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Government Intervention and Industrial Carbon Emission Efficiency

- Empirical Evidence from China

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Abstract: This paper shows the relationship between government intervention and industrial carbon emission efficiency by analyzing the provincial data in China from 2005 to 2020, and also briefly discusses other control variables. First of all, this paper gives a brief description of the relevant dynamics of environmental protection projects and carbon emission trading in various countries around the world. The overall trend indicates that improving industrial carbon emission efficiency and achieving green development has become a historical topic. Then, the author reviews the previous study. These studies mainly include the measurement of the efficiency of industrial Carbon emissions, the analysis of contributing factors of the efficiency and the discussion of econometric methods used in the study of this topic. Thirdly, using the control variable method, the panel regression model is used to analyze the data. Finally, conclusions and policy suggestions are given: government intervention will generally reduce the efficiency of industrial carbon emission, strong environmental regulations may inhibit the enhancement of industrial carbon emission efficiency, the transformation of energy structure will help reduce carbon emission and the improvement of opening-up degree is significantly positively related to the efficiency. Therefore, it is necessary to make reasonable use of government power, carry out environmental management according to reality, promote the transformation of energy structure and increase the openness to the outside world.

Keywords: government intervention, industrial carbon emission efficiency, China

1. Introduction

Reducing carbon emissions is greatly significant to sustainable economic growth in China and the green transformation of its growth mode. Since the 21st century, the contradiction between the unsustainability of resources and the goal of sustainability of human development has become increasingly intense. A series of international documents have been adopted or ratified by relevant countries, such as the Kyoto Protocol and the Paris Agreement. With the efforts of relevant parties, different levels of institutional arrangements have been made at the policy level, and different contributions have been made in practical actions. Among them, as a pioneer in the cause of green, low-carbon and emission reduction, the United States has always maintained the market-oriented principle in the growth of green economy and green finance and emphasized the decisive role of the

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market in the carbon trading market. In terms of financial products, services and innovation, the United States also has a lot to learn from. The Joint Crediting Mechanism (JCM) between Japan and Mongolia was launched in 2013; In 2015, France first proposed a "national low-carbon strategy" and formally established a carbon budget system. To achieve the objective of "carbon peak and carbon neutral", China adopted the Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Vision for 2035 in March 2021, which makes a top-level design for "dual carbon". China is trying to build a "1+N" policy system for peak carbon neutrality, which will contribute a positive effect on promoting of the "dual carbon" goal. In the process of realizing the goal of "dual carbon", increasing efficiency while reducing carbon needs to be focused on in the industrial sectors. As a country with the fastest process of industrialization, the positive effect of improving carbon emission efficiency should be paid close attention to, and how to reduce the use of energy and increase efficiency in the industrial field should be rationally considered. As the core growth pole of the world economy, China has an obligation to decrease carbon emissions, enhance the efficiency of carbon emissions, and bring positive externalities to the international economic environment. However, the reality is that the implementation of various energy-saving and reduction plans of emissions produced by various countries in the world is not in place, and extensive economic development still occupies a major position in the international economic system.

The correlation between the government and the market is a common topic in economics. China's special economic model based on its own special national conditions makes the government relatively powerful in the market. And its industrial carbon emission trading mechanism may be affected by this, showing some characteristics different from other countries. Government intervention through executive decrees and political connections also largely declines the environmental innovation induced [1]. Therefore, it is academically necessary to measure China's industrial carbon emission efficiency and analyze the influence of government intervention on it.

2. Literature Review

Under low-carbon development, industrial carbon emission efficiency is widely used as an indicator of carbon emissions by scholars. The measurement of the efficiency of carbon emission has been studied in two approaches. The first is to measure carbon emission efficiency by a single factor, it defines carbon productivity as the ratio of CO_2 emission to GDP [2]. The other way is based on the total factor perspective, including stochastic frontier analysis (SFA), M-L Index, data envelopment Analysis (DEA), and the improved model based on it [3].

In terms of factors affecting carbon efficiency, scholars have analyzed some agents like the industrial structure [4], opening up to the outside world [5], environmental regulation [6] and technological progress [7]. In addition, more literatures also use the control variable method to focus on a certain core variable affecting the efficiency of industrial carbon emissions. Some studies point out the impact of the indiscriminate use of burnable carbon products and market mechanisms on industrial carbon emissions [8]; some explore the correlation between the external economy and carbon emission efficiency [9]; and some try to understand the influence of industrial agglomeration on carbon emission efficiency [10].

