Energy Consumption, Carbon Emission Constraints and Regional Economic Growth

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Abstract: Have energy consumption and carbon emission constraints promoted regional economic growth? This article uses data from 30 provincial panels across China from 2000 to 2016 to explore the impact of energy consumption and carbon emissions constraints on regional economic growth. The study found that both energy consumption and carbon emission constraints have promoted regional economic growth, and that regional human capital levels, foreign direct investment, industrial structure, and financial support have played an important role in promoting regional economic growth, and cities have a "resource curse" "A region with a higher energy endowment is more detrimental to economic growth.

Keywords: energy consumption; carbon emission constraints; economic growth; FDI; human capital

1. Introduction

In the forty years of reform and development, China's economy has developed rapidly, but with increasing environmental pollution problems, the increase of carbon dioxide emissions has caused important issues such as global warming, which has caused many harms to the world's economic development. For this reason, the central government has introduced an environmental system to strictly control production, but because traditional industrial development cannot be separated from high-energy production modes, energy consumption plays a very important role in economic growth. Do energy consumption and carbon emission constraints promote regional economic development? About it. This paper is based on 2000-2016 inter-provincial panel data and empirical analysis based on various models. The results show that both energy consumption and carbon emission constraints have promoted regional economic growth, but there is a “resource curse” phenomenon in economic growth, and the higher the energy endowment The more the regions are not conducive to regional economic growth.

2. Literature Review

In order to build a resource-saving and environment-friendly society, China has strengthened the implementation of energy conservation and emission reduction policies, and restrictions on energy consumption and carbon emissions have increasingly become the focus of scholars' attention.

Lin et al. believes that the dual constraints of energy conservation and carbon emissions will increase energy costs and have a significant negative impact on the macro economy [1]. Zeng et al. incorporated the energy consumption and carbon emission factors into the C-D production function, and explored the coefficient of economic growth resistance under the constraints of energy consumption and carbon emissions [2]. The results show that carbon emission constraints do restrict economic growth. Lin explored the two endogenous and exogenous effects of clean energy consumption on GDP [3]. The study found that an increase in the proportion of clean energy consumption will increase GDP endogenously and reduce GDP exogenously, which will generally reduce GDP growth. Driven by the development of a low-carbon economy, both carbon emissions and energy consumption significantly affect the economic growth of countries and regions. Energy as an input element of economic growth can promote economic growth, but there may be "resource curse" in regions with high energy abundance. Shao &Yang researched the relationship between China's regional economic growth and local natural resources and found that energy dependence is not good for national enterprises' innovation input and innovation output, and has a significant crowding-out effect. Unfavorable [4-5].

3. Model Construction Data Source

3.1 Econometric Model Construction

The neoclassical economic growth theory holds that the economic growth of a country or region is mainly determined by the input of production factors and the production efficiency of the whole society. The input of production factors includes the capital and labor factors. The production efficiency of the whole society refers to the technological level of the society. —Douglas production function is expressed as:

$$Y = AK^{\partial}L^{\beta} \quad (1)$$

Where is the output, A is the technological level of the whole society, K is the capital, L is the labor input, and is the output elasticity of capital and labor.

Later, scholars studied the relationship between energy consumption and economic growth, and found that energy consumption is also a production input factor

for economic growth, and because of the background of the global environmental degradation, the government has restricted high energy consumption and Polluting the production of enterprises has had an important impact on regional economic growth. Based on this, based on the neoclassical economic growth theory, it is necessary to introduce the two factors of energy consumption and carbon emission constraints into the economic growth model, and establish an extended C-D production function. The expanded Cobb-Douglas production function is:

$$Y = AK^{\partial}L^{\beta}E^{\gamma}C^{\theta} \tag{2}$$

Among them, Y represents regional economic growth, and A, K, L, E, and C respectively represent technology, labor level, capital input, energy input, and carbon emission constraints. Divide both sides of formula (1) by L and take the logarithm:

$$\ln(\frac{Y_{i,t}}{L_{i,t}}) = \ln A + \alpha \ln K_{i,t} + (\beta + \gamma - 1)\ln L_{i,t} + \gamma \ln(\frac{E_{i,t}}{L_{i,t}}) + \theta \ln C_{i,t} + \ln \mu_{i,t} \tag{3}$$

make $\beta+\gamma-1=\omega$, $\ln \mu_{i,t} = \varepsilon_{i,t}$ Sort (2) to get:

$$\ln y_{i,t} = \ln A + \alpha \ln K_{i,t} + \omega \ln L_{i,t} + \gamma \ln PE_{i,t} + \theta \ln C_{i,t} + \varepsilon_{i,t} \tag{4}$$

Among them, in the formula, and respectively represent per capita GDP and per capita energy consumption.

