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A Study on the Development of Low-carbon Economy in Shandong Province-Based on Empirical Analysis on the Influence Factor of Carbon Emission

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Abstract

The idea of low-carbon economy will focus on humanity's future. During the process of socio-economic development, if we want to reduce carbon emissions, we should optimize human production and improve the efficiency of energy. Based on the calculation of the carbon emission caused by energy consumption, this article used the correlation data from 1995 to 2008 in Shandong to analyze the relationship among the economic development level, industrial structure, energy production, energy prices, population situation and carbon emission. The result of this analysis provides the policy theory and the practice support for the development of Low-carbon economy of Shandong province.

Keywords: low-carbon economy; carbon emission; industrial structure; rate of energy utilization;

1. Introduction

Low-carbon economy has become increasingly popular as a concept, and has become an important policy of Governments demand points. In the economic times, each country will try to combine economic recovery and economic transition, want to obtain one from this attractive cake, and seize the commanding height of the new round of economic growth.

China has a good opportunity to greatly develop a low carbon economy because it is beneficial to saving energy and reducing dependence on imported energy and easing the pressure of environmental pollution, and has been paid more and more extensive attention by society and cause state policies encourage. Now there are many favorable conditions for the development of low-carbon economy in our country. China is in a rapid industrialization and urbanization process, with the industrial growth will

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bring energy and resource consumption will be a substantial increase in coal-dominated energy structure, technological level lags behind as well as institutional mechanisms barriers, the development of low-carbon economy in China is also facing many challenges and adverse conditions.

For the Shandong Province, it also exist opportunities and challenges. Conform to trend of the times. We should take advantage of low carbon economy development opportunities, adjust the industrial structure, and promote the energy and new technology, so as to create new economic growth point.

2. The status of low-carbon economy in Shandong

According to data of the Chinese Statistical Yearbook 2009, GDP of Shandong Province reached 3.107206 trillion Yuan RMB, and the country's economic volume accounted for 10.33% in 2008. It ranked second only after Guangdong Province. However, when the economy in the top ten provinces and cities, the highest proportion of secondary industry in our province. Proportion of three industries in Shandong Province adjusted 15.2:50.0:34.8 in 2000 to 9.6:57.0:33.4 in 2008. Industrial structure has changed significantly. It is reflecting some problems of the long process of economic development in Shandong Province: over-development of the secondary industry, tertiary industry is relatively backward. And in recent 10 years, the proportion of tertiary industry in Shandong showed a trend of decline. Obviously, there are some problems about industrial structure of Shandong province must be adjusted, and the development of low-carbon economy is conducive to the adjustment of industrial structure, so the development of low-carbon economy in Shandong Province is imperative.

As irrational industrial structure, the problems about unit of GDP energy consumption in Shandong Province are also very serious. Unit of GDP Province energy consumption and energy consumption per unit of industrial added value ranked No. 5 in Shandong in 2008. This shows not only the energy consumption is so high in Shandong Province, but also the energy efficiency is so low. As shown in Figure 1, although the energy consumed for each 10,000 Yuan of GDP in Shandong Province has been reduced since 2005, the energy consumed for each 10,000 Yuan of GDP has been similar to the national level and it higher than the national level after 2006. And according to the NDRC released the " The completion of energy-saving goals for the provinces ,autonomous regions and municipalities in 2008" show that responsibility for energy-saving target of evaluation and examination results in Shandong Province has been completed in 2008, and the country ranked No. 6. However, it only completed less than 60% of the energy conservation targets of "11th Five-Year Plan". Therefore, the government must formulate policies to reduce energy consumption and improve energy efficiency. And this is same as the goal of development of low-carbon. These show that the development of low-carbon economy in Shandong Province is inevitable and necessary.