In the econometric analysis of data, most literatures mainly use the spatial econometric approach, heterogeneity analysis and control variable method.

3. Research Design and Methodology

3.1. Measurement of Industrial Carbon Emission Efficiency

This paper chose industrial carbon emission efficiency as an explained variable. For measuring the efficiency of industrial carbon emission, this paper uses the Super-SBM model with undesired output

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based on constant returns to scale [11], and selects input indicators, including labor force (the number of employees in industrial industries in different regions), capital (the net value of fixed assets in industrial industries above designated size in different regions) and total energy (the total energy consumption in different regions). The expected output is represented by the operating income of industrial entrepreneur owners above the designated size in different regions, and the undesired output is expressed as the CO_2 emissions of industry in different regions. Among them, the industrial CO_2 emissions by region are calculated by using the consumption of eight fossil fuels, including fuel oil, diesel oil and hard coke in each region of China according to the method in IPCC Guidelines for National Greenhouse Gas Emission Inventory 2006.

3.2. Variable Selection and Data Selection

For the selection of explanatory variables, this paper chooses the government intervention index (GI) as the core explanatory variable, and takes the energy structure index, industrial structure index, property rights structure index, environmental regulation and foreign investment level as control variables. The government intervention index is expressed by the Technology Choice (TCI) index. The basic idea of this index constructed by Lin and Liu is that a country's endowment structure determines its optimal industrial structure, but when the government tries to promote faster economic development and implements industrial policies to intervene in the economy, regional development strategies will deviate from their comparative advantage strategies. The greater the intensity of the intervention, the greater will be this deviation and the higher will be the TCI [12]. Therefore, the TCI index can be a desirable proxy variable for government intervention. The specific calculation formula of the TCI index is as follows: $TCI = \frac{\frac{AVM}{GDP}}{\frac{LM}{L}}$.Other control variables are constructed as follows:

Energy structure (ES): Coal occupies a major position in China's energy consumption structure as one of the major contributors of regional industrial carbon emissions. The proportion of coal consumption to total energy consumption can be used to show the energy structure. Property rights structure (PS): Different property rights tend to correlate with a gap between enterprises in pollution management and other aspects. This situation affects carbon emission efficiency. In China, the major business revenue of state-owned industrial companies accounts for a significant ratio of the major business revenue of industrial companies above the designated size, and poverty rights can be measured by using this proportion. Industrial structure (IS): Industrialization is an objective phenomenon and inevitable law of human social development. According to Malthus's theory, it starts because agricultural output still has a surplus after meeting the basic survival needs of human beings and this surplus forms accumulation after capitalization. Over the past forty years, China's industrialization has been increasing rapidly, industry become the main source of regional carbon emissions. The output value of the secondary industry-GDP ratio can be used to show the industrial structure, which reflects the changes in economic structure and certain historical trails of carbon emissions. Environmental regulation (ER): Environmental supervision is a special economic and political symbol in China, and with the advocacy for energy conservation and efficiency enhancement at the policy level, environmental regulations are also constantly strengthening. China's environmental regulation has increased. On the one hand, imposing environmental constraints on profit-oriented enterprises reduce pollution emissions and entices them to use clean technologies; On the other hand, too many restrictions may increase costs and impede the green transformation of the industry. The logarithm of the investment in industrial pollution control can be used to represent the intensity of environmental regulation. Foreign investment level (FDI): Foreign investment is a significant channel for the source of industrial intelligence and also causes technology lead-in to the market, which can be expressed by the proportion of foreign direct investment to GDP.

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The variables discussed are panel data with a time span of 2005-20, and the regions include 30 provinces, municipalities directly under the Central Government and ethnic autonomous areas in China (excluding Macao, Hong Kong, Tibet and Taiwan because of the missing of their data), and Mathlab2021a is used as the computing environment. All information comes from the National Bureau of Statistics, China Statistical Yearbook, China Energy Statistical Yearbook, China Economic Census Yearbook and China Industry Statistical Yearbook. Among them, because the regional data of the usage of the eight fossil fuels used to calculate the efficiency of industrial carbon emission are missing in some years, the linear interpolation method and the near-mean interpolation method are used to complete the data.

