The Grey Relational Analysis on Coal Consumption and the Economic Growth in Shandong Province

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***Abstract*- Based on expounding the current natural endowment condition of coal resources, this thesis collects relative statistical data from 1995 to 2007, using grey correlation analysis method and other mathematical statistics methods to analyze the relationship between coal consumption, economic growth (*Urbanization level*, Industrial structure, GDP) and the environment. The research indicates that coal consumption and economic growth of Shandong province has significant correlation. One more percent of urbanization level in Shandong province will add 4.8% of coal consumption. Coal consumption and consumption intensity both have a strong correlation with secondary industry and tertiary industry, particularly in most correlation with the secondary industry. 100 more million of GDP will add 12400 tons standard coal in coal consumption. Coal consumption per ten-thousand yuan GDP has firstly increased and then decreased. From 2000 to 2003, coal consumption per ten-thousand yuan GDP increased slowly, and from 2004, it decreased rapidly with nearly one-third improvement of coal use efficiency. Coal consumption and air pollutants emissions of per unit of GDP were negatively correlated. From 1995 to 2007 years, coal consumption has increased year by year, and the unit GDP SO2 emissions and soot volume decreased year by year. This benefits from pollution control efforts and energy structure adjustment and so on. Finally, according to the present situation of coal resources in Shandong province and the relationship between coal consumption and the economic growth and the environment, this thesis puts forward strategies and suggestions of coal resources utilization and continuous development in Shandong province.**

Keywords- Grey Correlation Analysis; Coal Consumption; Economic Growth; Industrial Structure; Urbanization Level; Environment; Shandong Province

I. INTRODUCTION

As one of the socio-economic development input factors, resource plays an important supporting role in economic development. Since the first global oil crisis in 1973, people have begun to pay attention to the relationship between resource consumption and economic growth [1, 2]. Taking GDP data and resource consumption data of America from 1947 to 1974 for an example, Kraft J and Kraft A (1978) found that the relationship between resource consumption and economic growth of America exists unidirectional causality. The causal direction is from GDP to energy consumption and economic growth is caused by the change of energy consumption [1, 3]. Shyamal Paula (2004) selected India's energy consumption and the GDP data from 1950 to 1996 as sample using cointegration theory and Granger causality test and other methods to study the relationship between the two factors above. Research shows that: the economic growth of India promoted the energy consumption to increase, while the energy consumption also promoted economic growth, so they have two-way causal relationship [1, 4]. Meng Yan and Zhang Yishan (2007) studied the relationship between China's coal consumption and economic growth, showing the long-term equilibrium relationship between coal consumption and economic growth [5]. Yu Chao (2007) applied the method of grey correlative analysis to research on the relationship between energy consumption and economic growth in China, which indicated a high correlation between resource consumption and economic growth [6]. Liu Aiqin (2008) used grey correlation analysis method to study the Shandong province's energy consumption data and industrial GDP data from 1998 to 2006, concluding that Shandong energy consumption and industrial economic growth had a significant positive correlation [7]. Ma Li and Zhang Qianjin (2008) used the co-integration theory of econometrics and Granger causality test to analysis the relationship between the energy consumption and economic growth of the Ningxia Hui Autonomous Region from 1985 to 2005 [8]. Qu Xiaoe, Yuan Xiaoling (2008) made an analysis on correlation of national total resources consumption, efficiency of resources utilization, stock of capital and GDP. Research showed that, China's total energy consumption and economic growth were most closely related. The correlation in structure of energy consumption and economic growth were significant. The correlation in the efficiency of sources energy, capital stock and economic growth were significant, but influences from other factors were small [9]. Gao Xincai, Jian Yanpeng (2009) researched on the relationship between China's resource consumption and GDP with the application of grey correlation analysis, which indicated that coal, natural gas, petroleum and hydroelectric power separately has most, high and distinct correlation with GDP in our national resource consumption structure [10]. To study the relationship between energy consumption and economic growth, the method generally has two kinds. One is the application of the econometrics cointegration theory, error correction model, Grainger causality test method. The other is based on the grey relational analysis method. The relationship between economic growth and the energy consumption are mainly three forms. Firstly the energy consumption and economic