Finally, in order to avoid endogenous problems caused by the omission of other important explanatory variables, this paper introduces a lagging period of energy consumption as its instrumental variable, which can effectively eliminate the endogenous bias between the explanatory variables through the panel measurement method. Coherent estimates of explanatory variable coefficients. At the same time, this paper considered a set of control variables including human capital level, foreign direct investment, industrial structure and financial support, and energy endowment, and finally came up with a measurement model (5).

$$\ln y_{i,t} = \ln A + \alpha \ln K_{i,t} + \omega \ln L_{i,t} + \gamma \ln PE_{i,t} + \beta X_{i,t} + \theta \ln C_{i,t} + \varepsilon_{i,t} \tag{5}$$

3.2 Variable selection and data description

In order to study the relationship between energy consumption and economic growth, data from 30 provinces and municipalities in the country from 2000 to 2016 were selected for research. At the same time, considering the large differences in economic development levels and energy consumption types in different regions of the country, this article is based on " The China Statistical Yearbook divides the country into east, middle, and west regions. The eastern region includes 11 provinces including Beijing, Hebei, Tianjin, Liaoning, Zhejiang, Shanghai, Jiangsu, Shandong, Fujian, Guangdong, and Hainan. The central region includes Shanxi, Heilongjiang, Jilin, Jiangxi, Anhui, Henan, Hunan, and Hubei. Western provinces include 11 provinces in Inner Mongolia, Yunnan, Guangxi, Chongqing, Sichuan, Guizhou, Gansu, Shaanxi, Ningxia, Xinjiang and Qinghai.

Regional Economic Growth (GDP): This article uses the per capita GDP of each province and municipality to describe economic growth. Based on the GDP of each province from 2000 to 2016, it is converted into real GDP according to the GDP index of each region (at 2000 constant prices). The GDP index and nominal GDP data come from the China Statistical Yearbook and the Sixty Years of New China Statistical Data Collection.

Energy Consumption (PE): Per capita energy consumption in each region is used to represent energy consumption indicators.

Carbon emission constraint index (C): The carbon emission index cannot be directly obtained. This paper mainly draws on the research of IPCC, etc., and proposes the carbon emission calculation formula as follows:

$$C = \sum_{i=1}^{3} EF_i = \sum_{i=1}^{3} E \frac{E}{E} F_i \tag{6}$$

In the formula, C represents the carbon emissions caused by energy consumption, represents the consumption of coal, oil, and natural gas, and represents the carbon emission coefficient of various types of energy consumption in China.

Human capital level (HR). Use the number of local higher education schools as a measure. Foreign direct investment (FDI). The ratio of the total industrial output value of the foreign-invested industrial enterprises above the local limit to the total value of production was used as a measure of foreign direct investment. Industrial structure (IS). Based on the ratio of the tertiary industry to the secondary industry as a measure. Financial support (FF). Provincial fiscal technology spending is used as a measure. Energy endowment. Measure the number of employees in agriculture, forestry, animal husbandry and fishery. Data are taken from China Industry Statistical Yearbook, China Population and Employment Statistical Yearbook, China Statistical Yearbook, and the Information Network of the Development Research Center of the State Council.

4. ANALYSIS OF EMPIRICAL RESULTS

This paper uses a variety of estimation methods to estimate the model, including the hybrid least squares method, the panel fixed effect model, and the generalized moment method of the panel system. Using multiple estimation methods can ensure the robustness of the estimation results.

As can be seen from Table 1, the value of the impact coefficient of energy consumption (PE) is positive and significant at 1%, which indicates that energy consumption has greatly promoted regional economic growth, which is in line with China's rapid economic growth in the past 40 years In line with the facts, high energy consumption and high pollution production models have been China's main development models in the past forty years. The impact factor of carbon emissions (C) is negative and significant at the 10% level.

This means that the increase in carbon emissions has reduced the regional economic growth rate, that is, carbon emissions constraints have promoted regional economic growth. A possible explanation for this is that the government's implementation of environmental governance to intervene in the carbon emissions of enterprises has stimulated green innovation in enterprises, thereby promoting the improvement of productivity and rapid economic development in the region.

