Research on the Forecasting of Electricity Demand in India State Maharashtra

Zichang Li *

Wuhan Britain-China school, Wuhan, 430000, China

* Corresponding Author Email: Andy_Li1234567@outlook.com

Abstract. This study centers on forecasting the electricity demand in the Indian state of Maharashtra. In the context of rapid technological and economic development, the demand for basic raw materials and energy is on the rise. Moreover, the conflict between Russia and Ukraine has imposed supply constraints, making the prediction of electricity demand of utmost importance. Various approaches have been utilized in this field; however, existing studies often lack specificity and tend to be overly general. This research employs time series analysis, sourcing data from POSOCO. The ARIMA model is selected, and its parameters are determined through multiple rounds of testing. The results demonstrate that the ARIMA (1,0,1) model effectively fits the data, offering valuable insights. Overall, this study presents short-term forecasting and emphasizes the necessity of conducting specific and comprehensive analysis for the Intelligent Power System. Such analysis is crucial for optimizing power generation, distribution, and consumption, ensuring the stability and reliability of the power supply in Maharashtra. It also provides a foundation for decision-making in power system planning and management, enabling stakeholders to make informed choices regarding infrastructure investment and resource allocation. Additionally, the study's findings can contribute to the development of more efficient energy policies and strategies, promoting sustainable economic growth and social development in the region.

Keywords: Short-term power demand prediction; ARIMA Model; Maharashtra.

1. Introduction

In the process of the rapid development of modern science and technology and the remarkable growth of the economy, the contradiction between the increasing demand for basic raw materials and energy for production and the currently tight supply situation, which is mainly caused by the booming of population, as continued to intensify and become more prominent. As a form of energy that is widely used and highly convenient, electricity holds a high level of importance for any country. It is essential for various aspects of a nation's development, including industrial production, daily life, and technological innovation. The efficient production and proper distribution of electricity are inseparable from having a clear understanding of the demand for electricity. Only by accurately grasping the electricity demand can power generation and distribution be optimized, ensuring a stable power supply and meeting the diverse needs of different sectors. Therefore, predicting electricity demand has become a widely studied and highly concerned topic. Researchers from various fields are devoting themselves to exploring effective prediction methods and models to provide valuable references for power system planning and operation.

Electricity demand in a certain region such as a country or an area is of great importance, too. The team of Huang claimed power supply enterprises should establish a power marketing system adapted to the market economy in order to enhance the competitiveness of the enterprises. These analyses can start with price elasticity in the demand curve, which indicates the demand curve is a crucial tool to maximum profits [1]. According to Liu et al, State Grid Electric Power Company should adhere to the goal of enabling users to use energy flexibly. It implied that understanding the demand also helps for the government and government-owned enterprises achieve specific policy goals [2].

However, most of current studies may be too general to be useful. Smith argued that the elasticity of electricity demand varies across different regions and user groups. This indicated that a one-size-fits-all production strategy may not be effective [3]. Another study by Johnson and Brown found that factors such as weather conditions and economic growth also significantly influence electricity

demand. They suggested that these factors need to be considered when deciding electricity production [4]. Some researchers, such as Davis, pointed out that the existing models often underestimate the complexity of consumer behavior, which calls for more specific studies to accurately predict electricity demand [5].

Many methods are applied in this field. For instance, some may think about finding the amount of electricity needed to produce via seeking for the relationship between the demand of electricity and another factor. Li et al. believed that the total GDP can be predicted by using the improved Solow growth model based on the obtained historical data of GDP. Based on the obtained historical data of GDP and electricity consumption, the historical value of electricity consumption per unit of GDP was calculated, and the future value of electricity consumption per unit of GDP was predicted by the exponential smoothing method. Based on the prediction results of GDP and electricity consumption per unit of GDP, the total future electricity consumption was predicted [6]. Similarly, De Felice et al. claimed to find a relationship between the average temperature patterns in summer (June-July) over Europe and Italian electricity demand using both a linear and non-linear regression approach [7]. Other than that, Pegalajar et al. developed Machine Learning models to predict electricity demand. Their study was based on data of the Spanish Electricity Network from 2007 to 2019. To achieve this, they proposed implementing a set of Machine Learning techniques using various frameworks [8].

