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An Empirical Analysis of the Influencing Factors of Carbon Emissions in China

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Abstract. China plays an important role in climate governance and reaching the carbon neutrality in the world. The paper stated the energy consumption and carbon dioxide emission of China. Following that, the paper analyzed the influencing factors of carbon emissions in China by using LMDI model. In the end, the paper this paper put forward countermeasures and suggestions, which include promoting the synergistic upgrading of industrial structure, optimizing the energy consumption structure, and practicing the low-carbon concept.

Key words: empirical analysis, influencing factors, carbon emissions, China

1. Introduction

With the rapid economic development and the increased energy consumption, challenges of environmental pollution governance have been aggravated in the world (Yan et al., 2021; Wang and Yang, 2020). The Paris Agreement, adopted at the Global Climate Summit 2016, which set the goal of holding global average temperature warming to within 1.5 degrees Celsius from pre-industrial levels, was the third landmark international legal instrument for humanity to address climate change, following the United Nations Framework Convention on Climate Change and the Kyoto Protocol, and forms the global climate governance pattern for the post-2020 period. At the 26th United Nations Climate Conference (COP26) in 2021, 137 countries around the world made commitments to net-zero emissions or carbon neutral (UNFCCC, 2021).

As the biggest developing countries in the world, China plays an import role in climate governance and reaching the carbon neutrality. In 2020, the China's energy consumption was 145.46EJ， and emission of carbon dioxide reached 9,899.3 million tons. To promote environment governance and the sustainable development of economy have become important issues of China. Moreover, China was aiming to reach carbon emissions peak by 2030 and realize the carbon neutral by 2060. Therefore, the research attempts to study the influencing factors of carbon emissions in China.

2. The Energy Consumption and Carbon Emissions of China

2.1 The Energy Reserves and Production of China

China has abundant fossil energy resources and the coal takes a dominant position. China had proven oil reserves of 138.9 billion tons in 2020, accounting for 59.2% of the global oil reserves. The natural gas reserves of China reached 8.4 trillion cubic meters, accounting for 4.5% of the global natural gas reserves. The coal reserves of China was 143.2 billion tons, accounting for 13.3% of the global coal reserves (BP, 2021).

The energy production of China has grown rapidly with the development of economy. In 2010, the oil production of China was 203.0 million tons, accounting for 5.1 per cent of global oil production. The production of natural gas reached 965.0 billion cubic metres, accounting for 3.1 per cent of global natural gas production. The production of coal was 69.72EJ, accounting for 46.2 per cent of global coal production. The production of renewable energy reached 75.0 Terawatt-hours, accounting for 9.9 per cent of global renewable energy production. In 2020, the oil production of

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China was 194.8 million tons, accounting for 4.7 per cent of global oil production. The productions of natural gas reached 194.0 Billion cubic metres, accounting for 5.0 per cent of global natural gas production. The production of coal was 80.91EJ, accounting for 50.7 per cent of global coal production. The production of renewable energy reached 863.1 Terawatt-hours, accounting for 27.4 per cent of global renewable energy production (BP, 2021).

2.2 The Energy Consumption and Carbon Emissions of China

In 2020, the China's energy consumption reached 145.46EJ， accounting for 26.1 percent of the global energy consumption. Among the total energy consumption of China, the oil consumption was 28.5 EJ, accounting for 16.4 per cent of global oil consumption. The consumption of natural gas reached 11.9 EJ, accounting for 8.6 per cent of global natural gas consumption. The consumption of coal was 82.27EJ, accounting for 54.3 per cent of global coal consumption. The consumption of renewable energy reached7.79 EJ, accounting for 24.6 per cent of global renewable energy consumption (BP, 2021). The energy consumption structure shows that the power generation demand of China mainly relies on coal consumption, which accounting for 56.9% of China's energy consumption in 2020. Therefore the energy structure of China is needed to be significantly optimized (Yan and Li, 2021).

Along with the continuous development of the economy, China's carbon emissions are increasing and accounting for a growing share in the world. From 2000 to 2020, China experienced the biggest increase in CO2 emissions, growing 1.95 times from 3.36 billion tons in 2000 to 9.9 billion tons in 2020. From 2000 to 2020, China's carbon emission share in the world is also rising, from 14.09% in 2000 to 41.51% in 2020, which is the biggest increase among the BRICS countries. As the world's largest energy importing country and energy consumption country, rapid economic development in recent years has brought considerable environmental pollution problems to China. The energy structure and the increased carbon emissions bring big challenges to strike a good balance between economic development and environmental protection and achieve a high-quality development.

3. Empirical Analysis of the Influencing Factors for Carbon Emissions of China

3.1 The Quantitative Model to Analyse Carbon Emissions of China

Logarithmic mean Divisia Index (LMDI）is a classical factor decomposition model. This model is the most popular exponential factor decomposition method among researchers, which can be used to decompose energy consumption or carbon emissions within a period of time (Ang,1997; Stretesky and Lynch, 2009; Behnaz and Jamalludin, 2013; Fatima, 2019; Wang et al., 2020; Wang and Yang, 2020;Yang el al., 2020).