growth don't have causal relationship. Secondly energy consumption and economic growth have a one-way causal relationship. Thirdly the energy consumption and economic growth have two-way causal relationship. The study about the relationship between energy consumption and economic growth of China and other countries mainly adopts the method of statistics to research the relationship between energy consumption and economic growth in different countries of the world. And then research about relationship between energy consumption and economic growth within a certain region is relatively less. Because of the research methods, the selected sample data and other reasons, the same country or area's studies may yield different results. The research about the relationship between coal consumption and the economic growth and environmental pollution of Shandong province is less. So this thesis uses the grey correlation analysis method, mathematical statistics methods to research the relationship between coal consumption and economic growth (urbanization level, industrial structure, GDP) and environment. The research about the relationship between domestic energy consumption and economic growth generally is the energy consumption and GDP single index relationship study. This thesis is from the coal consumption, economic growth of the urbanization level and industry structure and GDP three indicators to study.

Shandong province is one of important energy bases in China. The territory of coal bearing strata in the area of 50000 square kilometres, prediction of coal reserves of about 2680 tons. The province's coal output accounted for 6% of the whole country. The structure of Shandong province energy consumption is single, mainly about coal and petroleum, furthermore coal accounted for the total energy consumption of 81%. With the rapid speed of industrialization and urbanization in the following time, there will be a rigid growing tendency in the development and utilization of coal resources, which will strengthen the support and protection of economic. Therefore, to study the present situation of coal resources in Shandong Province, to identify the factors affecting coal consumption clearly and to know the relationship between economic growth and the energy consumption is the first issue of the energy strategy of Shandong province, but also the basis to ensure the health and sustainable development of economy of Shandong Province.

II. ANALYSIS ON CURRENT CONDITION OF COAL RESOURCES IN SHANDONG

Shandong is one of the eastern coastal areas that covering rich mineral resources and its basic industry mainly on raw mineral materials and relative industries can possess 70% of the total industrial output value, so that mineral is the essential part to support economic social development in Shandong province. However, with the fast development of economic society on industrialization and urbanization, the mineral resources, especially strategic mineral resources are demanded in an increasing tendency and tense situation to support mineral industry development.

A. Abundant Resources in Unbalanced Supply-Demand

Coal resources keep recoverable deposits of 24.872 billion tons, including base reserves of 8.411 billion tons and reserves of 4.205 billion tons, with higher abundance value of mineral resources on unit area. The coal supply constitutes about 12 percent of the nation's output and occupies the 5th place in China. With the development of economy, coal production and consumption of Shandong province in different period has different characteristics: from the reform and opening-up period to 2000, the coal production capacity increase slowly and the growth rate of production was low; from 2001 to 2003, coal production increased rapidly, growth rate is accelerated apparently; from the 2004, the coal production capacity presents trace fluctuation adjustment state and coal production changes slowly, with 2003 annual output was reduced and the coal consumption from the beginning of 2000 has showed rapid growth. From the 2004**,** the situation has been changing, that demand of coal begun to exceed supply rather than oversupply. Supply and demand gap is 15.8%, by 2007, the gap between supply and demand rises to 39.2%, coal supply and demand gap with an average annual growth rate of around 35%. From 2004, coal output has been increasing more slowly than coal consumption, and yearly coal consumption should be nearly 0.28 billion tons in rough estimation according to the entire coal consumption of a year in Shandong; the provincial coal in an entire year only outputs 0.15 billion tons and inputs 0.18 billion tons. Seeing from this, coal resources dependence on the outside world is above 60%.

B. Relative Centralization of Coal Resource Distribution in Incompatible Economic Region

In the middle, northwest and southwest of Shandong province, there distributes significant coal resources; but lacking in the developed eastern area of Shandong. This situation causes dislocation between main producing area and processing and consumption area, but can promote to form special mineral economic distribution in different regions.

C. High Degree of Geological Exploration with Abundant Minerals to Be Proved

There exists enormous potential for mineral resources in the main metallogenic province, and has bright prospects on mineral exploration. In depth, the province's mineral resources exploration and development most is above 500 meters. Deep prospecting has not spread out in the round. In the region, exploration is not balanced, the southwest and the west area still has a lot of prospecting space**.** The total predictive mineral resources can be above 40 billion tons, in which 16 billion tons still need to be explored.

