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Changes in Energy Consumption Based on Empirical Analysis of Econometric Models

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Abstract: Energy is the material basis of social production activities and plays an extremely important role in the development of society. Because the energy industry, as a basic industry, on the one hand provides raw materials for other production sectors, on the other hand, the development of the energy industry also occupies a large proportion in the development of the entire social economy. This paper takes petroleum energy consumption in K province as an example, selects variables such as GDP, permanent population, the proportion of tertiary industry, energy price index and other variables to establish a general econometric model, and analyzes the changes in energy consumption of three cities M, N and O in this province by these variables. The empirical analysis results show that, at a significant level of 5%, the level of economic development has a significant impact on the oil consumption in N and Q cities, and for each additional unit of regional GDP, oil consumption in N city increases by 1.97%, and O city increases by 3.16%. ; The population factor has a significant impact on the oil consumption in O city, and for each additional unit of population, the oil consumption in N city decreases by 11.34%; the industrial structure change has a significant impact on the oil consumption in N city and O city, and every increase in the proportion of the tertiary industry One unit, the oil consumption of N and O cities increased by 8.93% and 5.72%; and the energy price index had no significant effect on the oil consumption of each city.

1. Introduction

The development of the energy industry is like a double-edged sword. If the energy industry develops well, it can promote economic development. If its development cannot meet the requirements of national economic growth, it will become a factor that hinders the rapid development of society and economy. To ensure the rapid and stable development of a social

economy, it is necessary to put forward higher requirements for the development of the energy industry, and at the same time, it will also promote the increase of energy consumption to a certain extent.

At present, there have been many corresponding studies on the changes of energy consumption based on the empirical analysis of econometric models. For example, a scholar used the time series analysis method to study and obtained that the difference in household structure will have a significant impact on household gasoline consumption [1]. Later, with the continuous innovation and application of statistical methods, represented by the research results of Pedron, it can effectively solve the limitation of insufficient samples in time series cointegration analysis, and the panel cointegration method is more and more applied to this field [2]. Some researchers have established a CGE model to study the rebound effect of energy efficiency on energy consumption in a certain city. The results show that due to the improvement of technical level, the rebound effect of energy consumption in this city has decreased year by year, which has generally played a role in saving resources [3]. A western country attaches great importance to the strategic system of energy development and related energy extraction methods, and uses overseas investment funds as an effective marketing method to promote the development of its own energy. Commodities occupy a very large proportion [4-5]. Although there are many empirical studies on changes in energy consumption, the application of econometric models is not mature enough.

This paper first expounds the theory of energy consumption, then analyzes the current situation of energy consumption in K province, and then establishes an econometric model that affects the changes in energy consumption in the three cities of K province. The influence of consumption changes, and finally put forward the optimization of industrial structure, the development of new energy and other energy consumption policies.

2. Related Theories

Energy Economics Theory: In recent years, the world oil prices have fluctuated significantly. For example, after several years of rapid growth, oil prices have begun to fall sharply. The abnormal fluctuations in oil prices have had a certain impact on the macroeconomics of various countries [6]]. Energy shortage will not be able to meet the needs of economic development, and excessive energy supply will lead to excess capacity and waste of resources. Energy economics is a science that has evolved in order to coordinate people's lives and economic development. It studies the allocation of energy. Under the condition of reasonable and balanced energy allocation, the relationship between supply and demand of energy consumption can promote sustainable economic growth , and economic development will not cause any bottleneck in energy consumption [7-8].

Low-carbon city theory: Based on my country's national conditions, that is, my country is still in the stage of accelerated urbanization, and people's quality of life needs to be improved. On the one hand, efforts should be made to reduce the carbon emissions of urban social activities, and on the other hand, people's living standards should be continuously improved, and the quality of life should not be affected by the reduction of carbon emissions [9]. Second, the decoupling between the increase and decrease of carbon emissions and the speed of economic development. To realize the development of low-carbon cities in my country, we should consider the current national conditions according to local conditions. We should not adopt the same development method as cities in developed countries with the goal of reducing total carbon emissions. We should first reduce the carbon emission intensity of social and economic activities in cities. The growth rate of carbon emissions is lower than that of urban economic growth [10-11].

3. Overview of Energy Consumption in K Province

With the rapid growth of China's economy, the supply and demand of energy in K province has grown rapidly in recent years. The total consumption has jumped to the forefront of the country, but the per capita energy consumption is very low. From the perspective of energy utilization efficiency, the energy utilization efficiency of K province is generally at the middle level in the country, which is mainly related to the primary energy structure dominated by coal in K province, and also related to the level of industrial equipment in K province [12].

