t・(104 元)-1, representing decreases of 48.38% and 60.14% respectively compared to the 2005 carbon emission intensity. Among the nine development models, only the medium-low and low models can achieve the carbon emission peak task as scheduled, indicating that strict environmental regulation policies can effectively mitigate energy consumption carbon emissions in Northwest China. To promote the timely achievement of carbon emission peak targets in Northwest China, corresponding policy recommendations are proposed for carbon emission reduction efforts in the region.

Full Text

Abstract

This paper calculates the total carbon emissions from energy consumption in the five northwestern provinces of China from 1997 to 2016 based on the carbon emission coefficients of the IPCC list. Using the STIRPAT model, with total carbon emissions from energy consumption as the dependent variable, and taking environmental regulation intensity, FDI, population, per capita GDP, the proportion of secondary production, and energy carbon emission intensity as independent variables, the ridge regression method is used to fit the peak carbon emission prediction model of energy consumption in the five northwestern provinces. Under three patterns of high, medium, and low environmental regulation intensity, nine development models were set up by scenario simulation to predict and analyze the total carbon emissions from energy consumption in northwestern China from 2017 to 2030. The results showed as follows: (1) With the growth rate of each variable unchanged, the carbon emissions from energy consumption in northwestern China from 2017 to 2030 showed an overall growth trend, and could not reach the peak of carbon emissions as scheduled. The total carbon emissions in 2030 would be 10^4 t, an increase compared with 2016. (2) Under the background of low environmental regulation, the three development models of high, high-medium, and high-low cannot achieve the goal of peak carbon emissions on schedule. The carbon emissions from energy consumption of each model in 2030 are $X \times 10^4$ t, $Y \times 10^4$ t, and $Z \times 10^4$ t respectively. (3) Under medium and high environmental regulation, the carbon emissions from energy consumption in northwestern China have been effectively controlled. The carbon emissions hit their peak in 2025 and 2020 respectively under the low and medium development modes, with peak emissions of $A \times 10^4$ t and $B \times 10^4$ t respectively. The intensity of energy carbon emissions were 0.86 $\mathrm{t} \cdot (10^4\ \mathrm{k})^{-1}$ and 0.68 $\mathrm{t} \cdot (10^4\ \mathrm{k})^{-1}$, which were 48.38% and 60.14% lower respectively than that of 2005. This shows that strict environmental regulation policy can effectively slow down the carbon emissions from energy consumption in the northwestern region, and it is of great significance to achieve the goal of peak carbon emissions on schedule. Based on the above research, the following suggestions are proposed: Firstly, the proportion of environmental governance in government performance appraisal should be expanded; secondly, it is needed to optimize the structure of attracting investment and to promote the upgrading of industrial structure in northwestern China, enhancing the concept of green government in different regions; thirdly, it is urgent to improve the intensity of regional environmental regulation and formulate environmental governance policies in different stages.

Keywords: environmental regulation; carbon emissions from energy consumption; carbon emission peak prediction; northwestern China

1. Introduction

Global climate change has become a major challenge for human survival and development. Since the 1980s, the global average temperature has risen by 0.7°C, and China has become the world's largest carbon emitter [?]. The Chinese government has set the target of achieving carbon peak by 2030 and carbon neutrality by 2060. As an important energy base and ecological security barrier in China, the northwestern region faces the dual pressures of economic development and carbon emission reduction. How to achieve the coordinated development of environmental regulation, FDI, and carbon emission reduction in the northwestern region is an urgent problem to be solved.

Environmental regulation, FDI, and carbon emissions have attracted widespread attention from scholars. Existing studies mainly focus on three aspects: first, the relationship between environmental regulation and carbon emissions [?]; second, the impact of FDI on carbon emissions [?]; and third, the driving factors of carbon emissions [?]. However, there are few studies on the synergistic effect of environmental regulation and FDI on carbon emissions, especially in the context of northwestern China. This paper attempts to fill this gap by constructing a peak carbon emission prediction model based on the STIRPAT model and scenario simulation.

2. Methodology and Data

2.1 Model Construction

The STIRPAT model is an extension of the IPAT model, which can analyze the impact of multiple factors on environmental pressure. The basic form of the STIRPAT model is:

$$\ln I_i = a + b \ln P_i + c \ln A_i + d \ln T_i + e_i \quad (1)$$

where I represents environmental impact, P represents population, A represents affluence, T represents technology, and a, b, c, d are coefficients.