III. ANALYSIS ON RELATIONSHIP BETWEEN COAL CONSUMPTION AND THE ECONOMIC GROWTH AND THE ENVIRONMENTAL

Based on the province's coal resources development and utilization, combining the tendency of urbanization and industrialization of Shandong province and the situation about industrial structure, energy consumption structure, I use the related model to analyze the main influence factors of coal resource consumption, and to predict a future period of main coal resource supply and demand conditions.

A. Analysis on Correlation between Urbanization and Coal Resources Consumption

1) Relationship between Urbanization and Coal Resources Consumption:

The fast development of industrialization and urbanization has increased the coal resources consumption in Shandong province, as shown in Table 1.

TABLE Ⅰ URBANIZATION LEVEL, COAL OUTPUT AND COAL CONSUMPTION FROM 2000TO 2007 YEARS IN SHANDONG

Year	Urbanization Level (%)	Coal Output (Ten Thousand Tons)	Coal Consumption (Ten Thousand Tons of Standard Coal)	Gap of Supply and Demand (Ten Thousand Tons)	Supply Ratio in Consumption (%)	Ratio of Gap of Supply and Demand (%)
	CIVIL	CPROD	CCONS			
2000	38.00	8026.64	7461.07	565.57	107.58	7.58
2001	39.20	10897.26	10036.44	860.82	108.58	8.58
2002	40.30	12836.72	11808.97	1027.75	108.70	8.70
2003	41.80	14471.00	13855.31	615.69	104.44	4.44
2004	43.50	14062.70	16702.40	-2639.70	84.20	-15.80
2005	45.00	13087.50	17872.30	-4784.80	73.23	-26.77
2006	46.10	13849.84	20586.40	-6736.56	67.28	-32.72
2007	46.75	13688.85	22515.00	-8826.15	60.80	-39.20

From Table 1 we can see that in 2000 coal supply is greater than demand, but from 2004 coal demand is greater than supply. Supply is accounted for 84.2% of demand. The gap between supply and demand is 15.8%. By 2007 coal supply is accounted for 84.2% of demand. The gap between supply and demand rose to 39.2%. From 2004 to 2007, coal supply and demand gap is with an average annual growth rate of around 35%. This is mainly because of the sustained rapid growth of investment in fixed assets, especially the high energy heavy chemical industry production, resulting that Shandong province coal resource consumption is more than its total production, becoming a net input provinces.

2) Analysis on Correlation between Urbanization Level and Coal Resources Consumption:

By establishing the coal resources production and consumption relating to urbanization of linkage analysis, we use the regression model to carry on the analysis, obtained the following conclusions:

The regression model of coal output and urbanization level is:

- Ln(CPROD)=2.328511+1.892796Ln(CIVIL)
- P (0.1930) (0.0026)
- R^2=0.6973 is adjusted to R^2=0.6594 F=18.4308

The regression model of coal consumption and urbanization level is:

- Ln(CCONS)=-8.554929+4.833272Ln(CIVIL)
- P (0.0004) (0.0000)
- R^2=0.9744 is adjusted to R^2=0.9701 F=228.4562

From the above, it presents poor fitting of correlation between coal output and urbanization level, but good fitting of correlation between coal consumption and urbanization level. From each regression coefficient P, less than 1% significant level, urbanization level is the significant influent factor of coal consumption. According to the above regression model to calculate, in other condition invariable situation, Shandong province city level increase one percentage, coal consumption will increase 4.8 percentage points.

B. Analysis on Correlation between Industry Structure Adjustment and Coal Resources Consumption

1) Relationship between GDP and Coal Consumption:

Generally speaking, it seems relatively stable of the relationship between economic growth and coal consumption growth in Shandong province, with the same

fluctuated directions basically, and no exceptions occurred (shown in Figure 1, where GDP is current value).

