A Study on factors influencing low-carbon production behavior of industrial enterprises in China

Xizhou Dai, Xin Meng, Shenrong Gao, Xia Tong*
Nantong University, School of Business, Nantong, Jiangsu, P. R. China 226001
*Corresponding author, E-mail address: tongxiagao@126.com

Abstract
China industrial enterprises as the main low-carbon production, and its low-carbon production is affected by energy consumption structure and industrial structure, the impact of such factors as gross domestic product, the quality of education. Regression models to empirical analysis of the factors related to, it can be concluded, energy consumption structure and industrial structure, the gross domestic product of China's industrial enterprises has a positive impact on carbon emissions, the quality of education has a negative effect on carbon emissions of industrial enterprises in China. Through an analysis of these factors can be targeted to adopt improvement measures for low-carbon production of industrial enterprises in China

Key words: industrial enterprises, low carbon production, regression models

1 Introduction

The global climate situation is growing tense, with the Copenhagen climate agreement, the Paris climate Protocol and other related agreements signed, people are increasingly aware of the urgency to change the current climate situation. Therefore, mankind must improve the current economic structure, energy saving and emission reduction, development of low-carbon economy. The Low-carbon economy is an economic model of sustainable development and, as yet, a proven way to improve the current climate, sustain economic sustainability and respond to the various energy crises that may arise. As an industrial enterprise with energy consumption and carbon emission, promoting its low-carbon production will have an important impact on the future sustainable development. Therefore, it is necessary to find out the main factors affecting the low carbon production of Chinese industrial enterprises, in order to promote Chinese industrial enterprises to better low-carbon production.

2 The literature review

Industrial enterprises are the main source of carbon emissions, control of industrial enterprises carbon emissions is to achieve China's emission reduction targets in the most important. At present, many scholars at home and abroad have studied deeply, and foreign scholars focus on the market driving factors, the relationship between carbon emission and economic growth and government regulation. Luken (2008) believes that market characteristics have a greater impact on the cleaner and energy-efficient production practices of enterprises in developing countries, and that the export of industrial enterprises has an important impact on the willingness and behavior of their low-carbon production. However, Sarumpaet (2005) Studies of Indonesian enterprises have concluded that the export of products is not significantly related to the use of environmentally-friendly production methods. Eban Goodstein (2002) uses the Lmdi factor decomposition method to obtain the positive correlation between the economic growth and the carbon emission change. Montalvo (2008) found that the government's compulsory system arrangement is an important driving force for enterprises to adopt low-carbon related production behavior. Domestic scholars have less relevant research, which mainly involves the guidance of national policy, the influence of technological change and the drive of market economy, which affect the Low-carbon production behavior of industrial enterprises. Gao Liangmou and Tan Yu (2008) think that exerting the government's leading role is of great significance to improve the enterprise's low carbon production intention. Su Lihua (2011) believes that only the government has the ability to organize and promote low-carbon economic development. Liu, Yin Xiangdong (2011) In

the study found that a wide range of market prospects will encourage industrial enterprises to be more willing to do low carbon production. Yu Guopu, welcome, Cao Jianping. (2012) This paper expounds the influence of low carbon production technology on the low carbon production of industrial enterprises. Wang (2014) believes that higher technological levels in the industrial sector will help reduce industrial carbon emissions. Juan (2016) that the low carbon technology directly determines the various input resources can achieve low carbon conversion efficiency.

3 Analysis on the current situation and influencing factors of carbon emission in Chinese industrial enterprises

Combined with "China Statistical Yearbook 2016" in the various industries Energy balance table, the carbon emissions from coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, liquefied petroleum gas and natural gas 9 fossil fuels are calculated synthetically, and the data from the IPCC 2006 National Greenhouse Gas Inventories guide is selected to calculate carbon emissions (As shown in table 1, units: ton of carbon/ton coal) Get the accounting formula: $\mathbf{C} = \sum_{i=1}^{9} \boldsymbol{E}_i \times \boldsymbol{A}_i \times \boldsymbol{B}_i$

Among them: I=1,....., 9, indicating energy type, EI for energy consumption total (unit: million tons), AI for each fossil energy of the folding coal coefficient, bi is the carbon emission factor of standard coal. A variety of energy-folding coal coefficient and the carbon emission factor after the dismantling of the coal are shown in table 1.

