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Research on Influencing Factors of Electricity Consumption in China Based on Grey Theory and Big Data Technology

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Abstract. With the development and application of computer theory, electronic information technology, economics and other disciplines, more and more models are being used to discuss electricity consumption factors. Thesis based on actual data of China, this paper discusses the influence of economic growth, electricity price, urbanization level, industrial structure, science and technology investment level and opening degree on electric power consumption level of our country, and analyses the influence of grey correlation analysis method. To drive electricity consumption, the first is to optimize and upgrade the industrial structure, and the second is to further improve the level of urbanization. The research results of this paper have certain reference value for relevant managers and government departments to formulate policies.

Keywords: grey relational analysis; electricity consumption; factors influencing consumption; grey relative coefficient; big data technology.

1. Introduction

Economic growth and energy consumption have always been the focus of social attention. In recent years, with the overall rise and rapid development of the national economy, economy has maintained a good momentum of development, and electricity has become the lifeblood of a country 's development, the impact on economic development has become increasingly prominent. As the leading industry of state governance, the supply situation of electric power industry needs to be closely and carefully monitored. Control errors will not only cause the loss of electric power enterprises, but also disrupt the national electricity order, and then cause serious social impact and losses. Therefore, it is of great significance to effectively adjust power and realize power informatization to provide reference for government decision makers to carry out macro-control and control of power demand in China.

Since the reform and opening up, economy has developed rapidly in China, and the demand for electricity in various industries has increased, and the growth rate is roughly the same as the economic growth rate. It is undeniable that the driving effect of economic development on electricity consumption is obvious. However, with the development and wide application of econometrics, it is no longer reasonable to only include economic growth in the study of electricity consumption. Based on this, more and more factors are considered. It includes industrial structure, industrial structure, sales price, population, energy price, efficiency improvement, urbanization level and so on. Some of them even introduce indirect factors such as climate, temperature and water inflow into the research. The role and influence of the studied factors electricity consumption in China are also different. In summary, based on the previous discussion of the relationship between electricity consumption and economic growth, this paper further explores other influencing factors of electricity consumption.

2. literature review

Most of the articles that study the influencing factors of electricity consumption use a small number of research factors. Among them, most of them study economic development, industry, industrial structure or energy structure, and there is little in-depth exploration of the causes of the conclusions. On the basis of most scholars ' research, this paper analyses the electricity consumption and its influencing factors from 1983 to 2020 by introducing more influencing factors and using grey system theory to model, and makes a reasonable explanation of the results, so as to provide more reference value for scholars who do electricity consumption forecasting later.

Grey system theory is mainly aimed at the analysis of non-deterministic problems with neither experience nor data, that is, the theory of analyzing the problem of less data uncertainty, which was first proposed by Professor Deng Julong in 1982[1]. At present, grey theory covers a wide range of fields, including society, science and technology, economy, ecology and so on. The main theories of grey modelling, grey prediction [2], grey decision-making [3], grey control [4] and grey evaluation [5] have achieved unquestionable results in the study of less data uncertainty.

As an important part of grey system theory, grey relational analysis is the theoretical basis of grey system analysis, grey prediction and grey decision. The correlation of its main manifestations should also be paid enough attention to. Specifically, the degree of correlation is literally the degree of correlation between two things. Gray is between white and black, that is, the degree of correlation of gray correlation is between (0, 1), and the closer the value is to 1, the higher the degree of correlation. It is worth noting that the basic idea of grey correlation is to judge whether there is a close relationship between different sequences based on the geometric shape of sequence curves. Most scholars have put forward a variety of representative grey correlation analysis models following the grey correlation theory, including grey point correlation degree, grey slope correlation degree and grey generalized correlation degree. In this paper, the grey generalized correlation degree is used as the main analysis model to explore the relationship between electricity consumption and its influencing factors in China. This method studies the relationship between absolute or relative increments between sequences, supplemented by taking the area between the middle of the fold line corresponding to the sequence as the standard to measure the correlation between the factors represented by the sequence. It is a more comprehensive index that reflects the tightness between sequences.

