Trends in Social Sciences and Humanities Research
ISSN: 2959-9938
DOI: 10.61784/tsshr3017

TREND ANALYSIS AND FORECAST OF HOUSEHOLD APPLIANCE OWNERSHIP AND ELECTRICITY CONSUMPTION IN XIANGYANG

MinShi Zheng
School of Mathematics and Statistics, Guangxi Normal University, Guilin 541006, Guangxi, China.
Corresponding Email: 1229564969@qq.com

Abstract: With the development of the times, the types of household appliances are also diversified, and then people's demand for electricity is also growing. So it is worth thinking about whether there is a relationship between the amount of household durable goods and the amount of electricity used. Whether the energy-saving and emission-reduction implemented by the state is carried out by the manufacturers or not, the relationship between the two can also be reflected. In this paper, we focus on Xiangyang, the results show that household electricity consumption is closely related to household appliances. It can be inferred that the total electricity consumption will continue to increase in the next few years, but it will fall slightly each year. It is also a bold bet that when all appliances reach saturation, there may be a negative increase in electricity consumption driven by some policies.
Keywords: Electricity consumption; Principal component analysis; Multiple regression analysis; Energy saving and emission reduction

1 INTRODUCTION

1.1 Research Significance

With the development of science and Technology and People's pursuit of high quality of life, the purchasing power of durable goods in China's households has increased significantly, thus directly contributing to the increase in the ownership of household appliances per 100 households, taking the quantity of household appliances as the starting point of electricity consumption of urban and rural residents can be relied on. In theory, the quantity of electricity consumption and the quantity of household appliances are increasing in direct proportion. However, the national policy of energy conservation and emission reduction is being vigorously implemented, whether the implementation of this model can also be reflected. This paper analyzes the relationship between the changes in the ownership of typical household appliances in Xiangyang and the average electricity consumption per 100 households in the corresponding years, to analyse the implementation of energy saving and emission reduction measures for household appliances in Xiangyang in recent years. At the same time, the trend of electricity consumption research is also helpful to the power industry, as follows: first, electricity can not be stored, power generation and use must be completed in an instant, therefore, the amount of electricity generated by the power plant should be consistent with the load required by the city. Second, the power industry is an industry that requires very high capital and technology requirements. The construction time of any power plant is more than three to five years. Only accurate forecasting can make reasonable arrangements for the use of human, material and financial resources, there will be no shortage of electricity or excess generating equipment.

1.2 Research Status

With the increase of electricity consumption year by year, the development of electricity consumption has become the most potential growth point in the electricity market. The analysis of residential electricity demand has gradually become one of the hot spots of people from all walks of life.
The scholar Yang Zhengde, compared the energy consumption data of various home appliances in China with that of other countries, such as the European Union, which has established energy-saving standards, analysis of our country in the standardization of energy-saving home appliances there are still some gaps[1]; Gu Xinling, a scholar, used the factor analysis method to study the different factors of the amount of durable goods owned by urban residents in various cities and towns in the country. In the end, the score factor tells us that the amount of durable goods owned by the coastal areas is the most, second, the average ownership of durable goods is relatively low in the central region and other inland cities, and in the northwest and southwest regions, where the economy is relatively low. Therefore, it can be considered that the difference in the ownership of durable goods is closely related to the local economic level, this is especially true between urban and rural areas[2]; Liang Huifang, a scholar, has divided household electricity into two parts: electrical appliances and electric lamps. The amount of electricity used for electric lamps is related to the number of people and the size of houses, while the amount of electricity used for electrical appliances is related to the amount of various household appliances owned, the power consumption level is analyzed and predicted under the above factors[3];There are various approaches to the study of electricity consumption and household appliances and the relationship between them, and different approaches will draw conclusions from different levels[4].

1 DATA SITUATION

1.1 Data Pre-processing

In the process of data collection, there is a small amount of missing data, so the mean interpolation is used to deal with the missing values. The mean interpolation can be calculated to estimate the missing value. The mean interpolation method is to estimate the value of the middle point (X_0, Y_0) through two points (X_1, Y_1) and (X_2, Y_2) .Assuming $y = f(x)$ is a straight line, calculate the function $f(x)$ from two known points, you can find y as long as you know x .When only one value is missing, the unknowns can be estimated by means of the average of two known values to fill in the missing values.