Table1 Carbon emission coefficients for various energy sources

The sources of energy	Coefficient of marking coal	Carbon emission factor
Coal	0.7134	0.7476
Coke	0.9714	0.8388
Crude oil	1.4286	0.8363
Gasoline	1.4714	0.814
Kerosene	1.4714	0.8442
Diesel oil	1.4571	0.8616
Fuel oil	1.4286	0.8223

Liquefied Petroleum Gas	1.7143	0.8631
Natural gas	1.33	0.5956

According to the formula, the specific values of China's industrial carbon emissions are obtained, as shown in Figure 1 (units: million tons)

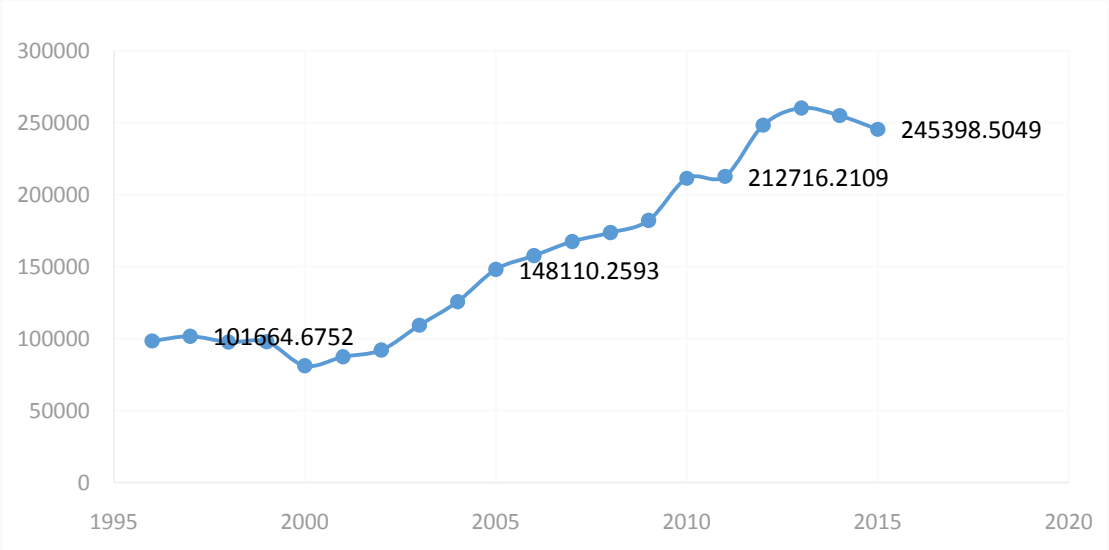

Fig.1 China's industrial carbon emissions 1996-2015

The low carbon production behavior of Chinese industrial enterprises is influenced by many factors, Lin Wei-ming and Yu Jianhui (2014) are analyzed from three aspects of government environment, consumer and enterprise characteristics, and this article analyses from four aspects of energy consumption structure, industrial structure, GDP and education quality according to the research practice.

3.1 Energy consumption structure

Reform and opening-up in the past more than 30 years, China has initially formed a comprehensive energy supply pattern with coal as its main body, electric power as the center, oil and natural gas and renewable energy to develop comprehensively, and has basically established a comparatively perfect supply system. As can be seen from table 2, China's energy consumption has changed dramatically during the 20 years of 1996-2015. Coal, as a major source of carbon emissions, has always been the dominant energy consumption market in China. However, with the development of Low-carbon technology and new energy in recent years, the proportion of coal in energy consumption is also declining, oil energy has been standing still, while the share of other energy sources represented by electricity and natural gas has been

rising, which shows good prospects for clean energy. The change of this energy consumption structure has promoted the Low-carbon production of Chinese industrial enterprises.