3. Index Selection and Correlation Analysit

Electric power industry is a typical uncertain system with incomplete information. Grey correlation theory is suitable. Electricity consumption is the result of many factors. The main factors of electricity consumption in China, such as industrial structure, technological level, energy structure, degree of opening to the outside world, economic development level and so on, have been discussed above [6-8,10]. Referring to the previous scholars ' research results on electricity consumption and the difficulty of data acquisition [9,11], and based on the principle of starting from the actual situation in China, this paper selects the ratio of the secondary industry to the tertiary industry (industrial structure) as X1. Proportion of output value of heavy industry in industrial output value (Industrial structure of China), denoted as X2. Energy intensity, denoted X3. Urbanization level, recorded as X4. Proportion of fiscal investment in science and technology in GDP of the year (level of investment in science and technology in China), recorded as X5. Ratio of total exports to total imports (openness of China), denoted as X6. In addition, GDP, electricity prices, energy prices, and year-end population, which have been repeatedly demonstrated in previous literature, are denoted as X7, X8, X9, and X10, respectively. In summary, this paper selects the above 10 variables as the influencing factors to demonstrate electricity consumption in China, and the data used are natural logarithm processing of the original data. As shown in Fig.1.

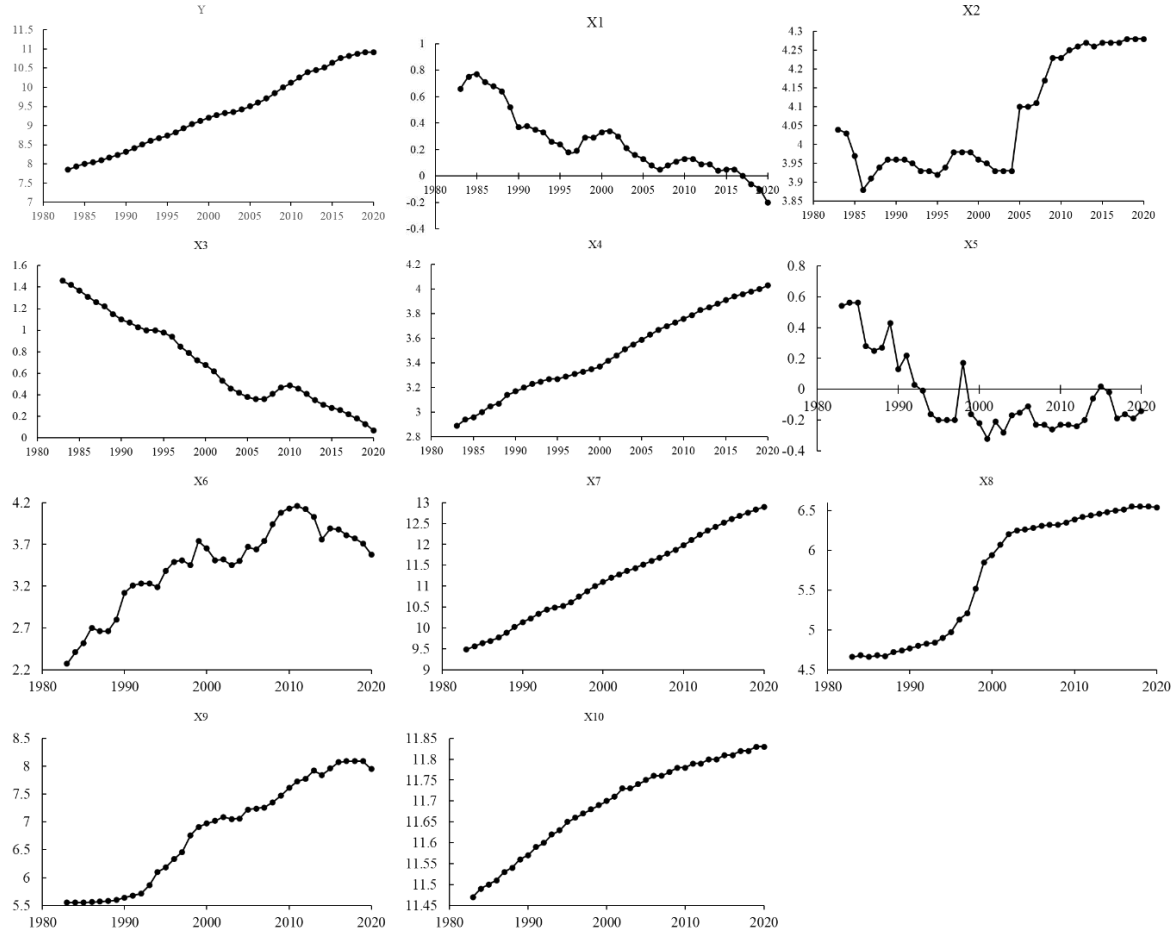

Fig. 1 Electricity Consumption and Its Influencing Factors in China from 1983 to 2020

Note: The original units of each variable are, X1, X6 dimensionless; x3 (tons of standard coal / ten thousand yuan); x2, X4, X5 units are %; x7 2000 as the base period, the unit is 100 million yuan; the value of X8 and X9 is 100 in 1953. X10 unit is ten thousand people; y units are billions of kWh; the above tables take the natural logarithm based on e. Data source: National Bureau of Statistics, China Statistical Yearbook, China Electric Power Statistical Yearbook, China Economic Network.