1.2 Descriptive Analysis

2.2.1 Analysis of domestic electricity consumption data in Xiangyang city

The annual total electricity consumption of the city is a group of very complex and lengthy data. In order to make the data more intuitive and facilitate the follow-up analysis, we need to use statistical software to make descriptive statistics of electricity consumption. This paper uses R software to make a time series diagram of the total living electricity consumption in Xiangyang city in the past ten years. The timing diagram is a horizontal axis for time, and the horizontal axis for a two-bit plane coordinate diagram of the total living electricity consumption in Xiangyang city every year. It can intuitively help us master the changing trend of electricity consumption over time.

As can be seen from Figure 1, the annual electricity consumption in Xiangyang city has an obvious increasing trend, which is conceivable. With the development of society, our demand for electricity is more and more, and the domestic electricity consumption is naturally increasing trend. And can be seen by figure 1, during the period of 2008-2011, the growth trend of electricity consumption is relatively slow, after 2011-2013 and 2016, the rapid growth of electricity consumption, and the popularity of household appliances in life, and the emergence of a wide variety of household appliances, of course, may be with global warming, the world temperature, hot summer, colder winter more environmental factors.

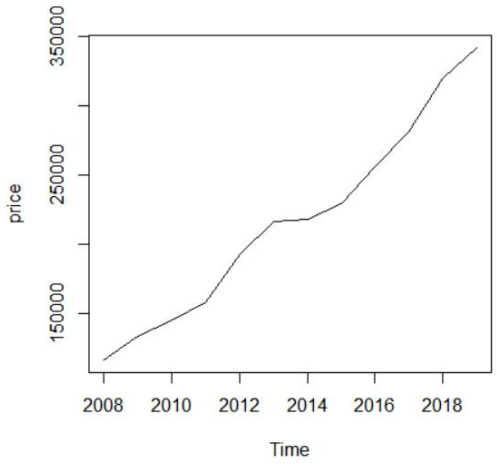

Figure 1 Electricity Consumption Sequence Diagram of Residents in Xiangyang City

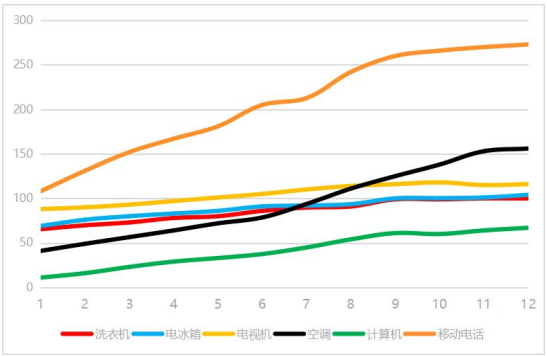

Figure 2 Statistical Chart of Household Electrical Appliances Ownership

2.2.2 Descriptive statistics of the ownership data of various household appliances

As can be seen from Figure 2, any kind of home appliance shows a trend of growth over time; The growth rate of mobile phone is the fastest, but after 2016 (the abscissa is 9), the upward trend is obviously flat, the peak is around 275, indicating that in recent years per capita mobile phone is about 2.5-3; Second faster growth rate is the air conditioning

and computer, and the annual growth rate is almost a value, also can be seen that air conditioning and computer in 2008, their ownership is very little, every hundred less than half of the people have, with the improvement of the quality of life, the pace of rapid development and social development is consistent; Relative TV and refrigerator starting point is very high, in 2008 both hundred household ownership is close to 100, with 12 years of growth, refrigerators reached 100%, can think every household has a refrigerator, and television in 2012 (5) reached 100, in the later growth has more than 100%, the average every family has more than one TV.

This result is also just like the common phenomenon in our life, air conditioning and computers are step by step towards our life, but in some rural areas, the ownership of these durable goods is still relatively low; Washing machines and refrigerators are almost one unit in both urban and rural areas; most households have two or more.

2 MODELING AND ANALYSIS

2.1 Regression Analysis of Electricity Consumption and Household Appliances

2.1.1 Plot scatters

Before using SPSS software to do regression analysis on electricity consumption and household appliances, it is necessary to understand the correlation between electricity consumption and each influencing factor, and judge whether there is a linear relationship between the two, whether the regression analysis can be carried out. So we take the electricity as a dependent variable on the y-axis, and then take each household appliance as an independent variable on the x-axis, making scatter plots.Too many graphics, no longer display one by one.

From the results of the graph, we can see that there is an obvious linear relationship between each type of household appliances and their electricity consumption, washing machines have not had a strong linear relationship with electricity consumption in the last four years, and you can also see that computers and mobile phones tend to follow the same pattern. To sum up, it is possible to set up linear regression equation with these six factors as independent variables.