According to the LMDI decomposition model, main factors affecting carbon emissions include carbon emission intensity, energy consumption structure, energy intensity, economic development and population size, etc. The following decomposition form is thus obtained:

$$C = \sum_i C_i = \sum_i \frac{C_i}{E_i} \cdot \frac{E_i}{E} \cdot \frac{E}{G} \cdot \frac{G}{P} \cdot P = \sum_i R_i S_i IDP$$

Therein, C represents carbon emissions, i represents primary energy sources, including oil, natural gas and coal, E represents energy consumption, G represents gross domestic product (GDP), and P represents population size; R is energy carbon intensity, representing carbon emissions per unit of consumption of energy source i; S is energy consumption structure, representing the share of energy source i in energy consumption; I is energy intensity, representing energy consumption per unit of GDP; and D is economic development, representing GDP per capita.

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3.2 Data Source and Empirical Analysis Result

The time span of LMDI model is 2000-2020. The data of carbon emissions, clean energy consumption and total energy consumption are obtained from the BP Statistical Review of World Energy 2021; the data of total population, urbanization rate, total labor force, fertility rate, life expectancy, GDP per capita, industrial value added and total GDP are obtained from the World Development Indicators (WDI) database of the World Bank; and the data of energy carbon emission intensity are taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories which is published by the IPCC.

The LMDI model is used to check the main influencing factors of carbon emissions in China, which including energy consumption structure, energy intensity, economic development level and population size. The empirical analysis aims to obtain the contribution value of each influencing factor to carbon emissions from 2000 to 2020 and the total contribution value. Figure 1 shows the empirical analysis result of LMDI model.

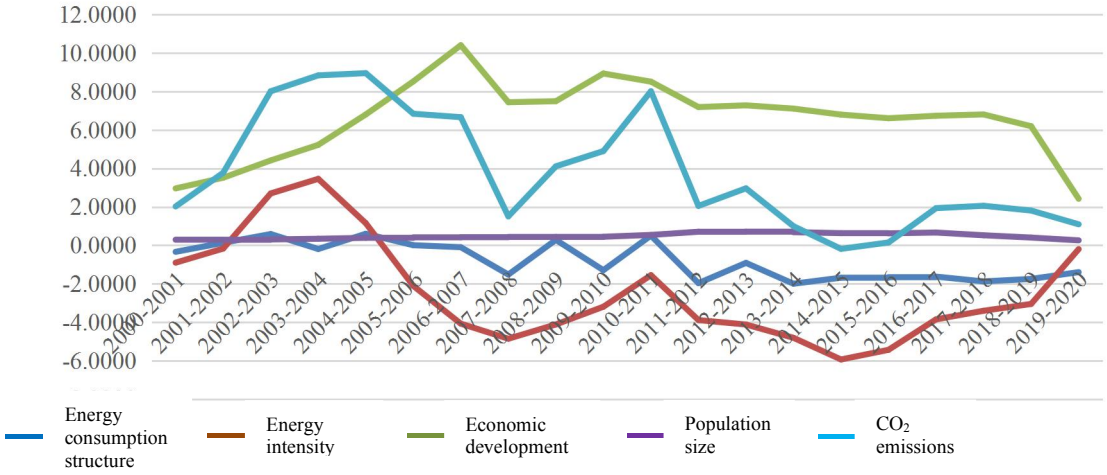

Figure 1 LMDI Empirical Analysis Result

According to the empirical analysis result, the contribution of economic development level and population size to China's carbon emissions is positive, while the contribution of energy consumption structure and energy intensity is negative, which indicates that economic development level and population size have positive driving effects on the increase of China's carbon emissions. The energy consumption structure and energy intensity have negative effects. According to the empirical result, the economic development level bring the largest positive contribution to the increase of China's carbon emissions, and the energy intensity takes the largest negative contribution to the increase of China's carbon emissions .

The positive effect of both economic development level and population size on carbon emissions stems from the demand for energy consumption for human production and living and economic development. In particular, the rapid growth of China's population and economy leads to the same rapid growth of carbon emissions. The negative driving effect of energy consumption structure on carbon emissions is due to that China's energy consumption structure has been improved, and the share of coal consumption in China has dropped significantly, indicating that the optimization of energy consumption structure has a certain inhibiting effect on the increase of carbon emissions. Similarly, China's energy intensity decreases significantly during 2000-2020, indicating that China is gradually paying attention to the improvement of energy efficiency and strengthening innovation, which also has a dampening effect on the growth of carbon emissions.

Among demographic factors, population size, urbanization rate and life expectancy all contribute to China's carbon emissions, and the labor force rate has a dampening effect for most countries. Overall, the contribution of population to carbon emissions is due to that human production and life are inseparable from the demand and consumption of energy, so the population size has a

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contribution to carbon emissions in almost every country, i.e., population growth implies an increase in carbon emissions. With the rapid growth of Chinese economy, the urbanization rate is also increasing, and the construction of public facilities, buildings and roads in urban construction is inseparable from the massive consumption of energy. During the process of urbanization, people's consumption pattern and scale have changed dramatically, all of which will increase carbon emissions. Life expectancy has also contributed to carbon emissions. The increasing life expectancy of the Chinese population in recent years reflects the improvement in people's life quality, which will be accompanied by a change in consumption habits and an increase in the scale of consumption, and contributes to carbon emissions. The labor force rate has a dampening effect on carbon emissions, mainly because that China is facing the industry optimization and upgrading. Therefore, the increase in the labor force rate has a dampening effect on the increase of carbon emissions.