The modelling method of grey correlation analysis is adopted, with electricity consumption (Y) as the reference column and the above influencing factors (X1-X10) as the comparison column. Based on the grey correlation analysis of the annual statistical data (sample size is 38) from 1983 to 2020, the grey absolute correlation degree, grey relative correlation degree and grey comprehensive correlation degree between electricity consumption and its influencing factors are obtained, and sorted according to the size of grey correlation degree. As shown in Tab.1

Table 1. Grey incidence matrix 1983-2020

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Absolute correlation degree	0.6389	0.5124	0.7575	0.7008	0.6963	0.8990	0.9399	0.8545	0.9278	0.5761
Rank	⑧	⑩	⑤	⑥	⑦	③	①	④	②	⑨
Relative degree of incidence	0.6628	0.5475	0.6907	0.9662	0.5942	0.6893	0.9726	0.9246	0.9182	0.5791
Rank	⑦	⑩	⑤	②	⑧	⑥	①	③	④	⑨
Comprehensive correlation degree	0.6509	0.5300	0.7241	0.8335	0.6453	0.7942	0.9563	0.8896	0.9230	0.5776

Rank	⑦	⑩	⑥	④	⑧	⑤	①	③	②	⑨

The following paper analyses the data from the perspective of comprehensive correlation, absolute correlation and relative correlation, and compares them with comprehensive correlation as the standard. From the results of comprehensive grey correlation analysis, it can be seen that from 1983 to 2020, the influence degree of each variable on power consumption is quite different. GDP (X7) ranks first with a comprehensive correlation degree of 0.9563, followed by energy price (X9), power price (X8), urbanization level (X4), opening degree (X6), energy intensity (X3), industrial structure (X1), science and technology input level (X5), population at the end of the year (X10), and finally industrial structure (X2), with a comprehensive correlation degree of only 0.5300 ; In terms of absolute correlation degree, the absolute correlation degree between each variable and electricity consumption is similar to the ranking of comprehensive correlation degree, among which the degree of opening to the outside world (X6) has a more obvious decline ; in terms of relative correlation degree, it is generally similar to the comprehensive correlation degree of ranking, but there are some differences. Among them, the urbanization level (X4) and energy price (X9) rank change greatly. However, from the data, it can be seen that the relative correlation degree of the previous four variables is very close, so it can be considered that there is basically no change. The most obvious change is the degree of opening to the outside world (X6), and the difference of its influence degree is more than 0.2. The nuances between the correlations may be related to policies and the actual situation at that time in China.

