International Journal of Intelligent Information and Management Science
ISSN: 2307-0692, Volume 9, Issue 2, April, 2020

Multivariate Linear Analysis of Energy Consumption in Anhui Province

Xiaoyu Zhu[1*], Ling Shi[2], Lei Yu[3]
[1]Institute of International Economics and Trade, Anhui University of Finance and Economics, Bengbu, 233030, China
[2]Institute of Finance, Anhui University of Finance and Economics, Bengbu, 233030, China
[3]Institute of Preschool Education, Jiangsu Second Normal University, Nanjing, 210000, China

Abstract: Energy is an essential factor for modern economic and social development and daily lives of people. Establishing a regression model of energy consumption is of great significance for predicting future energy consumption, formulating energy supply plans, and saving and efficient use of energy in Anhui Province. This study used the data of Anhui Province from 2000 to 2018 to sort out a multivariate regression model using eviews software; and it is regression tested according to related theories to make it have a higher degree of fit and practicability. Research results: Among the energy consumption in Anhui Province, the three indicators of the province's GDP, population number of household registration, and coal consumption have the greatest impact on them. It also proposed that Anhui Province should actively make energy strategic plans, carry out scientific and technological innovation, and develop new energy in the future energy utilization, in order to provide some policy ideas for the study of energy consumption in Anhui Province.

Keywords: Energy consumption; Stepwise regression model; Test of regression model; Eviews

1. Introduction

Energy is a resource that can provide energy. Energy usually refers to a variety of resources that can be obtained directly or through processing and conversion, including coal, oil, natural gas, and so on. Energy is an important material foundation for economic growth stably and social development sustainably of China, and is the lifeblood of the national economy. On the one hand, energy resources are the main driving force of China's economic growth. Economic development requires more energy to support it, and energy shortages will further restrict economic development of China. On the other hand, economic growth in turn will affect energy consumption. Nowadays, the global economy is developing at a high speed, and energy and resource security has risen to the national level. All countries have formulated energy policies with energy supply security as the core. This study addresses the issue of energy consumption in Anhui Province. First, the relevant influencing factors are analyzed theoretically, and then a set of prediction models that fit the energy consumption is constructed based on the stepwise regression method and its test. It is of great guiding significance for the formulation of the energy planning strategy of Anhui Province.

2. Theoretical Analysis of Influencing Factors of Energy Consumption

From the historical process of human society, energy has a decisive role in human social development. This is specifically reflected in the fact that energy can not only promote the development of social productive forces, but also promote the expansion of the economic scale. It is an indispensable material foundation for improving the living standards of a country's people. There are many factors influencing energy consumption, but according to previous research, it is mainly the regional economic level. The demand of energy for economic growth and the role of energy for economic growth are usually the strongest when the energy supply cannot meet the demand [1]. Combining many domestic and foreign experts and scholars with a large number of research results, this study selects four major factors: GDP, population number of household registration, total output value of industry and coal consumption [2].

2.1. GDP

For the causal relationship between GDP and energy consumption, experts and scholars at home and abroad have made a quantitative study. Abroad, two scholars, Kraft J and Kraft A, discovered for the first time in 1978 about economic research on energy that there is a one-way causal relationship between GDP of USA and energy consumption, that is, GDP can promote energy consumption. Although many scholars have different opinions about the research conclusions of Kraft J and Kraft A, the research on the causal relationship between energy consumption and GDP has been extended to Britain, Germany, Canada, Japan and other countries. With the acceleration of urbanization and industrialization, China's energy consumption has increased rapidly. The contradiction between the constraints of resources and the envi-

ronment and the rapid economic growth is intensifying, which has become a severe challenge for China's economic and social development. Domestically, Han Zhiyong, Wei Yiming and other people selected data from 1978-2000 to analyze the co-integration and causality of China's energy consumption and economic growth. They also concluded that there is a two-way causal relationship between China's energy consumption and economic growth, that is, energy consumption promotes economic growth, which in turn increases energy consumption [3]. Therefore, this study selects GDP as an important influencing factor for the energy consumption in Anhui Province.

2.2. Population number of household registration

The population of household registration refers to people that have registered their permanent residence at the public security household registration management office of their place of permanent residence in accordance with the Regulations of the People's Republic of China on Household Registration. The possession of energy resources is a necessity for the progress of human society and the people's production and life. Because the absolute amount of energy savings and output in China is large, but the large population base leads to a small per capita possession, with the large-scale increase in population and the rapid development of industrial modernization, China's energy is becoming increasingly tight. Especially since the 21st century, the smooth implementation of China's urbanization strategy has led to a rapid and large-scale increase in population number of household registration in various regions [4]. And with the advancement of urbanization and the increase in the population number of household registration, energy consumption of China is also increasing, and energy resources are becoming increasingly scarce. For Anhui Province, the increase in population number of household registration brought by rapid urbanization has become another important factor affecting energy consumption.