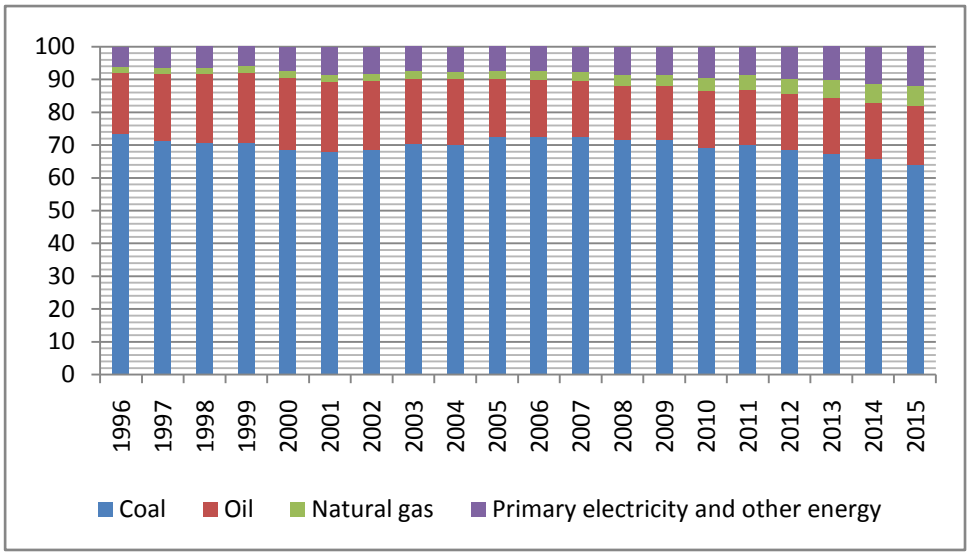

Fig. 2 Main energy consumption in China (%)

3.2Industrial structure

Industrial structure will not only have a significant impact on economic growth, but also the decisive factor of energy consumption and carbon emission. Therefore, the change of industrial structure is a factor that can not be neglected in the process of studying the main factors affecting the low carbon production behavior of Chinese industrial enterprises.

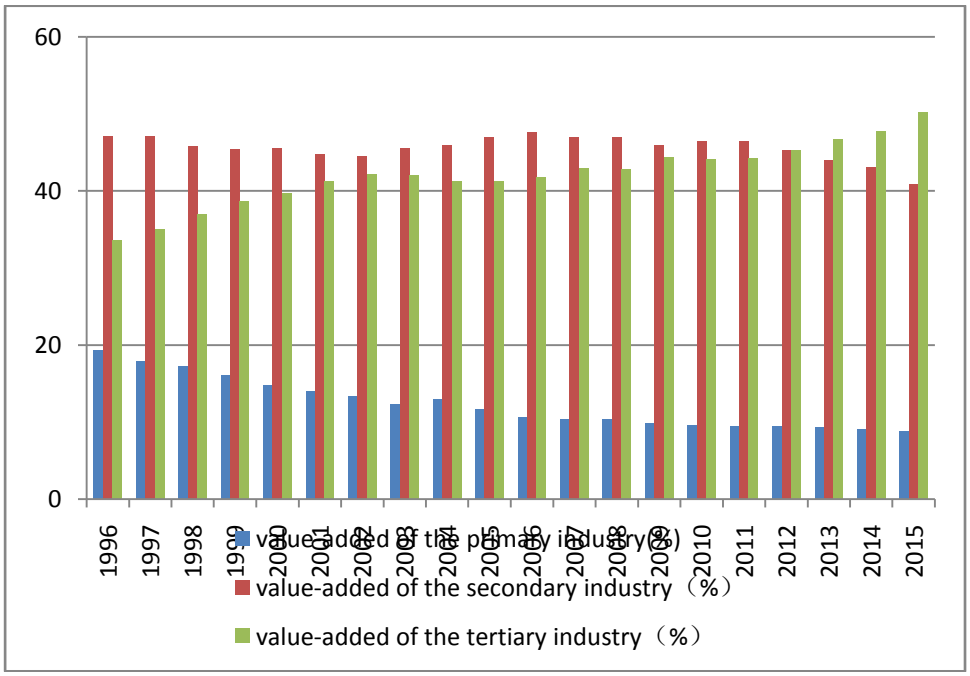

Fig. 3 China industrial Structure

As shown in Fig. 3, the proportion of primary GDP is declining, the second industry has a relatively stable situation in the last 20 years, and the tertiary sector has a general rise in GDP. Because industry is the main cause of carbon dioxide emissions, so China's energy consumption, high pollution of the economic model occupy "half of the" second industry is the main cause of China's carbon emissions.