3.1. Level of Energy Consumption

Table 1. Total energy consumption in Province K (10,000 tons of standard coal)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	3826	4753	5128	5439	7416	8358	8672	9527	10695	12136	12750

From the data trends in Table 1, it can be seen that in the 10 years from 2010 to 2020, the total energy consumption of K province increased from 38.26 million tons of standard coal in 2010 to 127.5 million tons of standard coal in 2020. 2.33 times, this is the beginning of industrial construction in K province in the past 10 years. Since 2010, energy consumption in K province has entered a period of rapid growth, that is, a period of rapid development of industrialization and urbanization, so the total energy consumption of our province has also risen.

3.2. Structure of Energy Consumption

While the energy consumption level in K province is rising, the structure of energy consumption is also changing gradually, as shown in Table 2. From the data in the table, we can see that province K is dominated by coal consumption. In 2020, the coal consumption in K province will reach 81.36%, and the total consumption of oil, natural gas, hydropower and other energy sources will be around 12%, which shows the drawbacks of K province energy consumption, which is excessively dependent on coal with low utilization efficiency. Non-renewable energy will bring a lot of hidden dangers to future economic development.

Table 2. Composition of energy consumption structure in K province (%)

	Coal	Oil	Natural gas	Hydropower
2010	63.82	24.53	0.63	0.87
2011	64.75	23.61	0.52	1.12
2012	65.23	21.83	0.46	0.96
2013	65.94	21.04	0.57	0.73
2014	73.16	18.67	0.43	0.64
2015	74.34	17.62	0.36	0.42
2016	75.68	14.15	0.31	0.57
2017	77.49	13.38	0.27	0.82
2018	78.57	11.52	0.26	1.24
2019	79.08	9.84	0.45	1.08
2020	81.36	9.37	0.34	0.96

3.3. Elasticity Coefficient of Energy Consumption

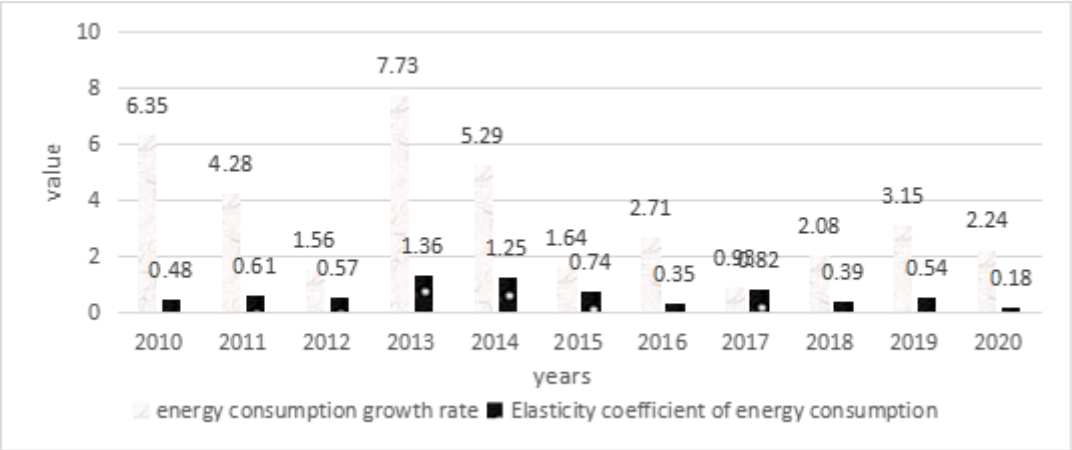

Figure 1. K province energy consumption elasticity coefficient

Figure 1 shows the elasticity coefficient of energy consumption in K province from 2010 to 2020. Except in 2013 and 2014, the energy consumption elasticity coefficient of K province is less than 1. This shows that since 2013, K province has maintained a relatively stable economic growth while its energy consumption has also increased year by year. The elastic coefficients of energy consumption in K province in 2013 and 2014 were 1.36 and 1.25, respectively, and both were greater than 1, indicating that the economy of K province maintained a trend of increasing economic growth year by year during this period, and energy consumption continued to grow substantially. , and the level of growth is greater than the level of economic growth created.

