Political economy analysis of carbon emissions

Based on empirical data from the central region

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***Abstract*—In order to correctly understand the influencing factors of carbon emissions in central China and the important role of government governance capacity in achieving the goal of "carbon neutrality". In theory, unit carbon emission is explained by Marxist axiology. In the empirical analysis, this paper selects the data from 2004 to 2017 in the central region as samples to verify the theoretical part, and finally puts forward relevant policy suggestions based on the above conclusions, so as to realize the sustainable economic growth in the central region.**

Keywords- Carbon dioxide emission; traditional factor; endowment effect; industrial; structure effect technological progress effect

I. Introduction

In the context of new economic development, global warming and greenhouse gas issues are once again widely concerned. From Marx to China's leaders for the unremitting efforts of ecological protection. Now, the 19th National Congress of the Communist Party of China has further put forward the strategic goal of building a "beautiful China" and made the construction of ecological civilization an important part of realizing the goal of building a modern socialist country. China's total carbon emissions account for about 25% of global carbon emissions, and as the world's largest carbon emitter [1]. The 19th National Congress of the Communist Party of China pointed out that "China's economic development model has been transformed into a high-quality development model, accelerating the pace of transformation from extensive growth to intensive growth, and taking the road of green development [2]." At the general debate of the 75th Session of the United Nations General Assembly held on September 22, 2020, China proposed to strive for the peak of carbon emissions by 2030 and achieve carbon neutrality by 2060.

On April 23, 2021, the Opinions on Promoting High-quality Development in the Central Region in the New Era was reviewed and approved by The State Council. The central region is an important carrying area for the development of The Yangtze River Economic Belt and the ecological protection and high-quality development of the Yellow River Basin in China, and the economic volume of the central region accounts for more than 1/5 of the national population and nearly 1/4 of the national population [3]. To promote high-quality development in the central region, energy consumption and carbon dioxide emissions in the six provinces of the central region have also increased sharply. So how can the six provinces in the central China achieve high-quality development while maintaining stability in the context of "carbon neutrality"?

At present, most domestic scholars have analyzed the relationship between carbon emissions and economic growth from the perspective of technology. Wang Jie (2021) discussed the relationship between carbon emissions and economic growth based on the carbon emission panel data of BRICS countries from 1987 to 2017, and used IPAT equation and LMDI model to decompose the driving factors affecting carbon emissions change [4]. Liu Manzhi (2021) developed decomposition and decoupling technology based on LMDI method in combination with C-D production function and quantified seven effects, providing a new perspective for energy conservation and emission reduction in transportation industry [5]. Although econometrics and technical analysis of the development of the relationship between the two often only exist in describing the characteristics of economic phenomena and operation mechanism, has a strong operability. Domestic research on the essential economic phenomenon between carbon emissions and economic growth is very scarce. Qi Xinyu (2010) used Marx's reproduction model and the basic idea of division of two major categories to conclude that carbon emissions can be reduced by slowing down the pace of economic growth, improving technological level and increasing the proportion of the second sector [6].

II. The Decomposition of Regional Carbon Emission Effect

Analyzing the principle of ecological destruction from the perspective of Marx, first of all, the nature of capital is to pursue profit, and the surplus value created by laborers is the only source of profit. Capital expands reproduction and increases the proportion of surplus value production to obtain more surplus value. With the excessive demand, the discharge of waste in the process of absorbing surplus value gradually exceeds the carrying capacity of the ecosystem, leading to ecological damage. As Marx said, "Only by correctly understanding the laws of nature can human beings coexist harmoniously with nature, and the development and change of nature can make the situation change in the direction of human economic and social development [7]. Second, the capitalist mode of production as the main form of the economic growth of industrial civilization is invested capital, labor, land, natural resources), and technology so as to achieve the proliferation of capital and the increase of material wealth, as the pursuit of better add value, industrial civilization need to constantly in natural resources and bring a lot of cost and excessive use of natural resources. Finally, labor

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originally changes natural material form with the help of nature, but with the improvement of labor productivity, labor appears "alienation". "The improvement of labor productivity and the increase of labor quantity come at the cost of the destruction and decline of labor force itself."