3.3Gross domestic product

Since 1997 especially into the 21st century, China's total economic growth in global GDP ranked across the rise. Overtook Italy at the end of 2005, ranked sixth in the world, surpassed the UK after 1 years, fourth in 2007, and overtook Japan in 2010 to become the third in the world. From the 20 years of 1996-2015, China's total economic growth from 1996 to 68,905,210,000,000 Yuan in 2015, the increase of more than 9.6 times times, China's economy in a rapid development era, creating a world-famous "Chinese-style economic miracle."

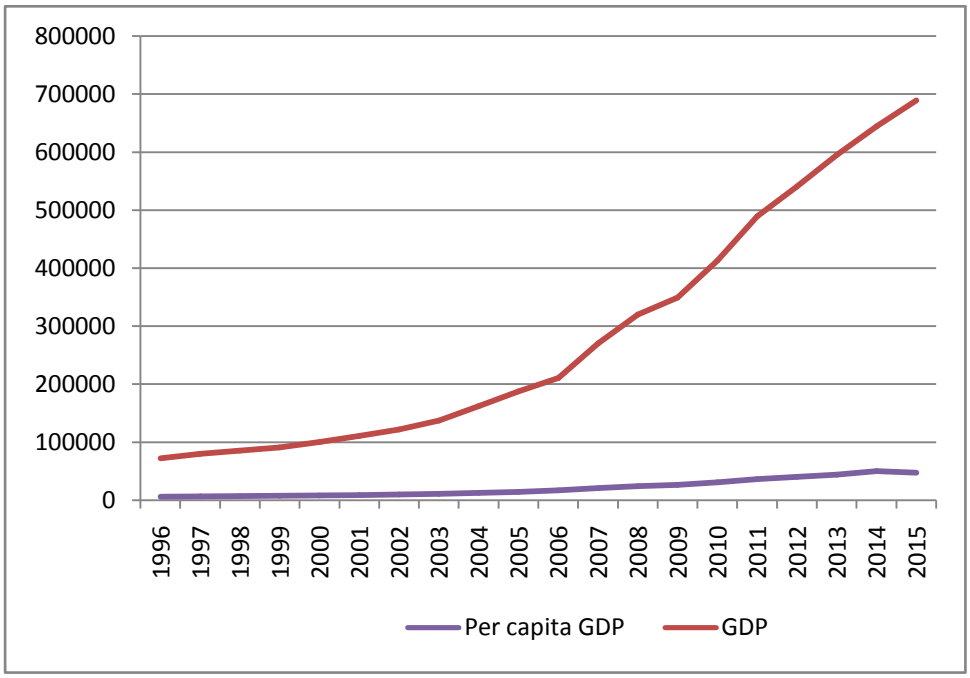

Fig. 4 China's GDP and GDP per capita (1996-2015)（unit：yuan）

3.4The quality of education continues to rise

After 977 years of resuming the college entrance examination, China has been increasing the investment in education. In the past 20 years, China's education quality and teaching scale has been rising, whether it is the general undergraduate enrollment number or graduate enrollment number have made great strides. The overall level of education in a country often means a country's future trends. Since 1996, the general undergraduate college and graduate enrollment has undergone a leap-forward development.