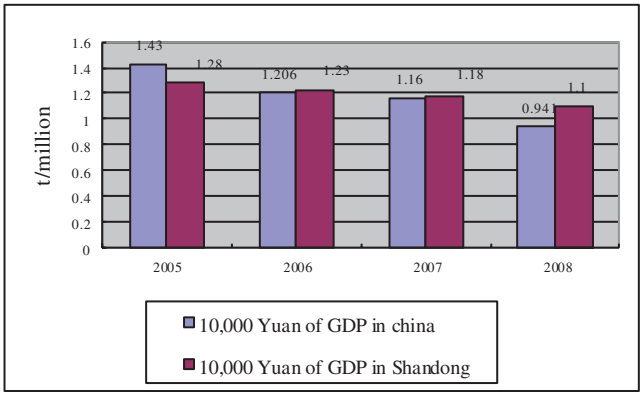

Figure 1. The comparison of Shandong Province and the country about the energy consumed for each 10,000 Yuan of GDP from 2005 to 2008

In recent years, in order to develop low-carbon economy, Shandong Province issued a series of policies. It mainly involves the " Ordinance of Energy Conservation in Shandong Province "(was revised in 2009), "Long-term development plan of Energy in Shandong Province", " '11th Five-Year Plan' special Plan of Energy Conservation in Shandong Province "," Proposals on Further Strengthening Energy Saving Work "," the Decision on Strengthening Energy Conservation "," Comprehensive Implement Measures of Energy Reduction in Shandong ", " the implementation of programs and approaches for Statistics, Monitoring and evaluation of energy saving in Shandong Province", and so on. Shandong Province also developed 177 local standards of energy efficiency and strict pollutant emission standards for thermal power, cement, paper and other industries. But these policies are still existed certain defects and deficiencies. Therefore, to better develop low-carbon economy needed to further improve the policy and legal system.

All in all, if we want to develop better low-carbon economy that will need to adjust the industrial structure, reduce energy consumption and carbon emissions, improve energy efficiency, and perfect the policies and legal requirements. In the following section, we will analyze the influential factors of carbon emissions to provide the policy theory and the practice support for the development of Low-carbon economy of Shandong province.

3. Based on empirical analysis on the influence factor of carbon emission

3.1. Set of variables and data sources

3.1.1Set of variables

In the basic model, carbon emissions by the provincial economic development, industrial structure, energy production, energy prices, the provincial demographic and other factors. Analysis and select the data in Shandong's population, economy, energy and others from 1995 to 2008. We refer to the four independent variables *GDP*, *STR*, *NZQ*, *NPRI* and *PEO*, and a dependent variable *CQ*. We use *GDP* that the level of economic development in Shandong Province, *STR* the industrial structure, *NZQ* that the total energy production, *NPRI* that energy prices, *PEO* that population, and *CQ* that carbon emissions.

3.1.2Variables handling

The independent variables are handed. Carbon emissions (*CQ*).Because the present statistics have not the index of carbon emissions, this index is made a new estimate. According to Xu Guoquan said that carbon emissions and energy consumption is proportional, we believe that the data of carbon emissions is based on the data of energy consumption which used formula *(1) to* estimate.

$$CQ_t = \sum E_{tj} * \eta_j \qquad (1)$$

Where CQ_t is carbon emissions of the t year, E_{tj} is a class j energy consumption of the t year, and η_j is Carbon emission coefficient of the class j energy. Carbon emission coefficient of coal is 0.7476t(c)/t. Carbon emission coefficient of oil is 0.5825 t(c)/t. Carbon emission coefficient of Natural Gas is 0.4435t(c)/t.

The dependent variables are handed. The status of Economic development in Shandong Province (GDP) is used the data of Shandong Province's GDP from 1995 to 2008. The status of industrial structure (STR) is reflected by the percentage of second industry value accounts for the total output value. The total energy production (NZQ) is closely linked with energy consumption and carbon emissions. It is used the data of primary energy output over the years in Shandong from 1995 to 2008. Energy prices (NPRI) is

used the arithmetic mean of ex-factory price indices of industrial products. High population growth rate and high population base is also an important factor to carbon emissions. So we used the data of total population (PEO) to reflect.