Further analysis shows that between 1983 and 2020, GDP, energy prices and electricity prices have a higher contribution to electricity consumption. Considering the rapid development of economy during this period, the demand for electricity has soared with economic growth. It is not surprising that there is such a high grey correlation between GDP and electricity consumption. Historical experience shows that in developing countries with rapid economic development, the growth rate of electricity consumption and economic growth rate will maintain a relatively stable proportional relationship (rigid demand). China is currently in the stage of urbanization and industrialization. Economic growth and electricity consumption also have similar proportional characteristics. The proportional relationship between GDP growth and electricity consumption growth from 1985 to 2017 is basically 1:1. Although there is an asynchrony between electricity consumption and economic growth between 2018 and 2020, with the gradual development of the economic structure, the trend of economic growth and electricity consumption will once again be basically the same. To sum up, as the conclusion of this paper, GDP is the most important reason that affects electricity consumption.

Electricity consumption is mainly derived from the rapid development of the secondary industry, which is driven by energy consumption. For a long time, high-energy consumption, low efficiency mode of economic development has significantly increased the scale of energy consumption, energy consumption has also increased significantly, and thus the effect of energy prices on energy consumption is significant; in addition, in China, electricity consumption and energy consumption are synchronized, that is, energy price (X9) has a great impact on electricity consumption, and its grey comprehensive correlation degree is 0.9230.

As an economic lever to measure the degree of national economic development, electricity price is an economic lever to measure the electricity market. In addition to the greater impact on industrial production, the electricity price (X8) has a greater impact on residential electricity consumption. For industrial production, the amount of electricity price directly affects the profit margin of industrial enterprises, and the same is true for residential electricity consumption. As the daily expenditure of residents, electricity price will be more or less affected by the living budget of residents, and electricity price is the standard to measure the budget, which can explain why electricity price has a greater impact on electricity consumption.

The grey comprehensive correlation degree between urbanization level (X4) and electricity consumption is second only to GDP, energy price and electricity price, ranking fourth, and the grey

comprehensive correlation degree reaches 0.8335. Since the reform and opening up, urbanization process has accelerated under the drive of economic development, coupled with the increase in population size, the impact of urbanization on electricity consumption has become increasingly important. It is mainly reflected in the following aspects. The urbanization process will drive the growth of demand for heavy industrial products such as cement and steel. Large-scale and large-scale urban construction needs to be supported by a flexible railway transportation system. The activation of the transportation system in turn acts on the production of cement and steel [9]. The promotion of urbanization level promotes the adjustment of industrial structure, technical structure and product structure in a more reasonable direction, and the allocation of various resources is optimized. Therefore, the development of urbanization in China is inevitable.

The grey comprehensive correlation degree of the ratio of total exports to total imports (X6) is 0.7942, ranking fifth. Since 1988, the rapid economic development, opening to the outside world is also in full swing in the preparation for the development of developed coastal areas during the introduction of foreign investment, learning advanced technology, broaden the export market and foreign trade and various forms of economic and technical cooperation, and have made some achievements ; in this advantage, emerging enterprises are in full bloom, which has a certain positive impact on the increase of electricity consumption. In fact, electricity consumption has increased significantly in recent years. Coupled with the impact of joining the WTO in 2001, power industry has been substantially changed. In contrast, before entering the WTO, power trade was basically venting, the power industry lacked market competition from international trade, and lacked external competitive pressure to urgently improve power efficiency; after joining the WTO, foreign investment in power has stimulated the development of power industry to high efficiency. By introducing advanced power generation equipment and learning advanced foreign technology, power production efficiency has been improved.

The comprehensive correlation between energy intensity (X3) and electricity consumption reaches 0.7241, ranking the sixth, which also shows that the change of energy intensity has an important impact on electricity consumption. Energy intensity reflects the overall efficiency of energy economic activities. The change of energy intensity in the industrial sector is a non-negligible factor affecting the change of electricity consumption in China. Therefore, on the premise of adhering to the road of sustainable development, the primary task of improving the utilization rate of electric energy is to develop clean energy, optimize energy structure and improve energy utilization. In addition to the above factors, industrial structure (X1), the level of investment in science and technology (X5) and the grey comprehensive correlation degree of power consumption are also more than 0.6, although there is a certain gap compared with the correlation degree of the above influencing factors, but the adjustment of industrial structure makes transition from the second industry to the third industry, which has a certain negative impact on power consumption ; although the level of investment in science and technology has a greater role in promoting technological progress, to guide consumption patterns from rough to intensive forward, but electricity consumption comprehensive grey correlation degree is only 0.6453, may be the current level of science and technology is not enough to control electricity consumption ; the grey comprehensive correlation degree between population at the end of the year (X10), industrial structure (X2) and electricity consumption is less than 0.6, which may be related to the implementation of family planning policy and the too large population base in China. Due to the family planning policy, population growth rate has slowed down, and the change in data is relatively small, so the effect is not obvious in the grey test. The proportion of heavy industry in industry has been high, and the amount of data change is small. In view of its low comprehensive correlation, there is not much explanation here.