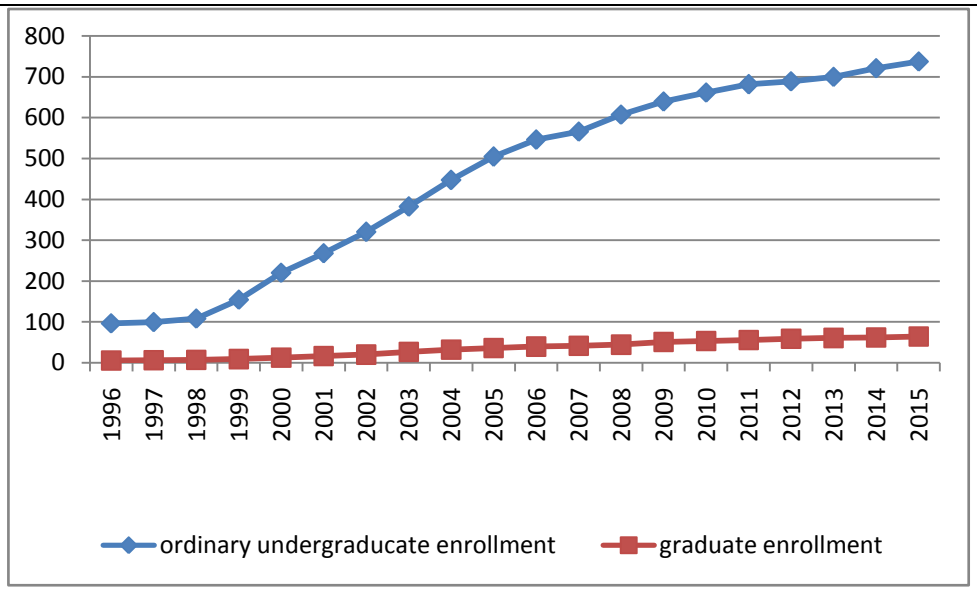

Fig. 5 The number of college enrollment and postgraduate enrollment in China (1996-2015)

4 Variable selection and model construction

4.1 Variable selection and data source

Choose China Industrial enterprise Carbon emission growth rate (ΔY) as the explanatory variable, energy structure (X1), industrial structure (ΔX2), educational aspect set up the average rate of enrollment growth (ΔX3) and the GDP index to select per capita GDP (ΔMGDP) and gross domestic product (ΔGDP) As an explanatory variable for interpreting dependent variables. This article selects 1997-2015 Year's sample data, the related data comes from the National Bureau of Statistics Network, the concrete sample value is as follows (the unit is%):

Table 2 Sample Data sheet for nearly 19 years

Year	ΔY	X_1	ΔX_2	ΔX_3	$\Delta MGDP$	ΔGDP
1997	5.31	71.40	47.20	3.52	9.88	11.00
1998	-3.91	70.90	46.00	8.40	5.85	6.88
1999	0.20	70.60	45.50	42.86	5.38	6.30
2000	-17.04	68.50	45.60	42.46	9.86	10.73
2001	7.67	68.00	45.00	21.61	9.76	10.55
2002	5.36	68.50	44.60	19.46	9.05	9.79
2003	18.71	70.20	45.80	19.25	12.20	12.90
2004	14.99	70.20	46.00	17.03	17.07	17.77
2005	17.79	72.40	47.20	12.78	15.06	15.74
2006	6.46	72.40	47.70	8.25	16.49	17.15

2007	6.24	72.50	46.80	3.63	22.51	23.15
2008	3.69	71.50	47.10	7.38	17.63	18.24
2009	4.88	71.60	46.10	5.24	8.71	9.25
2010	16.05	69.20	46.60	3.48	17.75	18.32
2011	0.62	70.20	46.60	2.98	17.90	18.47
2012	16.71	68.50	45.50	1.08	9.90	10.44
2013	4.81	67.40	44.30	1.60	9.61	10.90
2014	-2.03	65.60	43.30	3.08	7.64	7.46
2015	-3.74	64.00	41.10	2.28	6.46	7.00

4.2 Basic statistical description of variables

The basic statistical description of all variables, the overall development of the variable description, which will be the main reference to the difference between the mean and the maximum, the specific situation is as follows (%):

Table 3 Basic statistical Description of variables

Variable	ΔY	X_1	ΔX_2	ΔX_3	$\Delta MGDP$	ΔGDP
Average	5.41	69.66	45.68	11.91	12.04	12.74
Median	5.31	70.20	46.00	7.38	9.88	10.90
Maximum	18.71	72.50	47.70	42.86	22.51	23.15
Minimum	17.04	64.00	41.10	1.08	5.38	6.30
Value difference	35.75	8.50	6.60	41.78	17.13	16.85
Sample size	19	19	19	19	19	19

A statistical description of the results from table 3 shows that the average growth rate of industrial carbon emissions in 19 is maintained at 5.41%, as a whole, it shows that the volume of carbon displacement is larger, the maximum value of the growth rate is different, and the growth rate is in negative state in a year. Shows that the current policy of carbon emissions has a strong limit to deal with; From energy structure, the results of industrial structure, education and GDP show that the average growth rate of the whole is positive, indicating that all of them are in a certain growth trend, and the difference between the energy structure and the industrial structure is relatively small, which indicates that the growth rate of the two is relatively flat over time.