3.3. Regression Model Specification

Taking the carbon emission efficiency of 30 provincial administrative units (excluding Tibet, Hong Kong, Macao, and Taiwan) as the dependent variable, this paper studies the influence of government intervention on the efficiency of industrial carbon emission. In addition, the energy structure index, industrial structure index, property rights structure index, environmental regulation, and foreign investment degree are used as control variables. The panel regression model is as follows:

$$CE_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 ES_{it} + \beta_3 IS_{it} + \beta_4 PS_{it} + \beta_5 LnER_{it} + \beta_6 FDI_{it} + \mu_{it}$$

Where i represents the region and t represents the year.

4. Empirical Results

4.1. Variable Descriptive Statistics

In this paper, the mean, standard error, maximum value and minimum value of every variable are calculated, and the specific results are displayed in the table below:

Table 1: Variable descriptive statistics

Variable	Obs	Mean	Std Dev.	Min	Max
CE	480	0.529978	0.3178303	0.143714	1.790592
GI	480	1.867625	0.6540062	0.753723	4.720408
ES	480	0.2148443	0.1015606	0.0055677	0.6048184
IS	480	0.4268319	0.0830516	0.1596709	0.6196027
PS	480	0.3937978	0.1858	0.095887	0.8374592
ER	480	201013.6	193626	476	1416464
FDI	480	0.0034737	0.0030428	0.0000162	0.0194259

According to Table 1, the difference between the minimum value and the maximum value of efficiency of China's industrial carbon emission is nearly 1.5, indicating that there is obvious heterogeneity in various regions. The mean value is 0.529, indicating that by comparing with the developed industrialized states, the efficiency of carbon emission of various regions in China is at a low level. The range of the degree of government intervention is nearly 4, which that reflects administrative power has different intensities in different spaces, and the mean value is 1.867, indicating that the overall degree of intervention is high.

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4.2. Regression analysis

F-test, LM test and Hausman test are used to give a judgment about the model effect, and the test results are shown in Table 2.

Table 2: F-test, LM test and Hausman test

test	Statistics	Prob
F-test	2.69	0.0006
LM test	16.00	0.0000
Hausman test	2.13	0.9072

According to the results of F-test and LM test, P values are less than 0.05, so the mixed effect is rejected. Moreover, the p-value of the Hausman test is greater than 0.1, showing that the model is proper for random effect estimation.

Table 3: Regression results

	CE	CE
GI	-0.287***	-0.198***
	(-16.06)	(-8.22)
ES		-0.557***
		(-4.40)
IS		-0.576***
		(-3.24)
PS		-0.0845
		(-1.00)
LnER		0.0374***
		(2.85)
FDI		18.32***
		(4.34)
_cons	1.066***	0.793***
	(28.33)	(5.22)
R-squared	0.3592	0.4339
F-statistics	257.86***	356.24***
N	480	480

Note: ***, ** and * are the significance levels of 1%, 5% and 10%, and the figures in parentheses are T values.

From Table 3, the regression parameter of the level of government intervention is − 0.198, which passes the T-test. Therefore, the intervention of public power is negatively correlated with carbon emission efficiency, which means that when the government strengthens its intervention in the industry, the industrial carbon emission efficiency tends to decrease. The reasons for this phenomenon are multiple: Firstly, China's special system creates a deep nesting of administrative instructions and economic structure. In the industrial structure oriented by administrative rather than profit goals, producers in the state-owned sector tend to produce regardless of environmental costs for certain output targets. While in the private sector, due to the imperfect system and mechanism of the carbon emission trading market and the existence of government power, the carbon emission efficiency is low. Secondly, due to the tradition of planned economy, administrative power often adopts the method of directly giving administrative orders to enhance industrial efficiency rather than achieving

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policy goals through exquisite market research, reasonable policy planning, legal decision-making processes and democratic promotion. These situations are highly likely to cause resentment in the private sector, leading to a tendency for business owners to abandon new technologies to improve carbon emission efficiency. Furthermore, the special political structure also brings about rent-seeking phenomena. From the perspective of the political economy, rent-seeking is harmful without any benefit. It breaks the clean and fair political environment, creates a non-democratic economy and impedes the enhancement of efficiency of carbon emission. Rent-seeking also negatively influences almost any economic efficiency. In a word, the strong color of rule by man is the projection of China's social and historical tradition on the economic field. Through the use of party politics and the establishment of a modern economic structure, this form of governance has been internalized and thus exerts its harmful influence on the industrial structure and the enhancement of industrial efficiency. But in some special cases, the impact of administrative power may be exactly the opposite. Excluding statistical factors, the underlying causes are diverse. These regions typically contain certain characteristics, such as deep poverty, extremely unsound market mechanisms (let alone carbon emission market), deep-inland location, and hostile natural environment. In these situations, administrative power has to exercise some functions of the market in order to achieve certain policy objectives and thus show a positive effect on the efficiency of industrial carbon emission. This statement is also supported by the statistical results below. Of course, this is only a temporary solution and the method is difficult to implement. However, after regional market conditions improve.