This paper tries to build a political economy model of carbon emissions, find the factors that affect carbon emissions, and discuss from the perspective of policy impact and government governance mechanism.

Assume that the total value of the industrial sector of a region in period t is w_t;In the process of value production, the total input constant capital value is c_t; The value of the variable capital invested in the production process is v_t; The wages of the workers are denoted by $wage_t*N_t$; The industry average residual value ratio is m', it can be considered as the average profit rate of the industry . This paper assumes that e_i is the emission coefficient of this region in phase t. Assume that Carbon Emission per Value (CEV) represents the Carbon dioxide emitted per unit of Value. The model is expressed as:

$$CEV_t = e_t c_t / [c_t + (m'_t + 1) v_t] \quad (1)$$

For simplicity, assume that the unit value of constant capital is $\bar{c}$ and the growth rate of constant capital is α_t; Variable capital v_t can be determined by the wages of the workers and the number of workers, that is, $v_t = wage_t N_t$. By introducing the organic composition of capital, the organic composition of capital ($s_t = \alpha_t \bar{C} / wage_t N_t$), we can obtain the following formula:

$$CEV_t = (e_t * \alpha_t \bar{c}) / [wage_t N_t (1 + m' + s_t)] \quad (2)$$

Here, we divide the industrial sector into two sectors: high carbon industry and low carbon industry. It is assumed that the proportion of high carbon industry is θ^h and the proportion of low carbon industry is θ^l, and the proportion of low carbon industry and the proportion of high carbon industry are $\theta^h + \theta^l = 1$, $0 < \theta^h < 1, 0 < \theta^l < 1$. The emission intensity of the carbon industry is e^h, and that of the low carbon industry ise^l, and satisfies $e^h > e^l$, $e^l > e^h/m$.

Then the following formula can be obtained:

$$e_t \alpha_t \bar{c} = (\alpha_t e^h / m) * [(m-1)\theta^h + 1] \quad (3)$$

Government environmental control is mainly to take necessary administrative punishment for productive emissions to restrain enterprises, while government governance investment is to control existing environmental pollution emissions [8]. Therefore, we get the following formula:

$$e^h = f(regu, gov, rd) \quad (4)$$

Where, gov represents government governance investment and rd represents technology level. The above satisfies: $\partial e^h / \partial gov < 0$. Based on the economic substance, we derive the function expression of e^h basically as follows:

$$e^h = \beta / (gov \times rd) \quad (5)$$

Equation (3) can be further derived to obtain the following equation:

$$CEV_t = \frac{\alpha_t \times \beta \times \bar{c}[(m-1)\theta^h + 1]}{wage_t N_t (1 + m' + s_t) \times gov \times rd \times m} \quad (6)$$

From Equation (6), we can draw the following conclusions: ① The impact of factor endowment effect on carbon emissions per unit value is not clear, and the factor endowment effect is dynamically determined by the scale of capital investment, human capital investment and the organic composition of capital;② The relationship between government environmental regulation, government governance investment and technology level and the carbon dioxide emission per unit value; ③ The proportion of high-carbon industries is positively correlated with CO_2 emissions per unit value. If the development level of low-carbon and high-carbon industries in a region is unbalanced and the industrial structure is unreasonable, the CO_2 emissions in the region will rise.

III. DATA SOURCES AND EMPIRICAL ANALYSIS

The above assumptions of our political economy model are based on value theory. In order to verify our above theory, we use real data to conduct empirical analysis and test, in order to overcome the problem of inconsistency and disunity of measurement units. In order to find the internal relationship between value and price, Liu Xin (2000) revealed the internal logical contradiction of neoclassical general equilibrium theory and tried to construct Marx's general equilibrium theory model. Later, Feng Jinhua (2012) proved that there must be and only one general equilibrium price vector exactly equal to the corresponding value vector. Therefore, this part uses economic data under the price system to verify the feasibility of the carbon emission model under the value system [9].