In order to verify the accuracy of the grey correlation degree between power consumption and influencing factors, this paper uses Deng's correlation degree to verify. The results are shown in Tab.2.

Table 2. Grey Deng ' s correlation degree between influencing factors and electricity consumption

Variable	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Deng's correlation	0.564	0.8334	0.593	0.9823	0.4582	0.7374	0.985	0.9384	0.9397	0.8462
Rank	⑨	⑥	⑧	②	⑩	⑦	①	④	③	⑤

Through the comparison of Deng's grey correlation degree and comprehensive grey correlation degree, it can be seen that the ranking of variables on power consumption is generally consistent. The same is that the Deng's correlation degree and comprehensive correlation degree of GDP (X7), energy price (X9), power price (X8) and urbanization level (X4) are very high, ranking the top four under the two tests. Among them, the ranking of urbanization level (X4) has increased slightly, but considering that the correlation degree values of the top four are almost the same, they are ignored. The difference is that the population (X10) and industrial structure (X2) increased significantly at the end of the year, while the industrial structure (X1) decreased from the seventh to the ninth. Considering that the industrial structure (X2) is similar to the industrial structure (X1), it can be considered that the grey correlation degree of industrial structure (X1) remains basically unchanged, and the grey correlation degree of science and technology input level is still low. It is worth emphasizing that the comprehensive correlation degree of GDP (X7), energy price (X9), electricity price (X8), urbanization level (X4) and industrial structure (X1) is consistent with the results of Deng's correlation degree, which is in the top position.

4. Conclusion

According to the above analysis, GDP (X7) has the highest grey correlation degree. After connecting with reality, GDP (X7) is indeed the main influencing factor of electricity consumption of China and becomes the first variable selected in this paper. The comprehensive correlation between energy price and electricity price (X8) is equivalent, but considering that this paper mainly studies the influencing factors of electricity consumption, electricity price (X8) is selected. At the same time, the energy intensity (X3) consistent with the energy price (X9) is excluded. Considering that the comprehensive correlation degree of energy intensity (X3) is high, this paper intends to include power intensity into the research category, but the test results show that power intensity has a high endogeneity with GDP (X7) and power consumption. In order to eliminate this effect, this paper only eliminates it. The comprehensive correlation degree of urbanization level (X4) and industrial structure (X1) is more than 0.65. Throughout a large number of existing literatures, the above two variables are also confirmed to be the influencing factors of electricity consumption. Therefore, this paper includes the changes of urbanization level (X4) and industrial structure (X1) into the follow-up study. Because the opening up (X6) is seriously affected by policies and foreign economies, the economic cycle is too obvious, and it is inconsistent with the trend components of the follow-up main research in this paper. In addition, the comprehensive correlation degree is quite different from Deng's correlation degree, so the opening up (X6) is not included in the research scope. The comprehensive grey correlation degree and Deng's correlation degree between the population at the end of the year (X10), the level of investment in science and technology (X5), the industrial structure (X2) and electricity consumption are low. In summary, the factors selected in this paper that affect electricity consumption are GDP (X7), electricity price (X8), urbanization level (X4) and industrial structure (X1) changes.

In this paper, grey technology is used to calculate the correlation between electricity consumption and 10 related factors, and the relationship between them is analyzed. In order to vigorously promote the growth of electricity consumption in China, this paper suggests that we should continue to develop the economic level, maintain electricity price stability and continue to promote the development of urbanization.

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