Among the control variables, the coefficients of the energy structure indicator and industrial structure index are negative and pass the t-test. That is, the energy structure index and industrial structure index negatively influence carbon emission efficiency. This shows that in the process of economic development, the consumption of a large amount of coal resources has led to the emission of carbon products and environmental pollution. The parameters of environmental regulation and foreign investment level are positive and pass the T-test. That is, environmental regulation and foreign investment level are positively correlated with this efficiency, indicating that in the whole region, the improvement of environmental pollution investment control and foreign investment level will promote that carbon emissions are being produced in a more efficient way. The negative coefficient of property rights structure is consistent with the theoretical expectation because the monopoly of state-owned companies on production and distribution and the dictatorship over the widespread technologies lead to an inefficient consequence in the reform and innovation, impeding the healthy growth of the market economy, and forces insufficient motivation to drive the enhancement of industrial carbon emission efficiency.

4.3. Regional Heterogeneity Analysis

The research samples are further fallen into the eastern, central and western regions for heterogeneity analysis, and Table 4 shows the outcomes.

Table 4: Heterogeneity regression results

CE	The Eastern region	The Central Region	The Western region
GI	-0.552***	-0.112**	0.035*
	(-12.08)	(-2.36)	(1.98)
ES	-0.621*	-0.368***	-0.0856
	(-1.64)	(-2.72)	(-1.50)
IS	0.319	0.140	0.613***
	(0.88)	(0.70)	(5.31)
PS	0.217	-0.685***	-0.275***

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Table 4: (continued).

	(1.46)	(-6.20)	(-5.43)
Ln ER	-0.047	0.0944***	0.00757
	(-1.31)	(5.08)	(0.49)
FDI	10.09***	-34.93***	11.03*
	(2.64)	(-3.48)	(1.74)
_cons	1.924***	2.201***	0.0661
	(6.10)	(8.43)	(0.51)
R-squared	0.3784	0.4359	0.1918
F-statistics	296.09***	76.60***	59.24***
Hausman (Prob)	0.2635	0.0864	0.0014
N	176	128	176

Note: ***, ** and * are the significance levels of 1%, 5% and 10%, and the figures in parentheses are T values.

The regression coefficient of the degree of government intervention in the eastern region is − 0.552, which passes the T-test, which means the intensity of administrative power in the eastern region is negatively correlated with the efficiency of carbon emission. For each 1% increase in the degree of government intervention in the eastern region, the efficiency will decrease by 0.552%. The regression parameter of the level of government intervention in the central region is − 0.112, which passes the T-test, indicating that the level of government intervention in the central region is negatively related to efficiency of carbon emission. For every 1% increase in the level of government intervention in the central region, the efficiency will decrease by 0.112%. The regression parameter of the level of government intervention in the western region is 0.035, and it passes the t-test, which shows the degree of government intervention in the western region is positively correlated with carbon emission efficiency. In addition, the regression parameter of environmental control in the eastern region is − 0.047. That is, the level of environmental control in the eastern region is negatively correlated with carbon emission efficiency. The parameters of environmental control in the central and western areas are 0.0944 and 0.00757, respectively. That is, the regulation in the central and west of China is positively related to carbon emission efficiency.

Firstly, the degree of government intervention in the eastern and central regions has an inhibitory role in industrial carbon emission efficiency, and the inhibitory role in the carbon emission efficiency in the eastern area is the most significant. However, the degree of government intervention in the western area exerts a positive effect on promoting efficiency. Such spatial heterogeneity should come from the spatial differences in institutional mechanisms and market supervision. The most developed eastern and central regions have relatively free market structures with sound systems and mechanisms and proper supervision, so the existence of any government power will distort the market and reduce the efficiency of carbon emissions. However, the growth degree of the western area is relatively low, the lack of market supervision, the imperfect system and the relatively backward economy all make it necessary to rely on the government to enhance the efficiency of carbon emission. However, even so, the low coefficient of government intervention in Western China also shows the inefficiency of executive power in improving the efficiency of industrial carbon emissions. Secondly, the degree of environmental regulation in the eastern of China plays a restraining role in carbon emission efficiency, but the level of environmental regulation in the central and west of China plays a positive promoting role in carbon emission efficiency. This phenomenon means that environmental regulation in the eastern region negatively influences carbon emission efficiency, and this conclusion is exactly confirmed by the outcomes of previous studies. Hans-Werner Sinn put forward the "green paradox" in 2008 [13]. They believe that the increasingly strict government regulation reduces the profit margin

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of fossil fuel extraction, which in turn causes enterprises to accelerate the extraction in order to maximize profits, thus reducing the industrial carbon emission efficiency.