Based on the STIRPAT model and combined with the actual situation in northwestern China, this paper constructs the following carbon emission prediction model:

$$\ln C_i = a + b \ln P_i + c \ln PGDP_i + d(\ln PGDP_i)^2 + f \ln EI_i + g \ln ER_i + h \ln FDI_i + j \ln IS_i + e_i \quad (3)$$

where: C represents carbon emissions from energy consumption (10^4 t); P represents population (10^4 persons); $PGDP$ represents per capita GDP (10^4 Yuan/person); EI represents energy intensity (tce/10^4 Yuan); ER represents environmental regulation intensity; FDI represents foreign direct investment (10^4 USD); and IS represents the proportion of secondary industry (%).

2.2 Data Sources and Processing

The data used in this paper cover the period from 1997 to 2016 for the five northwestern provinces (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang). The data are mainly obtained from the *China Energy Statistical Yearbook*, *China Statistical Yearbook*, and provincial statistical yearbooks. Carbon emissions are calculated according to the IPCC carbon emission coefficients (Table 2). The calculation formula is:

$$E_i \times \theta_i$$

where E_i represents the consumption of energy type i (10^4 tce), and θ_i represents the carbon emission coefficient of energy type i (tC/tce).

shows the explanatory notes for variables in the model, and shows the carbon emission coefficients of various energy types.

3. Results and Analysis

3.1 Historical Trend Analysis

Based on the data from 1997 to 2016, the carbon emissions from energy consumption in northwestern China showed an overall upward trend, with an average annual growth rate of 11.78%. The carbon emissions increased from $X \times 10^4$ t in 1997 to $Y \times 10^4$ t in 2016. The main driving factors include rapid economic growth, expansion of industrial scale, and increase in energy consumption.

3.2 Model Validation and Forecasting

Using the ridge regression method, the model parameters are estimated and validated. The historical simulation values are compared with the actual values, and the results show that the model has good fitting effect [Figure 2: see original paper].

Based on the model, this paper sets up nine development models under three scenarios of environmental regulation intensity (low, medium, and high) to forecast the carbon emissions from 2017 to 2030. The growth rates of each variable are set according to the historical trend and policy orientation (Table 4).

[Figure 3: see original paper] shows the forecast results of carbon emissions under the current development scenario. Under the low environmental regulation scenario, carbon emissions will continue to grow and cannot reach the peak by 2030. Under the medium environmental regulation scenario, carbon emissions will peak in 2025. Under the high environmental regulation scenario, carbon emissions will peak in 2020.

3.3 Analysis of Environmental Regulation Intensity

Environmental regulation intensity has a significant negative impact on carbon emissions. The results show that for every 1% increase in environmental regulation intensity, carbon emissions decrease by X%. Under the high environmental regulation scenario, the carbon emission intensity in 2030 will be reduced to 0.68 $\text{t} \cdot (10^4 \text{ k})^{-1}$, a decrease of 60.14% compared with 2005, meeting the national emission reduction target.

4. Discussion

The research results indicate that strengthening environmental regulation is the key to achieving the carbon peak target in northwestern China. First, the government should improve the environmental performance evaluation system and increase the weight of environmental governance indicators. Second, it should optimize the structure of FDI, strictly control high-energy-consuming and high-polluting projects, and attract clean and high-tech industries. Third, it should implement differentiated environmental regulation policies according to local conditions and formulate stage-specific emission reduction targets.

The limitations of this paper include: first, the STIRPAT model assumes that the relationships between variables are linear, which may ignore nonlinear characteristics; second, the scenario setting has a certain degree of subjectivity; third, the impact of technological progress and energy structure adjustment on carbon emissions needs further study.

5. Conclusions and Policy Recommendations

Based on the STIRPAT model and scenario simulation, this paper forecasts the carbon emissions from energy consumption in northwestern China from 2017 to 2030. The main conclusions are:

1. Under the current development pattern, carbon emissions in northwestern China will continue to grow and cannot reach the peak by 2030. The total emissions in 2030 will reach $X \times 10^4$ t.
2. Under the low environmental regulation scenario, none of the three development models can achieve the carbon peak target. The emissions in 2030 will be $X \times 10^4$ t, $Y \times 10^4$ t, and $Z \times 10^4$ t respectively.
3. Under the medium and high environmental regulation scenarios, the carbon peak can be achieved in 2025 and 2020 respectively, with peak values of $A \times 10^4$ t and $B \times 10^4$ t.

Policy recommendations: - Strengthen environmental regulation and improve its intensity - Optimize the structure of foreign investment - Promote industrial upgrading and green development - Implement differentiated and stage-specific policies

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Note: Figure translations are in progress. See original paper for figures.