3.1.2 Establish a regression model

Import data into SPSS, select Regression analysis from the analysis menu, enter dependent variables and multiple independent variables, and select [stepwise] regression, the stepwise regression method selects the entry regression equation that conforms to the criterion and contributes the most to the dependent variable, and removes the model that conforms to the elimination criterion from the model, it is repeated until the independent variables in the equation meet the criteria for entering the model. The results of the analysis are as follows:

Table 1 Variable was Entered / Removed

Models	Variables have been entered	The variable was removed means
1	Air-conditioning	Step (criterion: F-to-enter probability <=. 050, the probability of F-to-remove> =. 100)

Table 2 Variance Analysis Table of Dependent Variable (Electricity Consumption)

Model	Sum of squares	degree freedom	ofmean square	F Value	significance
Regression	5.607E+10	1	5.607E+10	287.375	.000
Residuals	1951285548	10	195128554.8		
Total	5.803E+10	11			

As can be seen from Table 1, only one variable of air conditioning entered the equation, and the remaining five variables were excluded, indicating the existence of serious collinearity among the six independent variables.

Table 2 is the analysis of variance table, which shows the results of the analysis of variance in the process of regression fitting. Sig. indicates the probability that the F value is greater than the F critical value. The results show that when the regression equation includes air conditioning as an independent variable, the probability of significance is less than 0.001, which rejects the original hypothesis that the regression coefficients are all 0. Therefore, it is considered that the regression model included only one independent variable, namely, air conditioning. If forced to build a model in this way, it is contrary to the original intention of our research. Therefore, we need to do collinearity analysis between the excluded five independent variables and the included six independent variables.

In order to judge the collinearity between the six independent variables, we change the stepwise regression method to the input regression method when we build the model, that is, we force the six independent variables into the model, in the output statistics to add [collinearity diagnosis] , collinearity diagnosis, the output results are as follows. The "Eigenvalues" column in table 3 has five eigenvalues of 0.004, 0.000, 0.000, 0.000, 3.691E-5, all very close to 0, the corresponding five conditional indexes are 40.285, 131.862, 175.527, 232.522, 430.702, respectively, all of which are greater than 30. The two indexes indicate that there must be serious collinearity among these five variables.

Table 3 Diagnosis of collinearity of independent variables

model	Dimensions	Eigenvalues	Conditional Index	Proportion of variance						
				Constant	Washing Machine	Refrigerator	Television	Air conditioning	Computer	Mobile phones
1	1	6.847	1.000	.00	.00	.00	.00	.00	.00	.00
	2	.148	6.801	.00	.00	.00	.00	.00	.00	.00
	3	.004	40.285	.00	.00	.00	.00	.44	.03	.01
	4	.000	131.862	.03	.00	.09	.07	.02	.28	.09
	5	.000	175.527	.05	.00	.09	.10	.18	.66	.27
	6	.000	232.522	.22	.52	.00	.01	.01	.01	.24
	7	3.691E-5	430.702	.70	.48	.81	.82	.36	.01	.40

2.2 Factor Analysis of Electricity Consumption and Household Appliances

Using SPSS software, factor analysis of 6 variables including washing machine, refrigerator, TV, air conditioner, computer and mobile phone was carried out. One of the ways to determine the principal component is to take the component with an eigenvalue greater than 1 as the principal component, that is, table 4. The second column of the total variance interpretation table shows that only the eigenvalue of the first factor is greater than 1 and the total column shows that only the eigenvalue of the first factor is 5.897, the variance percentage of the first factor is 98.279% , which means that the variance explained by this component accounts for 98.3% of the total variance. Therefore, the determination to extract a principal component greatly reduces the complexity of the original data and only loses 1.7% of the information.

Table 4 Explanation of Total Variance

Component	Initial eigenvalue			Extract the sum of squares of loads		
	Total	Percentage of variance	Cumulative	Total	Percentage of variance	Cumulative
1	5.897	98.279	98.279	5.897	98.279	98.279
2	.065	1.089	99.368			
3	.027	.444	99.812			
4	.006	.100	99.912			
5	.003	.054	99.967			
6	.002	.033	100.00			

The factor score coefficient matrix is shown in table 5. According to the factor score coefficient and the standardized value of the original variable, the scores of each factor of each observation can be calculated. Finally, the principal component expression can be written as:

$$FAC1 = 0.169 \times xyj + 0.168 \times dbx + 0.167 \times dsj + 0.166 \times kt + 0.169 \times jsj + 0.169 \times yddh \quad (1)$$

Table 5 Table of Component Score Coefficients

	Components
	1
Washing Machine（xyj）	.169
Refrigerator（dbx）	.168
Television（dsj）	.167
Air conditioning（kt）	.166
Computer（jsj）	.169
Mobile phone（yddh）	.169