5. Conclusion

The empirical results show that (1), in general, government intervention has caused low industrial carbon emission efficiency in most regions of China, but in regions with low productivity levels, the rational use of government power can play a specific role in enhancing the efficiency of industrial carbon emission. (2) Empirical data show that economically developed regions are more likely to create the "green paradox" due to environmental regulation. In those areas with low productivity, environmental regulation is conducive to enhancing the efficiency of industrial carbon emissions. (3) The energy structure with high coal consumption will reduce the industrial carbon emission efficiency. (4) The degree of foreign investment has a positive promoting effect on industrial carbon emission efficiency.

Based on the above study conclusions, the policy suggestions below are given. In the eastern and central regions, excessive government intervention should be avoided. Secondly, we should seek a reasonable intensity of environmental regulation and formulate different environmental rules according to specific circumstances. Third, promote the transformation of the energy structure, seek cleaner energy as an alternative, and encourage reducing the use of coal and other raw materials in production. Finally, we should continue to open up to the outside world, take advantage of the transfer and spillover of advanced technologies from developed countries to drive the popularization of energy-saving technology and the revolution of carbon emission models in countries with relatively low productivity levels, and build green finance with the help of foreign capital.

References

[1] *Jianqiang L, Yaowen S, Gary T, Xiangchao Hao. Labor cost, government intervention, and corporate innovation: Evidence from China. Journal of Corporate Finance, 2020, 64, 101668.*

[2] *Kaya Y, Yokobori K, 1997. Environment, energy, and economy: Strategies for sustainability[M]. Tokyo: United Nations University Press, 16-26.*

[3] *Lin L, Heng Z, 2021. Study on the relationship between the integration of "Two industries" and carbon emission efficiency [J]. Economic Survey, 38(5): 71-79.*

[4] *Yingqi X, Yu C, Jing W, 2022. Spatio-temporal evolution and influencing factors of carbon emission efficiency in low-carbon pilot cities in China [J], Journal pf Natural Resources. 37(5): 1261-1276.*

[5] *Jian L, Min W. 2022. Dual environmental regulation, FDI and green Total factor productivity: a case study of three urban agglomerations in the Yangtze River economic belt [J], East China Economic Management. 36(1): 31-41.*

[6] *Sanliang J, Caibao L,2022. Externalities and heterogeneity of environmental regulation on carbon emission efficiency: an analysis based on the agglomeration synergy of producer services [J], East China Economic Management. 36(10): 56-69.*

[7] *Li Y, Liang H, 2022. Impact of different types of capital-biased technological progress on carbon emission efficiency [J]. Science and Technology Research, 42(14): 211-218.*

[8] *Guangming L, Weijie Z, 2017. Study on industrial carbon emissions and emission reduction mechanism under carbon trading in China [J], Chinese Journal of Population Resources and Environment. 27(10) : 141- 148.*

[9] *Hui W, Yijie B, Shuqiao W, 2016. Dynamic Evolution and spatial spillover of export trade, industrial carbon emission efficiency [J], Journal of Quantitative & Technical Economics. 12(1):3-19.*

[10] *Chenyao Qu, 2017. Impact of industrial agglomeration on carbon emission efficiency of China's manufacturing industry and its regional differences [J], Soft Science, 6(1): 34-38.*

[11] *Tone K,2003. Dealing with undesirable outputs in DEA: A slacks-based measure(SBM) approach[J]. GRIPS Research Report Series 1, 0005*

[12] *Lin, J.Y., Liu, M. Development Strategy, Transition and Challenges of Development in Lagging Regions". InF Bourguignon and B. Pleskovic(eds), Annual World Bank Conference on Development Economics2004: Accelerating Development (Bangalore conference proceedings),*

[13] *Hans-Werner Sinn. Public policies against global warming: a supply side approach [J]. International tax and public finance,2008,15(4).*