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RESEARCH PAPER

Electricity Consumption and Its Impact Factors: Based on the Nonparametric Model

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Abstract: The security of power consumption demand is an essential issue in maintaining a rapid economic development in China. Owing to the advantages such as the robustness and favorable estimation performances, the semiparametric model and nonparametric models have obtained wide popularity. In this article, based on the semiparametric and nonparametric models, a new estimation model is created, and the linear and nonlinear effects of influencing the power consumption are investigated. The results indicate that the economic growth, population, and economic structure play a vital role in the power consumption; the impact of the power price index on the electricity consumption is small, which can-not offset rapid growth of the electricity consumption that the economic growth, population and economic structure bring; the energy utilization efficiency still stays at a low level in China.

Key words: power consumption; impact factors; nonparametric model; semiparametric model

1 Introduction

At present, economic development in China is at an important stage in industrialization. With the rapid growth of economy, the transformation of economic structure, and the increase in the living standard, the power consumption demand is also increased dramatically. Security of electricity consumption demand is a vital issue in maintaining a healthy, harmonious, and rapid economic development in China, and achieving the goals of the medium-term and long-term planning. Therefore, it is very essential to analyze the power consumption and its impact factors.

Various factors, such as the economic growth level, the economic development stage, the characteristics of economic structure, the electricity price, the energy utilization efficiency and the living level, influence the electricity consumption. It is obvious that the relationship between the above-mentioned factors and the electricity consumption is very complicated. In China, based on different research methods, many scholars investigated and analyzed the electricity consumption system from different aspects. Based on the cointegration and the error correction model, Lin[1] studied the long-term demand model and dynamic short-term fluctuation of power consumption and its impact factors. Based on the cointegration and the error correction model within the framework of the production function of three elements, Lin[2] studied the electricity consumption and economic growth in the long-run equilibrium relationship and short-term dynamic adjustment process in China. Lin[3] analyzed the impact of electricity shortage on economic growth based on the cointegration method and discussed the main reasons of electricity shortage, and the short-run and long-run development strategy. Xiao[4−5] analyzed the effect of the regulation on electricity price and electricity industries, who believed that the regulation significantly improved the volume and efficiency of electricity industry in a statistical sense, reduced the price level and the monopoly profits, and the overall effect of regulation is desirable. Based on the development process of electricity industry in China, Lin[6] analyzed the macro-effect and measures in the process of electricity market reform. He proposed that the high concentration of the state-owned enterprises is a basic problem for the development of the electricity industry, and the reform of state-owned enterprise is very necessary. Lin[7] studied the impact of increasing the electricity price and restricting the electricity use on the different industrial sectors and different regions. He believed that the direct impact of electricity shortage is much greater than the cost of the industrial electricity supply; moreover, the impact of the electricity shortage on the regions with the higher industrialization may not be the greatest.

According to the above analysis, it can be seen that presently the cointegration theory, the error correction model, the causality tests, and the simple linear regression model had been employed to investigate the factors influencing the electricity consumption. In essence, however, the electricity consumption process is a complex system. The impact of different factors on the electricity consumption may be linear or nonlinear. And the cointegration theory, the error correction model, the causality tests, and the simple time series regression analysis may bring large errors. Therefore, in this article, a nonparametric model is developed to investigating the factors influencing the electricity consumption. Because the nonparametric estimation is

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mainly based on the characteristics of the sample data itself, it doesn't preestablish estimation model, which can avoid the terrible results that the imperfect model specification and the parameter estimation bias bring. At present, this method has obtained wide applications in the fields such as the economics and systems engineering. As a result, the nonparametric model is chosen to analyze the factors influencing the electricity consumption to achieve a more reasonable conclusion and interpretation.

2 Variable definitions and data features

We consider several factors affecting the electricity consumption, such as the economic growth level, the total population, the economic structure, the price index, the improvement of energy efficiency, which are defined as Y_t, N_t, M_t, P_t and EF_t, respectively. Economic growth level is the most important factor that affects the electricity consumption demand. In recent years, sustainable and rapid economic growth is a main impetus for the increase of the electricity consumption. Electricity price index is another important variable that influences the electricity consumption demand, which can be defined by the Producer Price Index of the electricity industry in that year. Unfortunately, only statistical data after 1980 is obtained, so we replace the electricity price index with the Consumer Price Index data before 1980. The changes of the economic structure, particularly changes of the industrial structure in the industries with large electricity consumption, will greatly impact the electricity demand. In this article, the change of economic structure is defined by the value of gross industrial output divided by GDP, which is employed to analyze impact of the changes of economic structure on electricity consumption. In addition, the improvement of energy utilization efficiency is described by the value of energy consumption divided by GDP, that is, the energy consumption of unit GDP. The higher utilization efficiency, the value is smaller. In addition, the total population is also an essential factor.