4.3 Setting of the model

The setting of the model, with a number of methods and approaches, combined with the variable characteristics of this paper, the establishment of industrial enterprise carbon emission growth rate (ΔY) and coal production accounted for the proportion of energy consumption (X1), secondary growth rate (ΔX2), the average number of college enrollment rate (ΔX3), per capita GDP (ΔMGDP) and the linear model of gross domestic product (ΔGDP). This is based on the development of variables between the trends in the direction of a similar feature to determine the number of variables between the development relationship.

The specific model is: $\Delta Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 \Delta X_{2t} + \beta_3 \Delta X_{3t} + \beta_4 \Delta MGDP_t + \beta_5 \Delta GDP_t + \varepsilon_t$ （1）

Where β_0 is a constant term, βn,n=1 ... 5, the explanatory factor of the variable to the dependent variable, the εt is the random error term.

5 Empirical analysis

5.1 Test of variable smoothness

In this paper, the ADF unit root test method is used to test the variables before the data are processed.

Table4 ADF unit root test output

Variable	Null hypothesis	Lag order	The value of ADF	P-Statistic	Whether it is stable
ΔY	unit root exists, the sequence is not stable	0	-1.258	0.183	P>0.05not pass the test, it is not stable
		1	-7.802	0.000	P<0.05pass the test, it is stable
X_1	unit root exists, the sequence is not stable	0	-1.363	0.154	P>0.05 not pass the test, it is not stable
		1	-0.993	0.274	P>0.05 not pass the test, it is not stable
		2	-9.505	0.000	P<0.05 pass the test, it is stable
ΔX_2	unit root exists, the	0	-1.567	0.108	P>0.05 not pass the test, it is not

	sequence is not stable				stable
ΔX_3	unit root exists, the sequence is not stable	1	-2.230	0.029	P<0.05 pass the test, it is stable
		0	-2.258	0.196	P>0.05 not pass the test, it is not stable
		1	-3.513	0.002	P<0.05 pass the test, it is stable
ΔMGD	unit root exists, the sequence is not stable	0	-0.490	0.487	P>0.05 ，not pass the test, it is not stable
		1	-7.411	0.000	P<0.05 pass the test, it is stable
ΔGDP	unit root exists, the sequence is not stable	0	-1.984	0.290	P>0.05 ，not pass the test, it is not stable
		1	-5.335	0.001	P<0.05refuse the null hypothesis, it is not stable

From the hypothesis of table 4, we can see that the variable itself does not pass the ADF test under the 0.05 significant level on the basis of the original hypothesis that the sequence has unit root and the sequence is non-stationary. In addition to the stability of variable X1 in the two-phase lag, the remaining variables are stable after a period of lag. In order to further study the long-term stability of variables, the cointegration test is carried out to determine the long-term cointegration effect and causality between variables.

5.2Cointegration test

From the stationary test, the variable itself is non-stationary, but has the same order (1-order) stationary characteristics. In this paper, cointegration test can be used to study the quantitative relationship between nonstationary variables, and whether the causal relationship described by regression equation is pseudo regression, that is, whether there is a stable

relationship between variables. According to the principle of cointegration test, it is found that the smoothness of residuals is the precondition of determining whether the equation has a long-term stable relationship. So this section uses the least square method to carry out the cointegration test, and puts forward the original hypothesis: the residual unit root is 0, that is, there is no co-integration relationship.

First of all, the regression equation is obtained by using least square method for the dependent variable and the independent variable, and the regression equations are as follows:

$$\Delta Y_t = -3.758X_{1t-1} - 2.328\Delta X_{2t} - 0.185\Delta X_{3t} + 1.114\Delta MGDP_t - 0.765\Delta GDP_t \quad (2)$$

(-0.722) (0.162) (0.187) (-0.996) (0.139) (-0.094)

R^2 =0.563 F=2.336 D.W=0.033

Secondly, the stability of the residual error $\hat{\varepsilon}_t$ caused by regression is tested.