Table 1 Descriptive analysis of variables

Variable			Sample	mean	standard	deviation	minimum
Explained variable	Regional economic growth	GDP	510	0.7467	0.8457	-1.5292	2.4692
Explanatory variables	Energy consumption	PE	510	0.8655	0.5636	-0.5863	2.1143
	carbon emission	C	510	8.6950	0.9588	1.0232	10.3972
Control variable	Human capital level	HR	510	7.5462	0.8336	5.0000	176.0000
	Foreign direct investment	FDI	510	11.4886	2.0060	0.6931	14.9827
	Industrial structure	IS	510	-1.0212	0.3786	-2.6870	-0.6342
	Fiscal expenditure	GI	510	7.1801	1.0877	4.1082	9.5064
	Energy endowment	NE	510	67.5942	27.4729	0.1329	83.2341

Note: In order to better reflect the initial values of the variables, the results in the table are descriptive statistics when the variables do not take natural logarithms.

In terms of controlling variables, the coefficient of human capital (HR) is positive, which is significant at the level of 5%, indicating that the improvement of human capital is also an important factor in promoting regional economic growth. Other positive effects on regional economic growth include foreign direct investment (FDI), industrial structure (IS), and financial support (GI). However, energy endowments hinder economic growth and increase per capita GDP. From the estimation results, it can be seen that the coefficient of energy endowment (NE) is negative and significant at the level of 1%, which indicates that the higher the degree of energy endowment in the region, the more unfavorable the economic development of the region. This also shows that there is a "resource curse" phenomenon in China. This is because China's major energy provinces are dominated by mining and raw materials industries, and the industrial structure is unbalanced, which has marginalized high-tech industries and restricted the development of high-tech industries. At the same time, the abundance of natural resources has made resource transfer effects, expenditure effects, and relative price effects prominent, leading to the decline of manufacturing. Under the conditions of imperfect legal system, unclear property rights system, and imperfect market rules, abundant natural resources have led to "opportunistic" behavior in resource use, and more rent-seeking activities have occurred, causing waste of resources and large-scale plunder. Sex mining. Excessive consumption of resources, low production utilization rate, excessive exploitation of resources without timely maintenance, greatly damage the ecosystem, and damage economic benefits.

5. POLICY RECOMMENDATION

5.1 Encourage technological innovation

Technological innovation is an important way to reduce unit energy consumption and pollution. To this end, the country must always adhere to the principle of science and technology as the primary productive force, vigorously develop high-tech industries with low emissions and unit value-added energy consumption, and accelerate the use of high-tech and advanced technologies. Applicable technology transforms traditional heavy industry industries, encourages enterprises to improve energy-saving and emission reduction technologies, promotes economic growth with technological innovation, and promotes sustainable development in the region.

5.2 Increasing fiscal investment and raising human capital

Promoting the development of science and technology requires the government to increase the intensity of technology introduction and the support for science and technology research and development. At the same time, it is necessary to appropriately increase investment in education, build an educational investment system, work hard to train talents, attract technical and intellectual talents, accumulate human capital, give play to the creativity of human capital, improve the independent

innovation ability and absorption capacity of green technology, and improve energy efficiency

Table 2 Impact of clean energy development on urban industrial green growth

	Model 1	Model 2	Model 3
GDP	0.1479***	0.0382*	0.1595***
	(14.72)	(2.15)	(1.02)
PE	0.3877***	0.4008***	0.3759***
	(6.97)	(8.35)	(7.75)
C	-0.0847**	-0.0378*	-0.0668*
	(-3.38)	(-2.25)	(-3.55)
HR	0.4150**	0.1521**	0.4323**
	(5.54)	(9.82)	(6.21)
FDI	0.0311**	0.0145	0.2930
	(2.20)	(0.53)	(0.79)
GI	0.3463***	0.3913***	0.3301***
	(2.19)	(5.10)	(2.49)
IS	0.3877***	0.4008***	0.3759***
	(6.97)	(8.35)	(7.75)
NE	-0.0575***	-0.0565***	-0.0559***
	(-2.20)	(-2.19)	(-2.24)
N	510	510	510
R-sq	0.9498	0.9691	0.9485
Estimation model	Mixed least squares	Fixed effect	Generalized moment of panel system

Note: The values in parentheses are standard errors, * represents P <0.1, ** represents P <0.05, and *** represents P <0.01.

5.3 Promoting industrial structure reform

It is necessary to accelerate the transformation and upgrading of traditional industries and the construction of green industry systems. Through the development of green industrial parks, we can strive to build green products, improve the green industrial chain, and further promote the decarbonization and efficiency of traditional industries. In particular, we must develop low-carbon and environmentally-friendly emerging industries, promote the optimization and upgrading of industries, and promote economic development. From high carbon to low carbon.

5.4 Adapt to local conditions

Due to the inequality of resources in China, the existence of the "resource curse" has forced local governments to introduce reasonable policies, rationally utilize natural resources, actively change development methods, avoid excessive dependence on energy and other production methods, and increase environmental protection and high-tech industries. Investment scale to promote the development of clean energy.

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