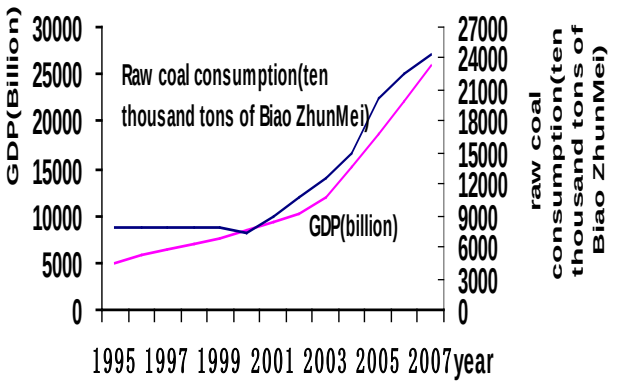

Fig. 1 The coal consumption and GDP trend graph over the years

By the Figure 2 we can get coal consumption and GDP function relations:

- Y=1.2388X-640.75 R^2=0.9441

In which, Y stands for coal consumption, X stands for GDP, and R is relative coefficient value.

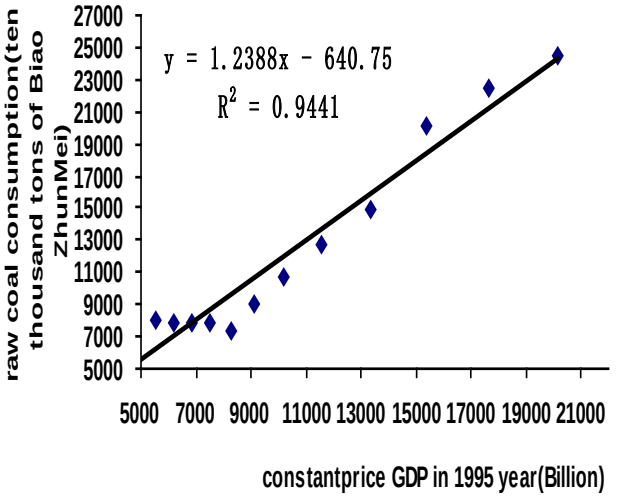

Fig. 2 Relationship between coal consumption and GDP

By calculated with linear equations, one more 100 million GDP will consume 12.4 thousands tons standard coal. Coal resources consumption of every ten thousand GDP reflects the relative index of coal resources utilization efficiency. Ten thousand yuan GDP coal consumption has experienced the process of increasing at first and then decreasing. From 2000 to 2003, Ten thousand yuan GDP coal consumption was slowly raising trend. From 2004, ten thousand yuan GDP coal consumption decreased rapidly and from 1.15 tons of standard coal in 2003 dropping to 0.87 tons of standard coal in 2007, dropping 24%, coal utilization efficiency by nearly 1/3. This indicates that there has achieved certain results in coal utilization efficiency in Shandong province.

2) Grey Correlation Analysis on Coal Resources Consumption and Industrial Structure:

2.1 Fundamental principle of grey correlation

Fundamental principle of grey correlation analysis is to adjust correlation according to the geometry shape similarity of sequence curve. If the curve is more closed, the corresponding sequence correlation is greater, otherwise the less. This judgment causes the development of primary and secondary factors. It is also suitable for sample size and sample rules. In view of the data source is only 8 years of data, the sample is small. So the application of Grey Relational Analysis on industrial structure and energy consumption and energy consumption intensity to analysis is effective. The calculation is as follows:

First step, determine reference sequence and comparative sequence:

- $X_0^{'}(t)=\{x_0(k)|k=1,2,.....n\}$

$X_0^{'}(t)$ Stands for reference sequence.

- $X_i^{'}(t)=\{x_i(k)|k=1,2,.....n\},\ (i=1,2,.....m)$

$X_i^{'}(t)$ Stands for Comparative sequence.

Second step, standardize data in order to wipe out difference of data dimension. Select a base data and other data standard with it by comparison. $X_0(t)$ and $X_i(t)$ stand for standardized reference sequence and comparative sequence.

Third step, Based on the formula obtained K:

$$\varepsilon_i(k)=\frac{\min\limits_i\min\limits_k|X_0(k)-X_i(k)|+\rho\max\limits_i\max\limits_k|X_0(k)-X_i(k)|}{|X_0(k)-X_i(k)|+\rho\max\limits_i\max\limits_k|X_0(k)-X_i(k)|}$$

ρ is resolution ratio. The smaller ρ is, the greater resolving power is. Generally the value is $\rho\in[0,1]$, but the value depends on circumstances. Some researches show that when $\rho\le 0.5463$, solution is best. So $\rho=0.5$ is the general value.