What is more, Semekonawo and Kam used electricity demand in West African countries based on the multivariate linear regression model and the Autoregressive Integrated Moving Average (ARIMA) model. Then, they found that different countries may fit for different models [9]. Lastly, Mao established combined forecasting model and a seasonal adjustment model for electricity demand. When establishing the electricity demand forecasting model, the missing data of power generation was first complemented, and the variance stability transformation was performed on the complemented sequence. Then, the additive and multiplicative seasonal exponential smoothing models and the seasonal autoregressive integrated moving average model were used respectively to model the fitted data. Based on the fitting and short-term forecasting error indicators, a better seasonal exponential smoothing model and the optimal seasonal autoregressive integrated moving average model were selected. Finally, the forecasting results of these two models were combined with the optimal weighting coefficient to obtain the electricity demand for the next two years [10].

Overall, these studies clearly demonstrate the importance of electricity demand prediction. The need for context-specific and comprehensive analysis is crucial. This study aims to establish a model for electricity demand prediction in Maharashtra, the Indian state with the highest GDP, using time series analysis. Given Maharashtra's economic prominence, understanding its electricity demand patterns is essential. Time series analysis will help uncover trends and patterns in electricity consumption, enabling better planning and decision-making for power utilities and policymakers.

2. Methods

2.1. Data Sources

The data is sourced from the weekly energy reports of Power System Operation Corporation Limited (POSOCO), which is an enterprise fully owned by the Government of India and falls under the Ministry of Power. This data is presented as a time series among 17 months, starting from January 2nd, 2019, and ending on May 23rd, 2020. The rows are identified by dates, while the columns stand for different states. In total, there are observations for 17 months.

2.2. Variable Selection

Power demand reflects the activity level of economic activities and changes in people's living standards, and plays an important role in power production, government management and other aspects. Power demand is affected by many factors, such as the expansion of industrial production, the advancement of urbanization, the improvement of residents' living standards and the development

of emerging industries, which makes it complicated to predict. In Figure 1, the power demand of Maharashtra is presented.

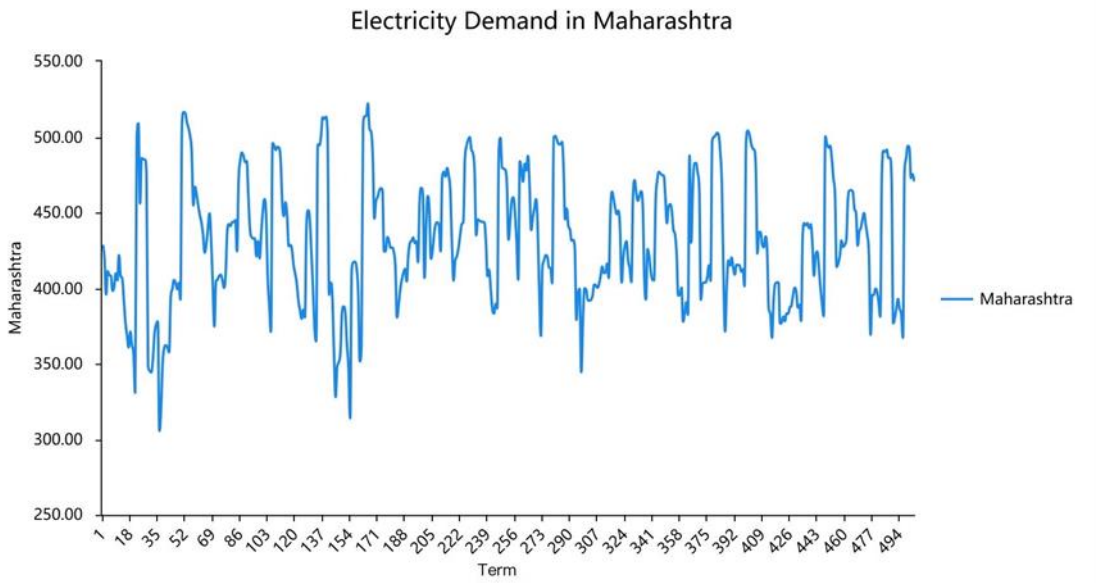


Fig. 1 Electricity Demand in Maharashtra

Figure 1 appears to show a complex trend. The values range from approximately 250.00 to 550.00. While it's difficult to determine a precise linear trend from this limited description, it seems that electricity demand in Maharashtra is not consistently increasing or decreasing.

2.3. Model Selection

ARIMA model is a traditional predicting model, which is popular in real-world applications. It is easy to understand, straightforward, and can be utilized to many conditions. The ARIMA model is often defined as ARIMA (p, d, q). The predicted object sequence is first converted into an entirely random sequence by the model, which then uses the combination of various mathematical models to simulate and approximate the sequence [11]. Consequently, The ARIMA (p, d, q) is:

$$S_t = a_1 S_{t-1} + a_2 S_{t-2} + \cdots + a_p S_{t-p} + \varepsilon_t + \beta_1 \varepsilon_{t-1} + \cdots + \beta_q \varepsilon_{t-q} \quad (1)$$

3. Results and Discussion

3.1. Time Series Plot

Firstly, the author examined the smoothness of the data. According to Figure 1, this data seemed to satisfy the conditions of stational time series. To make sure it, the ADF test is applied in order to determine the difference parameter.