4. Suggestions to Promote China's Carbon Emission Reduction

China, as the world's strongest developing country, is facing the pressure of environmental pollution and carbon emission reduction at the same time along with the rapid economic development. It is actively seeking a balance between rapid economic development and environmental protection, to ensure the ultimate achievement of their respective carbon neutral and net zero emission goals without compromising economic development. This is not only the demand of the Chinese people for a better living environment, but also to fulfill the responsibility as an emerging power, contributing to the improvement of international status and the establishment of an international image.

4.1 Promote the Synergistic Upgrading of Industrial Structure

The share of industry contributes to China's carbon emissions. The larger the industry share, the more the carbon emissions. This is mainly due to the fact that China's rapid economic development mainly relies on the development of secondary industries such as industry, which depends on the use of energies, especially oil and coal, while the use efficiency is low and the early cleaning work is not done. Due to the characteristics of high energy consumption and increased carbon emissions of the industry, in the face of environmental governance and carbon emission reduction and carbon neutral or net zero emission targets, it is necessary to promote a synergistic upgrading of the industry in the direction of low carbon, which is unstoppable.

On the one hand, we should promote the development of tertiary industries such as service industries and reduce the share of secondary industries with high carbon emissions and high energy consumption. The tertiary sector is characterized by low energy consumption and low carbon emissions. We should vigorously develop the tertiary industry and increase its proportion, which is conducive to promoting the development of low carbonization. On the other hand, we can promote the green development of industries, such as creating ecological agricultural parks and developing efficient and ecological modern agriculture, while we can carry out technological innovation and vigorously develop technologies such as desulfuration to improve the energy use efficiency. We can also promote the development of green service industry. The BRICS countries have respective advantages, so they can exchange experiences, complement each other's advantages and promote the synergistic upgrading of industrial structure.

4.2 Optimize the Energy Structure

Energy consumption structure, clean energy proportion and energy intensity have a dampening effect on carbon emissions of China. For the current pressure of carbon emission reduction faced by China, the energy consumption structure is not reasonable enough, the energy use efficiency is not high enough, and the green and low-carbon energy is not developed well. The shares of both oil and coal in total energy consumption of China have tended to decline in recent years, while the shares of natural gas and other clean energy sources have tended to increase, reflecting China's goal and

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actions to optimize its energy consumption structure. China has become a leader in promoting the development of new energy in the world, with the installed capacity of hydropower, solar photovoltaic and wind power ranking first in the world, and the production capacity of electric vehicles ranking front row in the world. It is necessary to continuously increase the proportion of clean energy production and promote the optimization of energy consumption structure.

4.3 Practice the Low-carbon concept

From the empirical analysis, it is clear that demographic factors have a great impact on carbon emissions. The demographic factors included population size, urbanization rate, and life expectancy, which contributing to carbon emissions in almost every country. Labor force rate also has a dampening effect in most countries. Therefore, it is of great significance to raise the public's awareness of low carbon and environmental protection and to play the role of the public in the coordinated governance of carbon emissions.

The contribution of population size and urbanization rate as well as life expectancy to China's carbon emissions stems is mainly resulted from the needs of human life, while the consumption demand driven by rapid economic development in recent years has further contributed to the rapid growth of carbon emissions. Therefore, if carbon emission reduction is to be carried out on the basis of rapid economic development, low-carbon awareness of the public must be raised by strengthening government guidance and promoting and advocating the concept of low-carbon life. Specifically, the government can set an example for the public by first implementing behaviors such as low-carbon offices within the government. At the same time, TV, magazines, social media and short videos can be used to promote the low-carbon lifestyle, guide the public to sort garbage and actively practice green travel, so as to make people root the green lifestyle in mind deeply and reduce the contribution of demographic factors to carbon emissions from the public perspective. The dampening effect of labor force rate on carbon emission is that more labor force is gradually invested in low carbon emission industries after industrial optimization and upgrading, so industrial upgrading can also strengthen the effect of labor force rate on carbon emission reduction.

5. Conclusion

As the biggest developing countries in the world, China plays an import role in climate governance and reaching the carbon neutrality. The paper stated the energy production, energy consumption and carbon dioxide emission of China. Following that, the paper analyzed the influencing factors of carbon emissions in China by using LMDI model. In the end, the paper this paper put forward countermeasures and suggestions, which include promoting the synergistic upgrading of industrial structure, optimizing the energy consumption structure, and practicing the low-carbon concept. The conclusions of this study can be used as a guide for future decisions of managers, and policy-makers regarding the strategies to promote carbon emission reduction and carbon neutrality goals.

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