Forth step, calculating correlation: correlation of reference sequence and comparative sequence is the average value of sequence at each point. Then sort the correlations [11].

$$r_i=\frac{1}{n}\sum_{i=1}^{n}\varepsilon_i(k)$$

2.2 Calculation and analysis of data correlation

Taking coal consumption and coal consumption intensity as reference sequence, to reflect total coal consumption index and coal consumption intensity index; considering industry structure of three industries proportion as comparative sequence, represented by $X_1^{(t)}$, $X_2^{(t)}$ and $X_3^{(t)}$. The data, including three industries proportion, comes from statistic yearbook from 2001 to 2007 years in Shandong and coal consumption is from sources balance sheet. The coal consumption from 2000 to 2003 is achieved by standard coal calculated from consumed quantity of raw

coal, cleaned coal, other washed coal and coal products. Through the above analysis, the result is shown in Table 2:

TABLE II CORRELATION AMONG COAL CONSUMPTION, CONSUMPTION INTENSITYAND THREE INDUSTRIES

Year	Correlation Degree between Consumption and Three Industries			Correlation Degree between Consumption Intensity and Three Industries		
	ε1(k)	ε2(k)	ε3(k)	ε1(k)	ε2(k)	ε3(k)
2001	0.967	0.977	1.000	0.509	0.527	0.571
2002	0.801	0.856	0.868	0.388	0.481	0.505
2003	0.674	0.765	0.729	0.346	0.553	0.454
2004	0.569	0.657	0.599	0.349	0.704	0.432
2005	0.520	0.619	0.567	0.389	0.803	0.630
2006	0.456	0.540	0.501	0.384	0.705	0.719
2007	0.423	0.492	0.465	0.433	0.606	1.000
Correlation degree	0.630	0.701	0.676	0.400	0.625	0.616

Through grey correlation analysis of coal consumption, consumption intensity and three industries proportions, we can see that:

First, coal consumption is closely related to coal consumption intensity in Shandong. The correlation degree between total coal consumption and primary, secondary and tertiary industries industry proportion is 0.63, 0.701 and 0.676. From this, we can see that the correlation extent between total coal consumption and secondary industry is much higher than the other two industries.

Secondly, coal consumption intensity is closely related to industrial structure, and has different correlations among different industries. The correlation degree between coal consumption intensity and primary, secondary and tertiary industries industry proportion is 0.4, 0.625 and 0.616, which indicates that correlation degree between coal consumption intensity and primary industry is much lower than the other two industries.

Through grey correlation analysis of coal terminal consumption and every kind of industry terminal consumption in the similar way, we found that the correlation extent between total coal terminal consumption and primary, secondary and tertiary industries proportion is 0.5809, 0.8612 and 0.6621 separately. This indicates that total coal terminal consumption is most closely related to secondary industry than other two industries, which reflects that coal consumption has distinct relation with secondary industry, strong relation with tertiary industry and light relation with primary industry. Directly shown in Figure 3, the standardized value curve of total coal terminal consumption has stronger correlation extent with secondary industry than tertiary industry, which corresponds with grey correlation analysis.

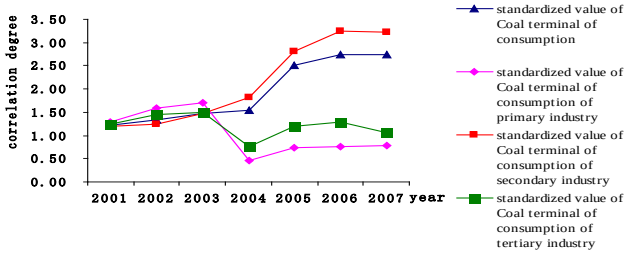

Fig. 3 Standardized value trends of Consumption of coal terminal and Consumption of various industrial coal terminal