2.3. Total output value of industry

Anhui Province is currently transforming into a strong industrial province and is in a transition period. However, according to statistics from relevant departments, our province is currently in serious shortage of energy resources. High energy-consuming and high-emission industries such as steel, nonferrous metals, and building materials account for a large proportion, which has become a bottleneck restricting the sustainable economic development of Anhui Province, which has seriously affected the transformation of our province. In addition, most domestic experts and scholars mainly study the relationship between GDP and energy consumption, ignoring the characteristics of different industries with different energy consumption structures and technological levels. Based on this, for the energy consumption in Anhui Province, in addition to some common influencing factors, the total output value of industry is selected as another important influencing factor. Research and analyze the annual data of Anhui Province's total industrial output value from 2000 to 2018 as a sample to analyze the relationship between the province's energy consumption and the growth of total output value of industrial. This is of great significance for promoting the sustainable development of industrial economy and society in Anhui Province.

2.4. Coal consumption

Coalis the main energy source of China. According to the statistics from relevant departments, the total natural resources of China are the seventh in the world and the total energy resources are the third in the world. The proportion of coal in China is about 70%; and the proportion of natural gas, oil, electricity and other energy sources in China accounts for about 30%. Compared with the other countries in the world, China has maintained its position as the largest coal producer and consumer of the world for many years. The production and consumption of coal has played an important role in China's social and economic development. In 2008, China's total coal production accounted for 42.5% of the world's total coal consumption and total coal consumption accounted for 42.6% of the world's total. And with the social and economic development and the acceleration of infrastructure construction, China's industrial production of coal has increased rapidly, and national consumption demand has increased significantly. Anhui Province is also rich in coal resources of the "Two Huai Rivers" and is an important energy export place in East China. Such good innate conditions determine the structural dependence of Anhui Province on coal in terms of energy consumption. Therefore, this study believes that coal consumption has a certain impact on Anhui's energy consumption.

3. Establishment of Stepwise Regression Model

After the above analysis of influencing factors on energy consumption. The study selected 4 influencing factors of GDP, population number of household registration, total output value of industry and coal consumption as explanatory variables, and total energy consumption as explained variables. An empirical analysis was made on the energy consumption of Anhui Province. Variables and their explainations of symbols are in Table 1.The data collected by the Institute from 2000 to 2018 in Anhui Province mainly comes from the Anhui Statistical Yearbook, the China Energy Statistical Yearbook and so on. At the same time, in order to make certain data comparable and operable, some data are averaged, summed and calculated in this study.

Table 1. Variables and their explainations of symbols

Symbol	Variable name	Symbol	Variable name
Y	Coal consumption (10,000 tons of standard coal)	X_3	Total output value of industry(100 million yuan)
X_1	GDP(100 million yuan)	X_4	Coal consumption(10,000 tons)
X_2	Population number of household registration(ten thousand people)	-	-

According to the above variables, a linear regression model between the energy consumption of Anhui Province and each influencing factor is as follows:

$$Y_A = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + m$$

Where b_0 is a constant; and b_1, b_2, b_3, b_4 is a regression coefficient; is a random perturbation term, which has nothing to do with the explanatory variable and the explained variable [5].

3.1. Correlation analysis

In order to explore the correlation between the variables, the research uses Eviews software to do a correlation analysis between the selected explanatory variables and 6 explanatory variables. According to the output results of software, the correlation coefficients between total energy consumption Y and GDP X_1, population number of household registration X_2, total output value of industry X_3, and coal consumption X_4 are 0.985, 0.976, 0.976, and 0.990, respectively. There is a strong correlation between explanatory variables and explained variables. At the same time, it can be seen from the output correlation coefficient that there is also a high correlation between the six explanatory variables. For example, the correlation coefficients between the three influencing factors of GDP X_1 and population number of household registration X_2, total output value of industry X_3, and coal consumption X_4 are all above 0.9, which indicates that there must be multiple collinearity between variables.

3.2. Inspection and correction of model

3.2.1. Goodness-of-fit test and equation significance test

Based on the collected data of Anhui Province from 2000 to 2018, the study uses Eviews to perform the least squares regression and obtain the regression results. Among them, the value of the determinable coefficient R^2 is 0.9982, and the value of the determinable coefficient $\bar{R}^2$ after correction is 0.9976, both of which are very close to 1, indicating that the model has a high explanatory power for the explanatory variables and goodness of fit is good; the value of the F statistic is 1638.268, its Sig value is very close to 0, and its value of significance level is 0.05, which shows that the four explanatory variables have a strong ability to explain the model together, and passed the significance test of the equation.