Table 1. Results of ADF Test

Difference of order	T	P	Critical value		
			1%	5%	10%
0	-6.567	0	-3.444	-2.867	-2.57

According to Table 1, for Maharashtra, the t-statistic of the ADF test of this time series data is -6.567, the p-value is 0.000, and the 1%, 5%, and 10% critical values are -3.444, -2.867, and -2.570 respectively. Since p = 0.000 < 0.01, there is more than 99% confidence to reject the original hypothesis. At this time, the sequence is stationary.

3.2. ACF and PACF Test

To prepare the ARIMA Model, autocorrelation function (ACF) and the partial autocorrelation function (PACF) are used. Via analyzing these two tests, parameter p and q can be roughly determined. As it is shown in Figure 2 and Figure 3, it is evident that both the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots are markedly non-truncated. Consequently, it becomes essential to select the appropriate order for the autoregressive integrated moving average (ARIMA) model. Generally speaking, the most significant order in the ACF graph can be taken as the value of q, while the most significant order in the PACF graph can be regarded as the value of p. After that, the author concludes that both the autoregressive order p and the moving average order q are equal to 1.

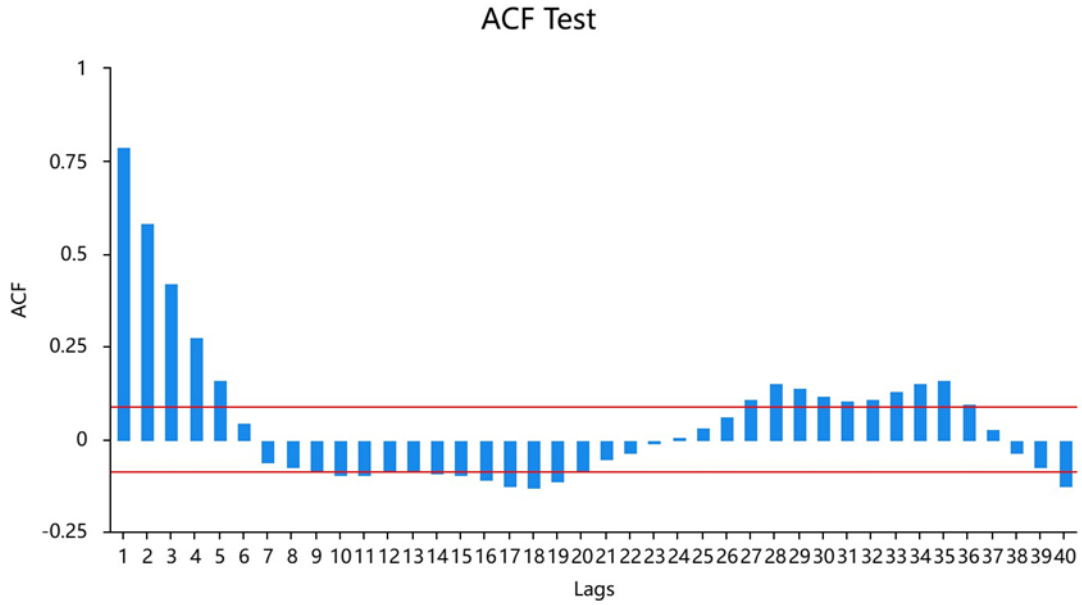


Fig. 2 Results of ACF

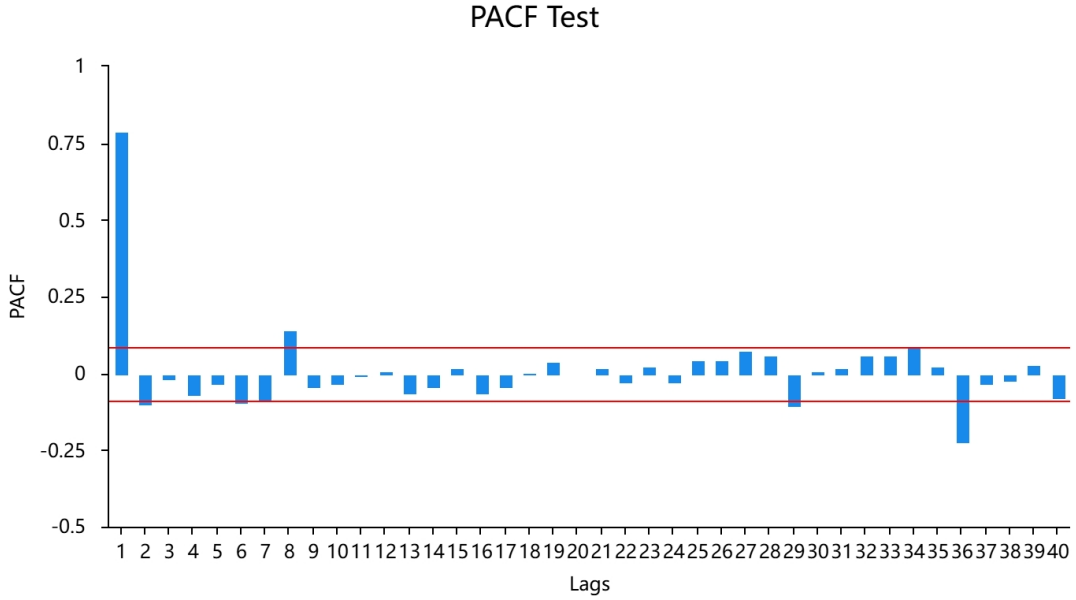


Fig. 3 Results of PACF

3.3. Model Forecasting

This essay applies ARIMA (1,0,1) to predict 30 numerical values for electricity demand data, and the results are shown in Figure 4:

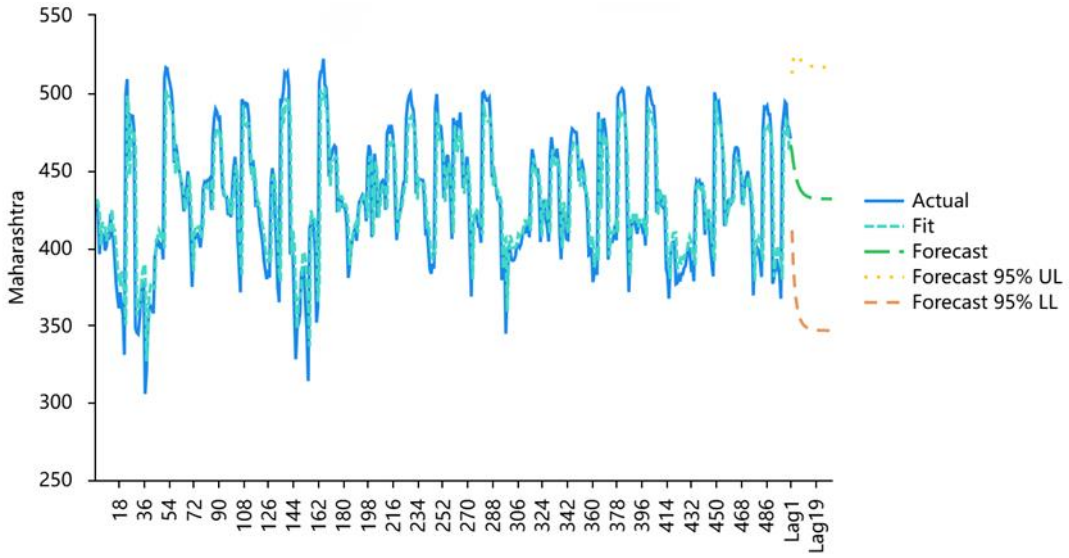


Fig. 4 Predicted Results and Real Results

It can be observed that the predictions generated by the ARIMA (1,0,1) are very close to the trend of the actual data. This means that it is quite possible to accurately forecast electricity demand. The model seems to be effective at capturing latent patterns and fluctuations in the data. This suggests that the ARIMA (1,0,1) could be a valuable tool for forecasting electricity demand, providing useful insights for decision-makers and producers in the power sector.

4. Conclusion

This research concludes short-term forecasting of electricity demand in Maharashtra by analyzing the data starting from January 2nd, 2019, and ending on May 23rd, 2020. Firstly, the ADF test is employed to determine the difference parameter, and the result suggests that there is clearly no need to engage in any form of data processing. Subsequently, the ACF and the PACF graphs are used to determine the exact ARIMA model. Finally, the ARIMA model, which is a flexible, accessible and accurate method, specifically ARIMA (1,0,1), is applied to the sample data for training, and the prediction generated by the model shows a good fit with the actual data, indicating the relatively high accuracy and reliability of the forecasting method. In terms of the real-word usages of this research, the forecasting model can provide crucial information for governments and firms to impose policies and arrange production respectively. Also, the result will better serve the formation of the well-organized power system in this state.

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