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An Empirical Study on the Impact of Industrial Structure Upgrading on Carbon Emissions in China

--Based on Panel Data of 30 Provinces and Cities

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Abstract

With the rapid development of our economy, the carbon emissions from various industries also increased. In order to reach peak carbon and carbon neutrality through industrial structure upgrading, the impact mechanism between industrial structure upgrading and per capita carbon emissions was studied based on panel data of 30 provinces in China from 2005 to 2019. The research shows that the advanced industrial structure can significantly restrain the growth of per capita carbon emissions..

Keywords

Advanced industrial structure; Carbon emissions; Baseline regression.

1. Introduction

Since September 22, 2020, the President of the People's Republic of China announced at the 75th United Nations General Assembly. China aims to peak its carbon dioxide emissions by 2030 and reach carbon neutrality by 2060. As the largest developing country in the world, China has not yet established an effective and sound long-term mechanism to deal with climate change. China is facing unprecedented pressure on environmental governance and low-carbon development. In order to solve the “Two-carbon” problem, the state council issued the “Carbon Peak Action Plan before 2030”, which proposes to adjust and optimize the industrial and energy structure, and promote green and low-carbon development in industry. But China's carbon emissions in 2022 are expected to fall by 0.9%, according to the 2022 global carbon budget. The secondary sector of the economy industry remains a major carbon emitter and has a high carbon intensity. According to China's 2022 Carbon Market Annual Report: 2022, the overall operation of the national carbon market stable, carbon price has increased. The smooth operation of the carbon market has promoted the reduction of carbon emissions, which has also greatly contributed to the reduction of China's carbon emission intensity. Therefore, in order to deal with China's carbon emissions problem, we need to find a suitable path to curb the growth of carbon emissions and achieve carbon peak and carbon neutrality, the government should focus on promoting the adjustment and upgrading of industrial structure in the industrial sectors of all regions, and at the same time ensure the smooth operation of the economy, realize the development of industry and the reduction of energy consumption, and reduce carbon emissions.

Based on this, this paper constructs the benchmark regression model, discusses the relationship between the advanced industrial structure and per capita carbon emissions and

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transmission mechanism. The impact of advanced industrial structure on per capita carbon emissions in China is shown by mathematical analysis.

2. Literature Review

China is now in the process of moving from high-speed economic development to high-quality development, and its energy consumption is huge, making China the world's largest carbon emitter. In order to achieve high-quality development, effort to strengthen the adjustment of industrial structure is absolutely the top priority. In the existing literature, the optimization of industrial structure can effectively restrain the growth of carbon emissions [1]. Among them, the advanced industrial structure of carbon emissions will be more significant than the role of rationalization of industrial structure [2]. Wu Zhenxin (2012)[3] added structural adjustment factors to the environmental Kuznets curve and further established the individual fixed effect model, an analysis of the fixed-effects model shows that the secondary sector of the economy share is proportional to carbon emissions, and each 1% reduction in the secondary sector of the economy share leads to a 0.3217% reduction in per capita carbon emissions. Zeng haiying and Yue Huan [4] used Yangtze River Delta data from 41 prefectural-level cities to analyze the impact mechanism between industrial structure and carbon emissions, it is demonstrated that both the advanced industrial structure and the rationalization of industrial structure can reduce the carbon emission level. To sum up, accelerating the upgrading of industrial structure in the region can promote the transformation and development of secondary sector of the economy industries, promote the development of new and high-tech Enterprises, improve the efficiency of production and use of resources, and achieve restraint in the growth of carbon emissions.