From the above model analysis, it is concluded that both coal consumption and consumption intensity have higher correlation degree with secondary and tertiary industries, especially the secondary industry. In 2007, coal consumption intensity of secondary industry is 0.442 tons standard coal per ten thousands GDP, 21 times as much as tertiary industry and 5.7 times as much as primary industry. In total coal consumption in 2007, coal consumption of secondary industry accounted for 88.88%, and primary and tertiary industries only accounted for 2.66% and 2.45%, and daily consumption accounted for 6%. However, on contributions to GDP in 2007, secondary, primary and tertiary industries accounted for 64.5%, 32.8% and 2.7%. It is seen that secondary industry consumed 88.88% of coal resources while it contributed 64.5% of GDP, but tertiary industry consumed 2.45% of coal resources while it contributed 32.8% of GDP. What should be known is that industry restructuring has great influence to coal consumption and consumption intensity. In order to support resource security, industry restructuring must be paid more attention. At the same time, under the condition of saving energy, industry restructuring should greatly develop the tertiary industry, optimize the internal structure of the secondary industry, develop high-tech industries of low energy consumption and relieve pressure on the demand for energy.

C. Analysis on Correlation between Environment and Coal Resources Consumption

The production and consumption of coal resources will be a significant impact on the atmospheric environment, water environment and natural ecological environment. But from the view of China's environmental problems, the most important thing is the atmospheric pollution producing by coal consumption and global climate change impacts.

1) Coal Consumption and Air Pollution Emissions:

Atmospheric pollution of Shandong Province mainly consists of soot. The main pollutants are sulfur dioxide, soot and nitrogen oxides. This is closely related with the consumption of coal-based energy consumption structure. Coal consumption situation and the major air pollutant

emissions in Shandong Province in recent years are shown in Table 3.

TABLE III COALCONSUMPTION AND THE MAJOR AIR POLLUTANT EMISSIONS IN SHANDONG PROVINCE

Year	GDP (One Hundred Million Yuan)	Raw Coal Consumption(Ten Thousand Tons of Standard Coal)	SO2 Emissions(Tons)	Soot Emissions(Tons)	Energy Consumption per Unit of GDP	SO2 Emiddiond per Unit of GDP(Tons /Million)	Soot Emissions per Unit of GDP (Tons/Million)
1995	4953.35	7796.92	232	130	1.5741	0.0468	0.0262
1996	5883.8	7940.35	239.5	119	1.3495	0.0407	0.0202
1997	6537.07	7852.87	247	108	1.2013	0.0378	0.0165
1998	7021.35	7875.62	226	92	1.1217	0.0322	0.0131
1999	7493.84	7779.50	183	71	1.0381	0.0244	0.0095
2000	8337.47	7392.04	180	67	0.8866	0.0216	0.0080
2001	9195.04	8955.26	172	65	0.9739	0.0187	0.0071
2002	10275.5	10738.97	169	62	1.0451	0.0164	0.0060
2003	12078.15	12694.94	184	62	1.0511	0.0152	0.0051
2004	15021.84	14896.75	182	52	0.9917	0.0121	0.0035
2005	18516.87	20093.03	200	62	1.0851	0.0108	0.0033
2006	22077.36	22442.31	196	58	1.0165	0.0089	0.0026
2007	25965.91	24489.04	182.2	46.3	0.9431	0.0070	0.0018

The coal consumption of Shandong Province was fluctuating between 1995 and 2000. The growth rate became lower. Energy consumption increased rapidly from 2001 to 2007. The energy consumption per unit of GDP decreases rapidly from 1.5741 in 1995 to 0.9431 (ton/million) in 2007. The energy efficiency increases rapidly. Sulfur dioxide and soot emissions per unit of GDP decreased year by year from 0.0468 and 0.0262 in 1995 to 0.007 and 0.0018 (ton/million) in 2007. This is related to the effort in pollution control and energy structure adjustment of Shandong Province.

2) Coal Consumption and Pollution Coefficient of Elasticity:

Pollution coefficient of elasticity means the pollution emission change caused by the change in one percent of GDP, which is the ratio between the amount of annual growth of pollutant emissions and the rate of GDP growth. Coal consumption and pollution emission coefficient of elasticity for nearly 10 years in Shandong Province are shown in Table 4.