3.1.3 Data sources

The data of level of economic development, the industrial structure, the total energy production, energy prices, population, and carbon emissions come from the data of Shandong Province's GDP, the percentage of second industry value accounts for the total output value, primary energy output over the years, ex-factory price indices of industrial products (mining and washing of coal), total population and final energy consumption (10000 tons of SCE) in "Shandong statistical yearbook (2000-2009)". The differential treatment of data does not alter the co-integration relationship between variables, can tend it to be linear, and eliminate the heteroskedasticity of time-series. So all the data have been differential treatment before calculated.

3.2. Variable inspection and the relation of variables

3.2.1 Variable of unit root test

In modern statistical theory, once the traditional regression analysis among the non-stationary data, there will appear the pseudo-regression phenomenon. Despite it have the very good fitting degree and t values, the regression results are not credible. So we need to test the stationary of the data before the regression. If it is not stationary, we should further process the data for the difference in order to achieve a stationary data. The accuracy judgment to the stationary of data is the premise of use econometric model for time series data analysis. Therefore, before the analysis of time series data, unit root test must be conducted to determine whether the time series are stationary. We use the ADF method to test the stability of variables, and test results in Table 1.

Table 1. Results of unit root test (ADF test)

Variable	t statistic	Test Category	Associated probability
CQ	-1.9202	c，t，0	0.587
△*CQ**	-4.6057	c，n，2	0.000
GDP	-2.8951	c，t，0	0.198
△*GDP**	-2.8171	c，n，2	0.000
STR	-2.2789	c，t，0	0.412
△*STR**	-3.6329	c，n，0	0.000
NZQ	-2.5439	c，t，0	0.306
△*NZQ**	-3.9023	c，n，2	0.000
NPRI	-2.9488	c，t，0	0.181
△*NPRI**	-8.6277	c，t，2	0.000
PEO	-2.8087	c，t，0	0.219
△*PEO*	-9.4182	c，t，2	0.000

Notes: ①In column of the test class, c that includes the intercept. t that includes the time trend term. k represents lagged differences. n that does not include the trend term. ②△is means the 2nd difference. ③* represents 1% level of significance rejected the null hypothesis, it can be said the time series is stationary process.

The results showed that the levels of the variable values are not stable, and their second differences are stationary. It is means there have the second unit root. So when we regress to values, the first process each data for the 2nd difference.

3.2.2 Basic relationship among variables and lagged structure

When we set the model, we should understand the various explanatory variables affect the period in which the dependent variable is the most significant impact. And also to briefly analyze the positive and negative relationships of explanatory variables effect on the dependent variable in the long-term. This will help us to generally understand the net effect of each variable. The results are shown in Table 2:

Table 2. Lag structure of each variable

Lag phases	GDP $\triangle GDP$	Industrial structure $\triangle STR$	Energy production $\triangle NZQ$	Energy prices $\triangle NPRI$	Total population $\triangle PEO$
T	-0.707 （-0.668）	-0.024 （-0.017）	-0.044 （-0.072）	1.927 （1.920）	8.073 (0.258)
T-1	4.696*** （2.124）	4.193*** （2.363）	0.937** （2.418）	2.008** （2.278）	-0.714 (-0.019)
T-2	-2.475 （-1.237）	2.592 （1.040）	1.909*** （4.854）	1.521 （0.852）	-22.303 (-0.580)
T-3	-0.866 （-0.966）	-0.497 （-0.307）	0.612 （0.9915）	1.668 （1.014）	36.601** (2.239)

Notes: △is means the 2nd difference operator (logarithmic). The number in parentheses is the value of t test. *** （**） indicates that 1%(5%) level of significance through t test.