3. Research design

3.1. Variable selection

3.1.1. The interpreted variable

Per capita carbon emissions (PC). First, on the calculation of total carbon emissions, this paper estimates the carbon emissions of China's 30 provinces and regions by using the standard coal conversion coefficient provided by the energy statistics yearbook of China and the carbon emission coefficient provided by the IPCC. The paper selects seven energy consumption items including raw coal, coke, gasoline, kerosene, diesel oil, fuel oil and natural gas, and uses the formula for calculating carbon emissions to refer to previous studies by Liu Xianzhao [5] and other scholars, the specific measurement methods are as follows:

$$C = \sum_{t=1}^{7} C_t = \sum_{t=1}^{7} E_t \times SCC_t \times CEC_t \times 44/12 \quad (1)$$

$$PC = C/POP \quad (2)$$

In the formula, C represents the measured carbon emissions; C represents the consumption of fossil energy type T; C represents the standard coal conversion coefficient of fossil energy type T; C represents the carbon emission coefficient of fossil energy type T; C represents the carbon emission coefficient of fossil energy type T 44/12 represents the molecular weight ratio of carbon; POP is the resident population; SCC and CEC values are shown in Table 1.

Table1. SCC and CEC Value

Types of energy	Coal	Coke	Gasoline	Kerosene	Diesel fuel	Fuel oil	Natural gas
SCC(kgStandard coal/kg)	0.7143	0.9714	1.4714	1.4714	1.4571	1.4286	1.2143
CEC(kg/kgStandard coal)	0.7559	0.8550	0.5538	0.5714	0.5921	0.6185	0.4483

3.1.2. Explain variables

The measurement of the advanced industrial structure (TS)，This paper refers to the method of Fu Linghui (2010) [6]. First, we measure the ratio of primary industry, secondary sector of the economy and tertiary sector of the economy output value to GDP as a component of the spatial vector, thus forming a set of 3-dimensional vectors X_0= (X_1,X_2, X_3). Then measure the vectors of X_0 and industry from low to high respectively X_1=(1,0,0), X_2=(0,1,0), X_3 =(0,0,1) angles.

$$\theta_j = \arccos\left(\frac{\sum_{i=1}^{3}(X_{i,j}X_{i,0})}{\left(\sum_{i=1}^{3}(X_{i,j}^2)^{1/2}\sum_{i=1}^{3}(X_{i,0}^2)^{1/2}\right)}\right) \tag{3}$$

Among them，j=1, 2, 3.

The formula of TS for industrial structure upgrading is as follows:

$$TS = \sum_{k=1}^{3}\sum_{j=1}^{k}\theta_j \tag{4}$$

3.1.3. Control variables

The economic level (GDP) is represented by the gross domestic product (GDP) of the region. To eliminate the effect of inflation, GDP is calculated as real GDP at the base price in 2000； Human capital (PER): PER 10,000 college students. Technological Progress (Ski). This paper uses R&D input per unit of GDP to measure technological progress.

3.2. Research methods and model building

3.2.1. Principal effects regression model

This paper constructs a two-way fixed effect model to study the impact of industrial structure upgrading on per capita carbon emissions.

$$PC_{it} = \alpha_0 + \alpha_1 TS + \alpha_2 control_{it} + \varepsilon_{it} \tag{5}$$

Among them, i is the province; t is the year; PC represents carbon emissions per capita; TS denotes advanced industrial structure; control is the control variable; ε_{it} represents a random perturbation term.

3.3. Data sources

This paper selects relevant research data of 30 provinces in China from 2005 to 2019. The data of the above variables come from China statistical yearbook, China Energy Statistical Yearbook, China Environment Statistical Yearbook, China Science and Technology Statistical Yearbook, etc.

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Table 2. Variable descriptions

Category	Variable	Symbols	Variable description
The interpreted variable	Per capita carbon emissions	PC	Derived from formula (1)(2)
Explain variables	Advanced industrial structure	TS	Derived from formula (3)(4)
Control variables	Technological progress	SKI	R&D investment per unit of GDP
	Economic level	GDP	Real Gross Domestic Product
	Human capital	PER	The number of college students per 10,000 people on campus

4. Analysis of Empirical Results

In this paper, the Hausman test is used to choose the fixed-effect model or the random-effect model before constructing the model. Based on the results of the Hausman test, the bidirectional fixed effects model was used to construct the model and estimate the conclusion. To avoid the Multicollinearity problem, the stepwise regression method was used to construct the baseline regression model, the estimated results are shown in table 3.