Table 5 Residual item ADF unit root test

Variable	Lag order	Test value of ADF	Incidental probability P	Pass situation of the null hypothesis	Whether it is stable
$\hat{\varepsilon}_t$	0	-4.0375***	0.0004	P<0.05, refuse the null hypothesis	stable

Annotation：***means passing the significance level test of 0.01,using Eviews7.0 software.

From the results of the ADF unit root test in table 5, we can see that the residual items pass the ADF unit root, which has the characteristics of smoothness, so it can be further explained that there is a long-term stable equilibrium relationship between two variables.

5.3Correlation test

The independent variable introduced in this paper is the expansion of a single target, and in the regression results of model (2), the model has a poor fitting effect and the variables are not validated by the corresponding significance, so the model variable has a large deviation. In the explanatory model of the dependent variable, the multiple collinearity is often present, which will cause error to the accuracy of the regression model. In this part, the correlation test is used to determine the collinearity characteristics of the variables. The general correlation coefficient which is more than 0.8 has a very strong correlation, the coefficient of 0.6-0.8 means variables

have a relatively strong correlation, and the coefficient which is less than 0.6 indicates that there is a weak correlation between the variables.

Table 6Correlation test

	ΔY	X_1	ΔX_2	ΔX_3	$\Delta MGDP$	ΔGDP
ΔY	**1.000** 0.000 0.000					
X_1	**0.608** 1.335 0.199	**1.000** 0.000 0.000				
ΔX_2	**0.638** 1.481 0.157	**0.928** 10.252 0.000	**1.000** 0.000 0.000			
ΔX_3	**-0.613** -1.361 0.191	**0.055** 0.229 0.822	**0.018** 0.076 0.940	**1.000** 0.000 0.000		
$\Delta MGDP$	**0.704** 1.823 0.086	**0.517** 2.488 0.024	**0.507** 3.149 0.006	**-0.278** -1.192 0.250	**1.000** 0.000 0.000	
ΔGDP	**0.704** 1.818 0.087	**0.537** 2.625 0.018	**0.526** 3.306 0.004	**-0.264** -1.127 0.275	**0.998** 68.100 0.000	**1.000** 0.000 0.000

Annotation：The first row is correlation coefficient. The second row is the value of t. The third line is incidental probability.

It can be seen from the results of correlation test in table 6 that there is a strong correlation between the dependent variable and the independent variable.At the same time, the variable X_1 has a strong correlation with the variable ΔX_2 and $\Delta MGDP$ has a strong correlation with ΔGDP. So variables have related characteristics.

In order to reduce the error caused by multi-collinearity, this paper adopts the stepwise regression method, gradually increasing the variables based on the basic model, and judges the

final optimal model according to the size of the determinable coefficient.So the fitting effect of the simulation is optimal.

Table 7 Optimal model selection result

Model		$X_1(-1)$	ΔX_2	Analyzing conditions
$\Delta Y_t = \beta_1 X_{1t}(-1) + \beta_2 \Delta X_{2t}$	coefficient	3.758**	5.886**	R^2 =0.563
	the value of t	2.328	2.376	F=2.694
	Incidental probability	0.033	0.030	P=0.012

Annotation：**"means passing the significance level test of 0.05.(-1)means the lag one of the variable.

From the table 7, by judging the condition, establishing ΔX_2 as the regression of the independent variable to the dependent variable makes the model fitting effect superior. Therefore, the interpretation variable $X_1(-1)$ reflecting carbon emissions is more ideal by choosing energy structure and industrial structure. The specific explanation equation is:

$$\Delta Y_t = 3.758 X_{1t-1} + 5.886 \Delta X_{2t}$$

（2.328） （2.376）

R^2 =0.563 F=2.694 D.W=0.012

5.4Empirical results and analysis

The statistic is tested, and the above model can increase the value of the coefficient of determination , which shows that the overall regression effect of the model is relatively good. The energy structure variable and the second industry change rate variable can be quantitatively explained by the influence of equation coefficient on industrial carbon emissions according to univariate significance test.