The results showed that: lagged one phase of Shandong's GDP, industrial structure and energy prices are impact carbon emissions in the most significant. Lagged two phase of total energy production is impact carbon emissions in the most significant, and lagged three phase of total population is impact carbon emissions in the most significant. So when we set the model, we refer to lagged one phase value of Shandong's GDP, the industrial structure and energy prices, and use lagged two phase value of energy production and lagged three phase value of the total population.

3.3. Set the basic model and the regression results

3.3.1 Set the basic model

After data processing, we set the basic model of the following equation (2):

$$lnCQ_t = \alpha+\beta_0*lnGDP_{t-1}+\beta_1*lnSTR_{t-1}+\beta_2*lnNZQ_{t-2}+\beta_3*lnNPRI_{t-1}+\beta_4*lnNPEO_{t-3}+\mu_i \qquad (2)$$

This is a logarithmic regression model. *ln* said on both sides of the logarithmic formula. t (t = 1,2, ..., 14) said that year. α said constant coefficient. β_0, β_1, β_2, β_3 and β_4 that the coefficient of each independent variables. μ_i that time dummies. Here only have the time dummies μ_i, it means the impact of the time. In the model, the data of all variables is generation going into formula after handled by the second difference.

3.3.2 The regression results

We use least squares (OLS) regression to the model, from Table 3 we can see, all results are through the mathematical test.

Table 3. Results of basic regression

Argument	$lnGDP_{t-1}$	$lnSTR_{t-1}$	$lnNZQ_{t-2}$	$lnNPRI_{t-1}$	$lnNPEO_{t-3}$	R^2	D.W value	F statistic
Coefficient	0.948***	2.388***	0.765**	0.699***	-14.09***	0.9977	3.3888	440.40
t statistic	7.0566	3.0128	3.4516	5.4226	-5.6479			

Notes: ***（**、*）indicates that 1%(5%、10%) level of significance through t test.

Regression results from the basic model in Table 3, we can sum up the results shown in following table 4:

Table 4. The direction, occurrence time and the elasticity of factors

factors	GDP	Industrial structure	Energy production	Energy prices	Total population
The direction of action	Positive	Positive	Positive	Positive	negative
Occurrence time	the one-year lag	the one-year lag	the two-year lag	the one-year lag	the three-year lag
Elasticity	0.948	2.388	0.765	0.699	-14.09

Through table 4 we can make the following summary of the factors which affect the amount of carbon emissions in Shandong Province.

(1) Direction of action

The impact of Shandong Province's GDP, the industrial structure, energy production and energy prices on carbon emissions is generated in the same direction. However, the proportional relationship between energy prices and carbon emissions differ from reality. Because the state and Shandong Province's monopoly on energy prices, and some energy sources are non-renewable, price control on the impact of energy consumption may not be obvious. The inversely proportional relationship between total population of Shandong Province and carbon emissions is due to the low population growth in Shandong Province from 1995, and compared to the growth of carbon emissions, it is not more obvious.

(2) Time of occurrence

For Shandong Province's GDP, the industrial structure and energy prices, their impact on carbon emissions are the most significant in the one-year lag. For energy production, its impact on carbon emissions is more obvious in the two-year lag. The total population is effect on carbon emissions more obvious in the three-year lag, there were mainly due to the low population growth in Shandong Province in recent years.

(3) Impact strength

GDP of Shandong Province, the impact of carbon emissions coefficient close to 1. This means that GDP per increase one unit, carbon emissions has also increased one unit. Visibly, the influence is so large. The industrial structure is expressed in the percentage of second industry value accounts for the total output value. And the correlation coefficient of carbon emissions and industrial structure is 2.388. This shows that the proportion of secondary industry increase each unit, the carbon emissions will increase in 2.388 times. The correlation coefficient of Total energy production and carbon emissions is 0.765.Its influence is also very strong.