3.2.2. Parametric significance test

The study uses Eviews to perform simple univariate linear regression on the total energy consumption and four explanatory variables, and summarizes the results output by Eviews. Finally, a table of parameter significance test is obtained, as shown in Table 2.

Table 2. The table of parameter significance test

Explanatory variables	X_1	X_2	X_3	X_4
b	0.3710	10.7961	0.1789	0.7321
$\lvert t \rvert$	22.3448	17.4942	17.4137	27.7423
$\bar{R}^2$	0.9708	0.9533	0.9529	0.9809

According to the analysis of the results in the above table, it can be known that the $|t|$ of GDP X_1, population number of household registration X_2, total output value of industry X_3, and coal consumption X_4 are much larger than their critical values, which indicates that they have passed the parameter significance test.

3.2.3. Correction of multiple collinearity

Here, Eviews software is used to perform manual stepwise regression correctionon the regression equation. The correction process is as follows:

First, perform simple linear regression on the four explanatory variables selected, and the regression results are shown in Table 2; according to the principle of selecting the optimal explanatory variable (whether it is economically meaningful; whether the determination coefficient is higher than the original one; whether the equation is significant; whether the parameter is significant), a optimal explanatory variable X_i is selected as the basis. According to Table 2, all explanatory variables have passed the parameter significance test, and they all conform to the principle of optimal explanatory variables.

Because coal consumption has the highest determinable coefficient, which is 0.9809, coal consumption X_4 is selected as the first explanatory variable, and other explanatory variables are sequentially added for the first regression, and the results are obtained.

Then, based on the results of the first regression, on the basis of X_4, the parameter significance test of the explanatory variables X_2 failed, and the principle of optimal explanatory variables was not satisfied. Although the remaining explanatory variables are in line with the principle of optimal explanatory variables, the highest determination coefficient of X_1 is 0.9949. Therefore, we choose GDP as the second explanatory variable, and sequentially add other explanatory variables for the second regression, and get the results.

Then, based on the results of the second regression, it was found that on the basis of X_4 and X_1, the coefficient of the total output value of industry X_3 was negative, which did not meet the economic significance and was contrary to the actual situation. While explanatory variable X_2 failed the parameter significance test, its $|t|$ is very close to the critical value (p value is very close to 0.05 and not more than 0.1). And this explanatory variable has a very large impact on total energy consumption. Therefore, the explanatory variable of population number of household registration X_2 is retained as the third explanatory variable.

Finally, through the above-mentioned series of amendments and analysis, it is finally determined that the regression model has three explanatory variables: coal consumption X_4, GDP X_1, and population number of household registration X_2.

3.2.4. Heteroscedasticity test

The study uses the White test in Eviews to test for the presence of heteroscedasticity, and the cross product term is checked during the test. According to the test results, the White test statistic was found to be 10.9950, and the corresponding P was 0.2020.This means accepting the null hypothesis that the model does not have heteroscedasticity.

3.3. Stepwise regression equation

After correlation analysis, a series of tests, and correction of multiple collinearity, Eviews was used to perform the least squares regression and the regression result was obtained, as shown in Figure 1.

From this, the regression equation of total energy consumption in Anhui Province is finally obtained:

$$Y = -18277.83 + 0.1454X_4 + 0.1905X_1 + 3.4539X_2$$

Among them, represents the total energy consumption (10,000 tons of standard coal) of Anhui Province in that year, X_1 represents the GDP of Anhui Province in that year (100 million yuan), X_2 represents the population number of household registration in Anhui Province (10,000 people), and X_4 represents the coal consumption in Anhui Province.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-18277.83	4701.401	-3.887740	0.0019
X4	0.145402	0.071237	2.041102	0.0621
X1	0.190471	0.017235	11.05109	0.0000
X2	3.453907	0.799749	4.318739	0.0008

R-squared	0.998165	Mean dependent var	8536.892
Adjusted R-squared	0.997742	S.D. dependent var	2760.317
S.E. of regression	131.1857	Akaike info criterion	12.79312
Sum squared resid	223657.8	Schwarz criterion	12.98917
Log likelihood	-104.7416	Hannan-Quinn criter.	12.81261
F-statistic	2357.644	Durbin-Watson stat	1.489762
Prob(F-statistic)	0.000000		

Figure 1. Result of the least squares regression

Moreover, from the above regression model, under the condition that other conditions remain unchanged, for each unit of GDP increase in Anhui Province, an additional 0.1905 units of standard coal will be consumed accordingly. In the same way, with other conditions unchanged, every additional unit of population number of household registration in Anhui Province will consume an additional 3.4539 units of standard coal. For every 1 unit increase in coal consumption in Anhui Province, the total energy consumption will increase by 0.1454 units.