3.4. Changes in Energy Production and Consumption

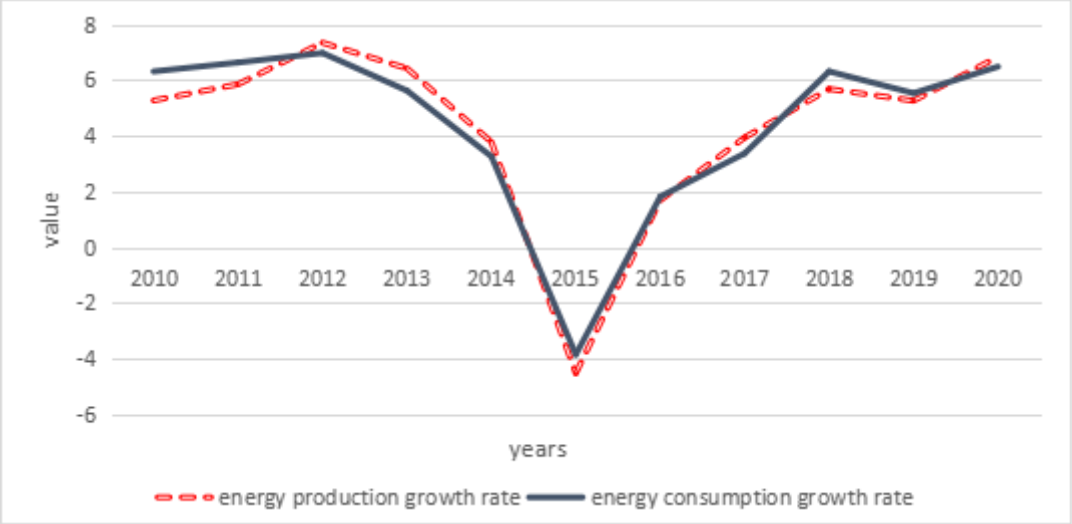

Figure 2. Changes in the growth rate of energy production and consumption in K province

As can be seen in Figure 2, the growth of energy production and consumption in Province K basically keep pace with the development level. In 2015, with the growth rate of energy production

falling to -4.51%, the growth of energy consumption also showed a negative growth phenomenon.

4. Empirical Analysis of Econometric Models Affecting Changes in Energy Consumption in Province K

4.1. Selection of Variables and Data Sources

The influencing factors of energy consumption changes selected in this paper are gross regional product (GDP), permanent population (P), the proportion of tertiary industry (TS), and energy price index (PI). Then, the above-mentioned data from 2010 to 2020 in the three cities of M, N, and O are selected from the statistical yearbook of K province as the influencing variables.

There are various forms of econometric models. This paper adopts a panel data model, which mainly relies on regression testing to make judgments. According to whether the econometric model has autocorrelation or heterogeneity, the models can be divided into four types. These four models can analyze both cross-sectional data and panel data [13-14]. The general form of the model is as follows:

$$y = \rho W_y + X\alpha + WX\beta + \theta \tag{1}$$

$$\theta = \eta W_2 \theta + \mu \tag{2}$$

Among them, α is the coefficient vector of X, ρ is the coefficient of the spatial lag variable W_y, η is the coefficient of the spatial autoregressive structure $W_2\theta$ of the random disturbance term θ, θ is the random error vector, and μ is the random error term that obeys the normal distribution.

4.2. Econometric Model Results

The least squares regression was performed on the model on Eviews7.0 software, and the model estimation results are shown in Table 1 below. (Note: ***, **, * indicate significant at the 1%, 5%, and 10% levels, respectively)

Table 3. Estimation results of petroleum energy consumption measurement model

	LNOIL_M		LNOIL_N		LNOIL_O	
	Regression coefficients	t-statistic	Regression coefficients	t-statistic	Regression coefficients	t-statistic
LNGDP	2.53	(6.283)*	1.97	(7.514)***	3.16	(14.768)***
LNP	1.26	(1.362)	0.05	(0.087)	-11.34	(5.841)***
TS	-1.07	(2.761)	8.93	(5.645)***	5.72	(10.538)***
PI	0.32	(5.427)	0.43	(0.715)*	0.19	(3.246)
C	-3.809		(-6.917)***			
R^2	0.9713					
Adjustment R^2	0.9348					
F statistic	241.35					

It can be seen from the model estimation results in Table 3 that at the 5% significance level, the influence coefficient of economic development level on oil consumption in N and Q passes the significance test, and the influence on M oil consumption is not significant. Among them, for every 1 unit increase in regional GDP, oil consumption in N city increased by 1.97%, and oil consumption in O city increased by 3.16%. With the development of the Internet and the logistics industry, the oil consumption of the transportation industry continues to grow, and its contribution to economic development is getting higher and higher. The influence coefficient of economic development level on oil consumption in O city is greater than that in N city. This is because fossil energy is the main energy source in City O. There are many large energy-consuming enterprises in City O, and economic development is more dependent on the consumption of fossil energy such as petroleum.