(1)In the energy structure, the proportion of coal accounting for energy consumption has a lagging effect,which is also has a positive lag effect with the dependent variable. That is, every time 1 unit is increased in the change rate of the proportion of coal accounting for energy consumption, the growth rate of carbon emissions will be increased by 3.758 unit in the next period.

(2)In the industrial structure, the change rate of the total value of the secondary industry has

passed the significance test, and has a positive contemporaneous effect with the dependent variable. That is, the growth rate of the unit second output value will increase, which will increase the growth rate of industrial carbon emissions by 5.886unit. Its impact is greater than the energy structure.

(3)In the educational structure, the number of students in the general undergraduate has continued to rise and has a reverse effect with the dependent variable. That is, the number of students in the general undergraduate has risen, the growth rate of industrial carbon emissions has declined, and the relative industrial and energy structure are not obvious.

(4)In the national economic structure, the growth of GDP and per capita GDP has a positive effect on carbon emissions.The growth rate of industrial carbon emissions has increased significantly during the period of rapid growth of the national economy. After the rapid growth, and the industrial carbon emission rate has dropped significantly in the slow rise period.

6 Countermeasure and suggestion

Through the empirical analysis of the main factors that influence the production behavior of low carbon production in Chinese industrial enterprises, the paper sums up the correlation and influence degree of several major factors. Based on the above results, five points are put forward to improve the low-carbon production of Chinese industrial enterprises.

(a) Improve the structure of economic development and promote the upgrading and transferring of industrial structure

At the present stage of China's economic development model, "High energy consumption, high pollution environment" is still the main characteristics of the second industry. Therefore, we should guide the development of the tertiary industry and gradually promote the tertiary industry to occupy the leading position in economic growth. At the same time, we should use science and technology to drive the primary and the secondary industries’technological innovation and use the technology products in high-tech industries to promote the transformation in the industry with high energy consumption and pollution . On the industrial transfer, we can start from two angles. From China's point of view, we should coordinate the development of various industries in the region and improve the situation of China's imbalance in the east and the west . From a global point of view, these industries can be gradually transferred to the developing countries where the human cost is low andthe environmental protection is insufficient.

(b) Strengthen national policy leadership to promote low-carbon consumer market development

At present,with the promotion of the government, media, enterprises and social non-profit

groups, the concept and awareness of low-carbon consumption begin to become more popular. Therefore, the Chinese government must be committed to building and establishing the right low-carbon consumption concept, guiding reasonably the production and consumption of enterprises and residents, encouraging the relevant product input, research and development and production. The country should promote the society to be accustomed to low carbon consumption, to form a kind of environmental protection, health and civilized low-carbon consumption.

(c) Increase education input and focus on low-carbon concept training

Education is a plan for the national quality and the long-term development of the country. While the development of low-carbon economy and the road to sustainable development are the country's long-term development of the necessary direction. Therefore, the state should increase the financial investment in education, provide sufficient funds for upgrading hardware facilities, improve the level of teachers, and update the concept of running school to meet international education standards. At the same time, in the education process, we should pay more attention to the concept of sustainable development and publicize the low carbon economy to babies,which is throughout their entire learning careers.

（d）Strengthen publicity

China's huge population base of more than one billion shows that energy conservation and emission reduction cannot rely solely on macro-level leadership and regulation at the government level. At the micro level, it is necessary to raise the environmental awareness of all citizens. While the government regulates the industrial structure and energy structure, it must also pay attention to the propaganda work of energy conservation and emission reduction measures within the social scope. Only when everyone pays attention to saving energy and reducing greenhouse gas emissions in their daily lives can they effectively reduce carbon emissions in their daily lives.

(e)Improve the existing judicial system and strictly control violations

China's current legislation on environmental protection is light.Many environmental laws was made too early and the punishment is insufficient. As China's economy has advanced, the illegal cost has become an inevitable and widespread question. Therefore, the government should focus on improving the judicial and legislative systems related to the environment, upgrading existing environmental standards, achieving international standards, increasing penalties, and being fair and open.

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