There are two variables with inconsistent theories in the measurement. One is energy prices. The correlation coefficient of carbon emissions and energy prices is 0.699, its value is positive. However, this model is based on the demand function, the most general factors affect the demand function is price (not the only factor), both value usually takes the negatively correlated, but the results are positively correlated. This may be due to that energy price has many monopoly phenomenon in Shandong Province, it caused energy consumption is not sensitive to the price. And resulting in the price parameters of the model may be invalid. But for the practical significance of the demand function, it should be retained in the model.

Another is the total population. The coefficient of it and carbon emissions is 14.09, its value is negative. Along with the growth of population and improved quality of life, living coal consumption is rising sharply. To meet the growing population's demand for coal, coal consumption is also increasing very high, which causes increased carbon emissions. But the measurement results show that high population growth does not cause increased carbon emissions, which may be because the population growth of Shandong province is relatively stable from 1995, compared to the rapid growth in carbon emissions, its stability let to the negative correlation with carbon emissions.

4. Conclusions and policy recommendations

Based on the calculation of the carbon emission caused by energy consumption, we analyze the relationship among the economic development level, industrial structure, energy production, energy prices, population situation and carbon emission. And we draw the following conclusions and policy recommendations.

First, especially with the rapid development of industrialization in Shandong province, the level of economic development in Shandong Province is one important factor to impact of carbon emissions. Empirical results show that impact factor is close to 1, it means that the mode of economic growth in Shandong Province should be optimized. Therefore, in order to develop low-carbon economy, economic system must be improved; low-carbon policy should be set up, and the long-term effective mechanism of low-carbon development should be formed in Shandong Province. Shandong Province should gradually establish a greenhouse gas emission standards and assessment system; Study and establish incentive low-carbon economy development policies and measures, and found special funds of low-carbon economy development; Study and establish the propulsion of low carbon economy development mechanism and laws safeguard system, and timely formulate promotion laws of low-carbon economy; establish innovation mechanisms of science and technology to support technology development, industrial demonstration and transformation; and raise public awareness. Shandong Province should focus on their development level and characteristics, and based on the target of low-carbon economic development to work. Summing up experience, Shandong should incorporate their conditions to explore the road of low-carbon economic development.

Second, the industrial structure of Shandong Province on the impact of carbon emissions is the largest, and the greater the proportion of secondary industry of the total industry, the higher carbon emissions. This explains that transformation of economic growth and industrial restructuring plays an important role for the reduction of carbon emissions and the development of low carbon economy. The extensive characteristics of the industrial development influence the efficiency of energy utilization, and increased carbon emissions. We should be in accordance with the principle of high technology density, high value-added industries, energy consumption, less water consumption, less sewage, less transportation, and small footprint to adjust industrial structure. Make the economy mode from extensive to intensive, thereby improve energy efficiency, and promote low-carbon economy.

Third, the total energy production is also an important factor to impact of carbon emissions. Because now the industry in Shandong still mostly use the high carbon energy sources ——coal, oil, natural gas, etc. Thus, with production of high carbon energy, carbon emissions continue to increase. In recent years, new non-carbon and low carbon energy sources mainly include hydropower, nuclear power, wind power, solar, biomass, alcohol fuel and biodiesel. The development of new energy, new technologies and improvement of the energy efficiency is one of the effective measures to promote the development of low-carbon economy. Therefore, Shandong Province should pay attention to research low-carbon technology and technical reserves. According to principles of technical feasibility and rational economic, research and propose a technology roadmap of low-carbon development in Shandong Province. Promote

energy-efficient low-carbon technology development and application, and gradually establish energy efficiency, clean energy, new energy and renewable energy systems such as a wide range of low-carbon technologies. There provide strong support for low-carbon transformation and growth patterns in Shandong.

Last but not least, the energy price also has important influence on carbon emissions, and it has great variation. As prices of coal, oil, natural gas controlled by government monopoly more serious, it caused energy consumption is not sensitive to the price. Therefore, it is unwise that the Government controls the consumption of these energy sources by price. Prices of coal, oil and natural gas are formed by market which may be changed this situation.

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