TABLE IV COAL CONSUMPTION AND POLLUTION EMISSION COFFICIENT OF ELASTICITY IN SHANDONG PROVINCE

Year	GDP Growth Rate (%)	Consumption Growth Rate (%)	The Growth Rate of SO2 Emission (%)	The Growth Rate of Soot Emission (%)	Coal Consumption Elasticity Coefficient	SO2 Emission Elasticity Coefficient	Soot Emission Elasticity Coefficient
1996	18.78	1.84	3.23	-8.46	0.0979	0.1721	-0.4505
1997	11.10	-1.10	3.13	-9.24	-0.0992	0.2820	-0.8326
1998	7.41	0.29	-8.50	-14.81	0.0391	-1.1476	-1.9998
1999	6.73	-1.22	-19.03	-22.83	-0.1814	-2.8274	-3.3920
2000	11.26	-4.98	-1.64	-5.63	-0.4424	-0.1456	-0.5004
2001	10.29	21.15	-4.44	-2.99	2.0560	-0.4321	-0.2902
2002	11.75	19.92	-1.74	-4.62	1.6951	-0.1484	-0.3928
2003	17.54	18.21	8.88	0.00	1.0382	0.5059	0.0000
2004	24.37	17.34	-1.09	-16.13	0.7116	-0.0446	-0.6618
2005	23.27	34.88	9.89	19.23	1.4992	0.4251	0.8265
2006	19.23	11.69	-2.00	-6.45	0.6081	-0.1040	-0.3355
2007	17.61	9.12	-7.04	-20.17	0.5178	-0.3997	-1.1453

Coal consumption elasticity coefficient in Shandong Province is less than 1 from 1996 to 2000, indicating that the growth rate of coal consumption is less than the growth rate of the national economy. In pollution emissions, the value of SO_2 emissions coefficient of elasticity except in 1998 and 1999 is greater than 1, the rest of the years the value is less than 1, and during the nine years from 1998 to 2007 except 2003 and 2005, it is negative. It reflects the speed of the discharge of pollutants is less than the rate of development of the national economy, and it decreases year by year. Soot emissions variation of the coefficient of elasticity is similar to coefficient of elasticity of the SO_2 emissions reflecting that both are subject to be influenced by the coal consumption.

IV. CONCLUSIONS AND SUGGESTION

This thesis is based on the analysis of coal resources' situation of Shandong Province, applying the method of grey correlative analysis to research the relationship between coal consumption and economic growth (Urbanization Level, industry structure, GDP) and

environment (including SO2 emissions and soot volume), drawing the following conclusions:

(1) The level of industrialization and urbanization is the significant factor affecting coal consumption. One more percent of urbanization level in Shandong province will add 4.8% of coal consumption. Until 2004 year, demand of coal begun to exceed supply rather than oversupply in 2000 year. From 2004 to 2007, the annual rate of coal insufficiency rose to nearly 35%.

(2) Both coal consumption and consumption intensity have higher correlation degree with secondary and tertiary industries, especially the secondary industry. Industry restructuring has great influence to coal consumption and consumption intensity. Industrial structure draws a distinct influence on demand structure of coal resources and demands. The proportion of coal consumption industry in national economy also directly affects the demand intensity and variety.

(3) The relationship between economic growth and coal consumption growth of Shandong province is relatively stable. Ten thousand GDP has experienced a process from ascent to descent. From 2000 to 2003, it was slowly increasing of coal consumption of ten thousand GDP. From 2004, it decreased fast. The coal utilization efficiency almost rose up one-third.

(4) The relationship between Coal consumption and air pollutants emissions per unit of GDP was negatively correlated. From 1995 to 2007 years, the coal consumption has increased year by year and SO_2 emissions and soot volume of the unit GDP decreased year by year. This is due to the government of Shandong province's effort to make the pollution control and energy structure adjustment and so on. Elasticity coefficient of coal consumption, SO_2 emission and soot emission fluctuate largely.

(5) Take relative policies and measures to ease the contradiction of coal resources in Shandong province. On the current natural endowment condition of coal resources, we should combine urbanization, industrialization and development trend in Shandong province together and make arrangement and layout of resources exploration and utilization. Under the province's industrial structure, coal resources consumption among industries should be scientifically matched and arranged, with an emphasis on increased resource utilization efficiency, in order to greatly develop the tertiary industry, optimize the internal structure of the secondary industry, develop high-tech industries of low energy consumption and relieve pressure on the demand for energy.

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