2.3 Regression Analysis of Power Consumption and Factor

In SPSS Software, the results of factor analysis are saved as variables. The factors after dimensionality reduction and electricity consumption were linear regression. R-square and modified r-square can reflect the goodness of fit. The output result shows that the adjusted r-square is 0.924, so the goodness of fit of the model is better. The results of analysis of variance table show that the probability of significance is less than 0.001 when the regression equation contains factor scores, so the equation fitting is better. According to the regression coefficient table, the regression model can be written as:

$$\text{Power} = 217453.592 + 70063.367 \times FAC1\_1 \quad (2)$$

Using R software to forecast the quantity of six kinds of household appliances per 100 households, the result is as table 6. The predicted factor scores are calculated by taking the data into the factor scores. Based on the obtained score factor, the power consumption in the next three years is predicted by introducing the functional expression between the score factor and the power consumption. The factor score formula is:

$$FAC1 = 0.169 \times xyj + 0.168 \times dbx + 0.167 \times dsj + 0.166 \times kt + 0.169 \times jsj + 0.169 \times yddh \tag{3}$$

Table 6 Each Electrical Appliances per 100 Households have Three-phase Forecast Table

	Washing Machine	Refrigerator	Television	Air conditioning	Computer	Mobile phone	FAC1_1
2020	105	105	116.8	154.6	70	274	138.6902
2021	108.5	108	117.3	158	76	276	141.7856
2022	112	111	117.8	163	82	279	145.3156

3 CONCLUSION

Whether we use computer ownership or car ownership to represent electricity consumption, we can see from the trend chart, the trend of electricity consumption has not significantly reduced, so energy-saving efforts still have to be carried out vigorously. At the same time, we used SPSS software to analyze the six household appliances studied, and found that there may be collinearity among them, and there is a large relationship between the amount of household cars and the amount of electricity used, the second is the amount of computers, so I think we can judge the intensity of energy saving and emission reduction and the implementation results mainly by the amount of household cars and computers, follow-up efforts to increase energy conservation and emission reduction can also focus on cars and computers to start.
We have found that domestic electricity consumption is closely related to household appliances. Therefore, it can be inferred that although Xiangyang's total electricity consumption will continue to increase with the increase of the year, but the annual increase will be slightly lower than the previous year. At the same time, it can be boldly predicted that when all electrical appliances reach saturation, under the promotion of "Energy conservation and emission reduction" policy, there may be negative growth in electricity consumption. This shows that with the development of social economy, home appliances in the family life more and more heavy proportion, people more and more enjoy the convenience of science and technology to people's lives. But Xiangyang's annual electricity consumption has not risen much from the previous year's, indicating that household appliances are becoming more environmentally friendly and energy-efficient. This is also the latest achievement of the country to vigorously promote energy saving and emission reduction[5]. It also proves that the energy-saving and emission-reduction policies have been implemented in every household. With the introduction of the 14th five-year plan, which aims to reach“Peak carbon” by 2030 and“Carbon neutrality” by 2060, policy after policy shows how determined the country is to save energy and reduce emissions[6]. The most direct manifestation of the effect of energy saving and emission reduction is the change in electricity consumption. We can boldly predict that after 10-15 years, the total electricity consumption of our country will reach its peak, after 50 years, the total electricity consumption of our country tends to a stable value and may even fall back.

COMPETING INTERESTS

The author have no relevant financial or non-financial interests to disclose.

REFERENCES

[1] Yang Zhengde. Speed up the energy-saving standardization of household appliances.Standardization in Shanghai, 2004(08): 31-35.
[2] Gu Xinling. Statistical application of factor analysis in durable goods ownership of urban residents. The Journal of Tongling University, 2016, 15(04): 29-33+48.
[3] Liang Huifang, Su Ming, Tian Lei. Is the China's residential electricity consumption mode consistent with the requirements of the new urbanization?—— Empirical study based on the electrical equipment and electricity consumption status of urban households . The Economic Journal, 2014, 1(01): 163-180.
[4] Meng Ming, Zhao Ningning. Analysis of the current situation and influencing factors of residential electricity consumption. Think Tank Era, 2019, (37): 246-247.
[5] Guo Songliang, Yan Pengjun, E Haokun. Short-term prediction of total social electricity consumption in Beijing based on ARIMA model. Journal of Beijing Information Science and Technology University (Natural Science Edition), 2020, 35 (05): 93-96.
[6] Hongyun Han, Radwan Amira. Economic and social structure and electricity consumption in Egypt. Energy, 2021, 231.