1 Estimation of CARBON dioxide emissions (e)

This paper refers to the calculation method of carbon dioxide emissions released by IPCC, and the carbon dioxide emissions are estimated based on the energy consumption in central China, that is, the following formula is obtained to calculate carbon dioxide emissions:

$$CO_{2i} = \sum_{i=1}^{n} E_i \alpha_i \quad (7)$$

For the estimation of carbon dioxide emission coefficient, the following formula is used:

$$\alpha_i = NCV_i \bullet CEF_i \bullet COF_i \bullet (44/12) \quad (8)$$

We gradually arrive at the following formula:

$$CO_{2i} = \sum_{i=1}^{3} E_i \bullet NCV_i \bullet CEF_i \bullet COF_i \bullet (44/12) \quad (9)$$

The method of Zhao Xin (2021) is adopted for carbon oxidation factor. We calculate the carbon dioxide emission coefficients for coal, oil and gas. Details are as follows:

TABLE I. CARBON DIOXIDE EMISSION COEFFICIENT

energy	Average low calorific value	Carbon emission coefficient	Carbon oxidizing factor	Carbon dioxide emission coefficient estimates
	(kj/kg)	(kg / 10^6 kj)	/	(kg/kg standard coal)
Raw coal	20908	26.0	0.99	2.763
Crude oil	41816	20.0	1	2.145
Natural gas	38931	15.3	1	1.642

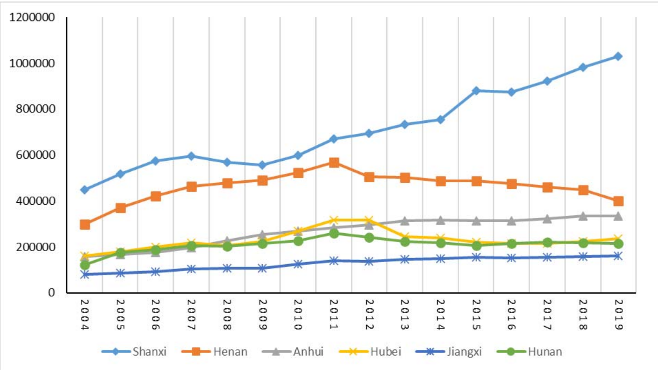

Figure 1. Carbon emission trend of the six central provinces.

2 Total output (y)

Total output is expressed in terms of gross domestic product (GDP) of the central region, which eliminates the effect of prices.

3 Capital stock per capita of the industrial sector

There is no direct data available for the per capita capital stock of the industrial sector in the statistical yearbook. However, due to the different degree of industrialization in each region, this paper adopts the accumulated depreciation amount of industrial enterprises above designated size to represent the factor of capital input [10].

4 Industrial structure (Indus)

The proportion of high-carbon industry is to indicate whether the industrial structure of a certain region is reasonable. This paper intends to use the ratio of the added value of the tertiary industry in each region to the added value of the secondary industry in each region to measure.

5 Average wage of industrial sector

In this paper, the average wage and employee number of mining industry, manufacturing industry and electricity, gas and water production and supply industry are weighted average treatment. The formula is as follows:

$$\overline{wage} = \sum_{i=1}^{3} \overline{wage_i} \bullet N_i \Big/ \sum_{i=1}^{3} N_i$$

6 Per Capita completed investment in Pollution Control in Industrial Sector (gov)

In this paper, the index of completed investment in industrial pollution control is adopted to represent the investment factor of government pollution control (GOV). These investments come from the fiscal expenditure of provinces and cities, reflecting the institutional power of local governments in pollution control.

7 Technology Market Turnover (rd)

Technology successful conversion is a complex process, and technology contract turnover is a reliable data source that is easy to quantify [11]. It is more appropriate to measure the technological development in the middle of China by the turnover of technology market.

As can be seen from the previous theory, CEV represents the carbon dioxide emission per unit value. The larger CEV is, the greater carbon dioxide emission per unit value is and the lower energy utilization rate is. The smaller the CEV, the smaller the carbon dioxide emission per unit value and the higher the energy efficiency of the region. In this paper, CEV indicators of six provinces in central China from 2004 to 2017 were selected to rank, and the current situation of emission reduction efficiency in central China was preliminatively understood.