At the 5% significance level, the influence coefficient of the population factor only on the oil consumption of the O city passed the significance test, and the influence coefficient of the oil consumption of the M and N cities did not pass the significance test, this is because the M and N cities did not pass the significance test. The urbanization level of the city is higher than that of city O. It can be seen from the influence coefficient that the resident population of O city and the consumption of oil show an inverse relationship. This is partly because the increase in the population of O City is mainly due to changes in the urban population, and urban residents choose public transportation for travel and other activities, thus reducing the consumption of oil.

At the 5% significance level, the influence coefficient of the change of industrial structure on the oil consumption of N city and O city passed the significance test, and the influence on the oil consumption of M city was not significant. It can be seen from the influence coefficient that for every 1% increase in the proportion of the tertiary industry structure, the oil consumption in N city increases by 8.93%, and the oil consumption in Hebei Province increases by 5.72%. Until this year, the proportion of the tertiary industry structure in N city and O city was 47.6% and 35.8% respectively. The tertiary industry structure of the two places still has a lot of room for development. Therefore, the change of the tertiary industry structure will affect the oil consumption. relatively large impact. In M city, the tertiary industry structure accounts for 69.3%, the structure proportion is relatively high, and the development tends to be mature. Therefore, changes in the tertiary industry structure have little impact on oil consumption.

The energy price index has no significant impact on the changes of oil consumption in the three cities.

4.3. Energy Consumption Policy

(1) Restrict the development of high energy-consuming industries and optimize the industrial structure

The imbalance between heavy industry and light industry in the industrial structure is not only unfavorable to the optimization and adjustment of energy consumption structure, but also forces economic growth to be at the expense of high energy consumption and high pollution [15].

In the process of accelerating industrialization, it is necessary to reduce the resource cost and environmental cost in the process of economic development according to the actual situation of industrial structure, energy structure and economic development. The development of heavy industries such as non-ferrous metals and chemical industry in the short term can rapidly promote the growth of GDP, but it is based on environmental pollution and a large amount of energy consumption. This extensive economic development model will inevitably lead to long-term economic development. have negative effects [16]. In response to this imbalance of industrial

structure and consumption structure, we should limit the development of high-energy-consuming industries, optimize the industrial structure, pay more attention to the development of light industry, and adjust the proportion of light and heavy industries in the industrial structure, which can not only give full play to the advantages of heavy industry but also It can give full play to the advantages of light industry, maximize the economic utility and environmental utility of both, and realize low energy consumption and high added value of industrial products, thereby improving the quality of GDP growth [17].

(2) Increase the development of new energy

Through the promotion of new energy and the extensive use of renewable energy, the diversification of energy consumption structure can be promoted, the energy consumption per unit of GDP can be effectively reduced, the problem of environmental pollution can be alleviated, and the healthy and sustainable development of energy, economy, society and environment can be promoted [18].

(3) Scientific and technological innovation

Technological innovation plays a vital role in the optimization and adjustment of the energy structure and the improvement of the level of the energy industry, and can effectively change the problems of low energy utilization efficiency, low industrial level, low product added value and environmental pollution in the past. With the development of economy and society, the total energy consumption has been greatly improved compared with the past. In order to increase the output value while minimizing energy consumption and environmental pollution, we all need capital, technology, management, talents and In terms of policies, enterprises are supported to encourage and help enterprises to use new technologies, purchase new equipment, and introduce advanced talents in the production process [19]. Technology research and development institutions such as energy technology research laboratories can be established, combined with economic and social conditions and natural resource conditions, actively carry out scientific and technological innovation and rapidly promote good technologies, and improve the development of coal, oil, natural gas, electricity and new energy from various aspects. technology level, thereby improving the level of energy utilization and increasing the quality of economic growth [20].

5. Conclusion

This paper empirically analyzes the changes in petroleum energy consumption in three cities in K province through an econometric model, and finds that each additional unit of GDP, population, and industrial structure in the province has a change coefficient or direction of change in urban petroleum energy consumption. All in all, to make the urban economy sustainable, it is necessary to adjust the industrial structure according to its industrial development, and to develop new energy through scientific and technological innovation, so as to realize the green energy economy.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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