Table 3. Main effects of industrial structure upgrading on per capita carbon emissions

	(1)	(2)	(3)	(4)
	PC	PC	PC	PC
TS	-3.522**	-3.305*	-4.384***	-3.816**
	(-1.98)	(-1.94)	(-2.59)	(-2.23)
GDP		-0.000***	-0.000***	-0.000***
		(-5.90)	(-5.55)	(-5.70)
PER			289.489***	216.997***
			(4.29)	(2.83)
SKI				-0.035**
				(-1.98)
cons	33.044***	33.003***	35.531***	35.567***
	(2.62)	(2.72)	(2.99)	(3.00)
N	450	450	450	450
R2	0.886	0.895	0.900	0.901

Note: * *, * * , * * * indicate significant at 10% , 5% , and 1% levels, respectively.

From Table 3, models 1 to 5 gradually control the regression of economic development (GDP), human capital (PER), and technological progress (Ski). The results show that the level of industrial structure upgrading is significantly negative at 5% level, and the R2 of the model increases with the increase of control variables. It shows that the advanced industrial structure can effectively restrain the growth of per capita carbon emissions.

From the perspective of the core explanatory variables, the impact of the upgrading of industrial structure on the economic growth of our country is obvious. By upgrading the industrial structure, the provinces have promoted the transformation and upgrading of their secondary sector of the economy. In this regard, the industry has started to use a lot of green energy and energy-saving technologies, thus improving the energy use and production efficiency of the industry, while also curbing the increase in carbon emissions in the process of business production. On the other hand, enterprises have also begun to shift from secondary sector of the economy to tertiary sector of the economy. In the process of industrial transformation and upgrading, enterprises absorb employees into tertiary sector of the economy on a large scale, while creating profits for the enterprises, it can also reduce the input of labour and capital by enterprises in the secondary industry, slowing the trend of further expansion of the scale of secondary sector of the economy development, thus reducing the per capita carbon emissions of provinces. This conclusion proves that the advanced industrial structure has a certain inhibitory effect on the increase of per capita carbon emissions.

In terms of the controlled variables, the level of economic development, human capital and technological progress have a significant impact on per capita carbon emissions. Economic performance is closely related to per capita carbon emissions. With economic development, the industrial development of provinces and the development of cities are accelerating. People have begun to pay attention to the low-carbon industry in the cities, economic development can effectively curb the increase of per capita carbon emissions. With the continuous increase of human capital, labor force in all industries are attracted to cities, thus providing more human capital for industrial development and further expanding the production scale of enterprises, this has led to a rise in corporate carbon dioxide emissions. Scientific and technological progress is an important driving force for promoting industrial development, improving efficient energy use and reducing per capita carbon emissions.

5. Conclusions and Recommendations

Based on the panel data of 30 provinces in China from 2005 to 2019, this paper measures and analyzes the advanced level of industrial structure and per capita carbon emissions. On this basis, we add control variables to investigate the inhibition of the advanced industrial structure on per capita carbon emissions. The conclusion is as follows: the advanced industrial structure can significantly inhibit the growth of per capita carbon emissions.

Based on the above analysis results, in order to reduce the per capita carbon emissions, this paper proposes the following policy recommendations:

First, all provinces and regions should speed up the pace of industrial transformation and upgrading, and promote the development of industrial structure in the direction of advanced. On the one hand, we should encourage the transformation and upgrading of traditional industries, promote industrial efficiency and resource utilization, realize low energy consumption and high output of enterprises, shift high energy consumption and high pollution enterprises out of the country, and speed up the construction of high-tech urban development zones, we will accelerate the formation of technology-intensive enterprises; on the other hand, we will increase investment in R & D, bring in talent, improve the coal-based energy structure, and increase the use of clean energy.

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