TABLE II. CARBON DIOXIDE EMISSION

Rank	Province	*CEV*	*MAX*	*MIN*
11	Shanxi	712941	1030080.56	450160.38
2	Henan	461719.81	569382.98	299756.28
3	Anhui	267442.6	335116.65	156986.74
4	Hubei	230041.5	317168.17	161615.23
5	Hunan	210098.5	260988.76	121201.54
6	Jiangxi	128027.53	160455.95	79143.14

As can be seen from the above statistics, there is not only a big gap in the traditional endowment (capital stock of industrial sector) in central China, but also a provincial difference in government governance. Governments at all levels have a big gap in their investment in environmental pollution control and governance. The industrial production mode in the central region of China is still dominated by extensive production, with high output accompanied by high energy consumption and high pollution emissions, coupled with insufficient investment in environmental control and governance, there is still a long way to go to achieve "carbon peak and carbon neutrality" in the central region.

This part analyzes the impact of traditional elements, industrial internal structure, technological progress and government governance on unit value carbon dioxide emissions in central China from 2004 to 2017 by panel regression.

The panel model established in this paper is as follows:

$$lnCEV_t = lncapital_t + lnwage_t + lnrd_t + lnindus_t + lngov_t + \theta_t + \mu_t + \varepsilon_t$$

This empirical analysis adopts mixed regression, individual fixed effect model and random effect model.

TABLE III. OVERALL REGRESSION RESULTS IN CENTRAL CHINA

Dependent Variable CEV			
Model Form	*Model（1）*	*Model（2）*	*Model（3）*
lncapital	3.42* （2.10）	3.42*** （4.36）	-0.09 （-0.38）
lnwage	-2.27 （-1.06）	-2.27** （-2.27）	-0.23 （-0.87）
lnindus	-1.25** （-3.47）	-1.25*** （-3.05）	-0.11*** （-2.16）
lngov	1.60 （1.81）	1.60*** （3.74）	0.00 （0.03）
lnrd	-1.80** （-3.33）	-1.80*** （-5.61）	-0.06 （-0.65）
C	-0.25 （-0.02）	-0.2502834 （-0.03）	3.61 （2.58）

From model 2 in the above table, we can conclude that the regression result is very significant. On this basis, we conduct the analysis of the results :(1) the per capita capital stock of the industrial sector is positively correlated with CEV. CEV will increase by 3.42% when per capita capital stock of industrial sector increases by 1%. Therefore, the transformation of industrial internal structure is an important factor to reduce carbon emissions and improve carbon efficiency. (2) The per capita wage of the industrial sector is negatively correlated with CEV. When per capita wage of industrial sector increases by 1%, CEV will decrease by 2.27% on average, and labor cost's forcing effect on carbon emission efficiency can be fully reflected. (3) Industrial structure is negatively correlated with CEV. When the industrial structure increases by 1%, CEV will decrease by 1.25% on average. The optimization of industrial structure has a relatively obvious promoting effect on CEV. (4) There is a positive correlation between the per capita investment in pollution control and CEV. CEV will increase by 1.60% when the per capita pollution control investment of industrial sector increases by 1%. The per capita pollution control investment of industrial sector, as an indicator of government governance, has a lower impact on CEV than other factors. (5) As an indicator of technological progress, technological market turnover is negatively correlated with CEV. The empirical analysis of this index is consistent with the theoretical conclusion. There may be the following situations: First, there is a long cycle of technological progress, and there is accumulation and lag.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the Marxist ecological theory, this paper introduces the political economy model and empirical analysis tools to investigate the factors influencing carbon dioxide emissions per unit value in central China and the differences in the contribution of traditional factor endowment, technological progress and industrial internal structure to carbon emissions per unit value.

Specific suggestions are as follows: First, formulate long-term governance management model, optimize the current environmental assessment indicators. In solving environmental governance problems, standards are often not unified, resulting in confusion. Secondly, the GDP-only assessment method also makes governments at all levels selectively ignore environmental problems and sacrifice the environment to preserve economic growth. Second, accelerate the transformation of industrial structure and promote the initiative of green industry. First of all, promote enterprise technological innovation, realize industrial structure upgrade, under the strong support and guidance of the government, actively cultivate green environmental protection, green energy saving and other related industries. Third, accelerate technological research and development, develop and popularize the use of new energy. First of all, increase investment in environmental research and development, establish international low-carbon technology transfer mechanism, the government should continue to strengthen support for environmental technology research and development, and actively formulate relevant preferential policies and incentives.

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