4. Analysis Conclusion and Policy Suggestion

4.1. Analysis conclusion

Through the above series of tests and corrections, the regression equation of total energy consumption in Anhui Province is finally obtained:

$$Y = -18277.83 + 0.1454X_4 + 0.1905X_1 + 3.4539X_2$$

From this, we find that the coefficient of the population number of household registration is the largest, so the impact on the total energy consumption is also the largest. The coefficient of coal consumption is the smallest, and it has the smallest impact on the total energy consumption of Anhui Province. This indicates to a certain extent that Anhui's coal energy utilization rate is low, the more coal is used, the more other resources need to be consumed to make up. The reason why the total output value of industry was excluded may be that the industrial energy consumption in Anhui Province is not high.

4.2. Policy suggestion

4.2.1. Optimize energy consumption structure and develop new clean energy

From the above analysis, we can see that coal consumption has a certain impact on the energy consumption of Anhui Province. Therefore, in order to promote the sus-

tainable development of the industrial economy in Anhui Province, the relevant provincial government departments should take a series of measures to make a strategic plan for energy. For example, we can implement a diversified energy consumption structure strategy, optimize the energy consumption structure, and make our province's energy use consistent with the industrial development strategy; can effectively use rural renewable energy, which not only solves the energy gap problem in our province, but also eases the environmental pollution situation; can also introduce corresponding industrial, technological, and economic policies to effectively promote the diversification of energy imports; can actively carry out scientific and technological innovation and develop new clean energy. In addition, clean coal technology can be vigorously developed, and technical means can be used to effectively solve the problem of resource shortage and environmental pollution caused by the large use of coal. In this way, a diversified and clean energy structure can be formed in the medium and long term, which can promote the healthy development of Anhui's industrial economy [6].

4.2.2. Integrate relevant policy systems and control the population growth rate

The population number of household registration has the greatest impact on the energy consumption of our province, and there are many reasons for the increase in the population number of household registration. In this regard, the provincial government needs to further integrate, perfect and improve the relevant policy system in order to control the increase in the population number of household registration; 0pppewssddddddddevarious control measures can be taken to effectively reduce the population increase and alleviate the severe situation of rapid growth of energy demand in our province. In addition, the energy authority in Anhui Province should also adopt a variety of policy measures such as total amount control, classified guidance, price control and energy-saving technological transformation, strengthen the development of new energy and improve the efficiency of energy use to effectively curb the problem of excessive growth of energy consumption demand.

4.2.3. Coordinate the relationship between economy and energy to promote sound and rapid economic development

There is also a quantitative relationship between GDP and energy consumption. It is necessary to coordinate the relationship between energy consumption and economic development. For example, in the future energy use, the provincial government of Anhui must handle the relationship between rural economic development and industrialization process, set scientifically and steadily the goal of reducing emissions, formulate low-carbon development policies, and change the way of economic development. This can achieve good and fast economic development in the province while ensuring people's daily lives. It is also necessary to adjust the relationship between energy consumption structure and ecological protection, expand energy supply channels, control total energy consumption, control greenhouse gas emissions and further support renewable energy.

4.2.4. Adjust the industrial structure and promote the development of the tertiary industry

In the above analysis, the total output value of industry did not pass the regression test and was eventually rejected. However, from the perspective of statistical indicators, the total output value of industry has a significant correlation with the province's energy consumption through significant tests and correlation analysis. Judging from the actual situation, the economic structure of Anhui Province is unreasonable, especially the tertiary industry is still in the development stage, and industrial development requires a large proportion of energy. Therefore, the provincial government must increase its efforts to adjust the industrial structure and vigorously develop industries with low energy consumption and high added value; for the development of the tertiary industry, incentive policies can be adopted to adjust the proportion of the tertiary industry in all industries; for the development of heavy industry, it is necessary to control the total volume, adopt technological advancement, and adopt high-tech transformation to change the industrial structure and reduce the energy consumption while creating economic value.

References

[1] Lu X.H. Multiple linear regression analysis of energy consumption in China. Technology Economy Market, 2011, (06), 45-47.

[2] Liang H. Research on Energy Consumption of Industrial Enterprises in China. Master Degree Thesis of Jiangsu University, 2009.

[3] Qu X.E., Yuan X.L. Grey correlation analysis of China's energy consumption and economic growth. Statistics and Decision, 2008, (14), 86-88.

[4] Song C.S., Ma J.J., Yang F. A study on the coupling of urbanization and resource environment system—taking Xi'an as an example. Resources and Environment in Arid Areas。 2010, 24(05), 85-90.

[5] Sun J.S., Ma S.Q. Econometrics fourth edition. Tsinghua University Press. 2018.

[6] Wang H.G., Shen L.S. Research on the relationship between China's economic growth and energy consumption——an empirical test based on panel data of 30 Provinces and cities in China. Statistics and Decision. 2008, (03), 125-128.