The sample data span the period 1952-2006[1]. Logarithm of above variables was taken.

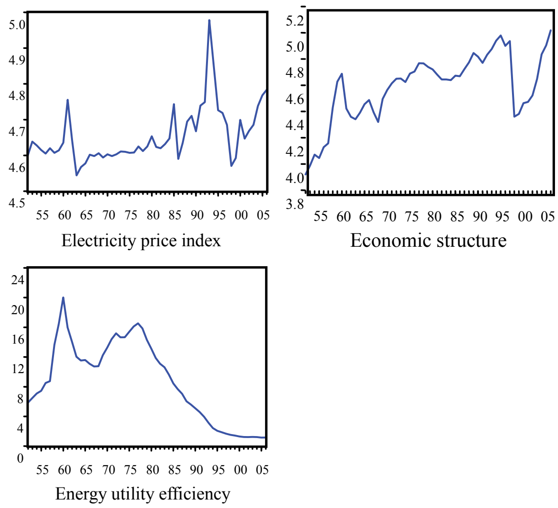

Figure 1. Trends of the electricity consumption

1.Data Sources: "China statistic Yearbook" and "China statistic Yearbook"

It can be seen from Figure 1 that the trends of the electricity consumption, level of economic growth, total population present a significant linear upward tendency in the considered samples, while the trends of the electricity consumption price index, energy efficiency and economic structure are relatively irregular. According to the above analysis, the levels of the economic growth and the total population, which present a significant upward tendency, are defined as a parametric part, and the expected signs of these two variables are positive, that is, rapid economic growth and increasing total population will lead to the increment in the electricity consumption. The electricity price index, energy efficiency, and economic structure are considered a nonparametric part because the relationship between the electricity consumption and these variables is not linear; moreover, it is also difficult to describe the complex relationship using a specific nonlinear model; as a result, a feasible semiparameteric model can be obtained.

3 Nonparametric model and explanations of its conclusion

Based on the above analysis, a semiparametric model can be obtained[8−9]:

$$Q_t = \beta_Y Y_t + \beta_N N_t + g(P_t, M_t, EF_t) + \varepsilon_t \qquad (1)$$

where, Q_t is the total electricity consumption; Y_t is the economic growth level; N_t is the total population; P_t is the electricity price index; M_t is the changes of economic structure; EF_t is the improvement of energy utility efficiency. For ease of presentation, equation (1) can be reformulated by

$$Q_t = B'Z_t + g(X_t) + \varepsilon_t \qquad (2)$$

where $Z_t = (Y_t, N_t)$ and $X_t = (P_t, M_t, EF_t)$; B is the coefficient vector that needs to be estimated; $g(\cdot)$ stands for a unknown function that is named the nonparametric part; ε_t represents a random error series, which satisfies $E(\varepsilon_t/Z_t, X_t) = 0$, $Var(\varepsilon_t/Z_t, X_t) = \sigma_\varepsilon^2$ and $\sigma_\varepsilon^2 = Var(Y_t/Z_t, X_t)$. It is worth mentioning that the semiparametric models do not contain the constant term, because the model cannot be uniquely identified when a constant term is included. As a result, the constant term is included in the unknown function $g(\cdot)$, and then unknown variables B and $g(\cdot)$ can be uniquely estimated.

In this work, the local linear least squares estimation is employed to estimate equation (2). The estimation process can be divided into four main steps: first, if B is known, based on the model $Q_t - B'Z_t = g(X_t) + \varepsilon_t$, the local linear estimation of $g(x, B)$, $\hat{g}(x, B)$ can be obtained; second, based on parametric model $Q_t = B'Z_t + \hat{g}(X_t, B) + v_t$, the estimation of B, $\widehat{B}$, can be obtained; third, we can find the final estimation $\hat{g}(x) = \hat{g}(x, \hat{B})$ of $g(x)$; and fourth, adjusting the bandwidth h_n, until a satisfactory result can be obtained. The matrix expressions of the local linear estimation of the parametric vector B and the nonparametric function $g(x)$ can be defined by

$$\hat{B} = (\tilde{Z}'\tilde{Z})^{-1}\tilde{Z}'\tilde{Q}, \hat{g}(x) = S'(x)(Q - \hat{B}Z) \qquad (3)$$