Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 2 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 Print ISSN:0975-5861

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GJRE-J Classification : FOR Code: 291899p

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Abstract- Australia is a leading developed country which is indispensable a proper planning and management of power generation. To take a unique planning decision forecasting of electricity production is badly in need so that electricity generation copes with the demand of the electricity smoothly. The main task of this study is to assess the performance of two time series models in forecasting electricity generation in Australia. Two time series forecasting methods such as ARIMA and Holt-Winter's additive trend and seasonality smoothing methods are considered. Applying Theil's U-statistic as the key performance measure, the study concludes that Holt-winter's method is more appropriate model.

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I. Introduction

At present electricity has become a first and foremost precondition of macroeconomic development of a territory. Each day, electricity plays key rolein keeping homes and business running smoothly, powers transportation that take people work, school and other places, and supplies electricity to appliances in all sectors. The demand of electricity especially in for industrial sector need not to say. Without electricity not only a single day but also a moment is unimaginable. A country's economic growth directly related to electricity production. That's why sustainable electricity production badly in needs to fulfill the demand of households as well as industry and communication sectors. To manage such kind of demand of electricity a country's power development board has to take sophisticated decision to produce electricity that can cope with demand with supply of energy.

Being a developed country monthly electricity production of Australia is a seasonal and trending behavior. So, electricity production authority of Australia should take plan for proper management of production with demand. To overcome uncertainty of future production smoothing or forecasting approach time series analysis is the most applied method. For predicting Australian electricity production, we will use conventional smoothing methods and well known ARIMA modeling. Hence we want to show the comparative performance of referred model. This paper is divided into six sections. The section one of this study is the introductory part. The second section of the study will present forecasting approach where we present stationarity, Holt's-Winter trend and additive seasonality, Box-Jenkins methodology SARIMA modeling and accuracy measurement approach. Section three is the empirical data analysis and forecasting while sections four is the accuracy measurement and finally conclusion

Basic Terminologies: The following keywords are used throughout the research approach.

Stationarity: Stationarity means that there is no growth or decline in the data. The data must be horizontal along the axis. A time series is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time is computed.

Suppose y_t be a stochastic time series then,

$$E(y_t) = \mu$$

$$\operatorname{var}(y_t) = E(y_t - \mu)^2 = \sigma^2$$

Holt's-Winter's trend and additive seasonality method

The basic equations of Holt-Winters' trend and additive seasonality method are as follows:

Level $L_t = \alpha(Y_t - S_{t-s}) + (1-\alpha)(L_{t-1} + b_{t-1})$

Trend: $b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1}$

Seasonal: $S_t = \gamma(Y_t - L_t) + (1-\gamma)S_{t-s}$

Forecast: $F_{t+m} = L_t + b_t m + S_{t-s+m}$

Where s is the length of seasonality (e.g., number of months or quarters in a year), L_t represents the level of the series, b_t denotes the trend, S_t is the seasonal component, and F_{t+m} is the forecast for m period ahead.

Box-Jenkin's methodology and ARIMA modeling

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The general ARIMA model proposed by Box and Jenkins (1970) is written as ARIMA (p, d, q) but when the characteristic of the data is seasonal behavior then it said to be SARIMA. And the seasonal ARIMA model is written as very formal notation like this

$$\text{ARIMA } (p, d, q) \quad \times \quad (P, D, Q)_m \qquad \downarrow \quad \downarrow$$

Non-seasonal Seasonal
Part of the model part of the model

AR: p = order of the autoregressive part
*I:*d = degree of differencing involved
MA: q = order of the moving average part
m = number periods per season

The basis of the Box-Jenkins modeling in time series analysis is summarized the following figure and consist of three phases: identification, estimation and testing, and application.

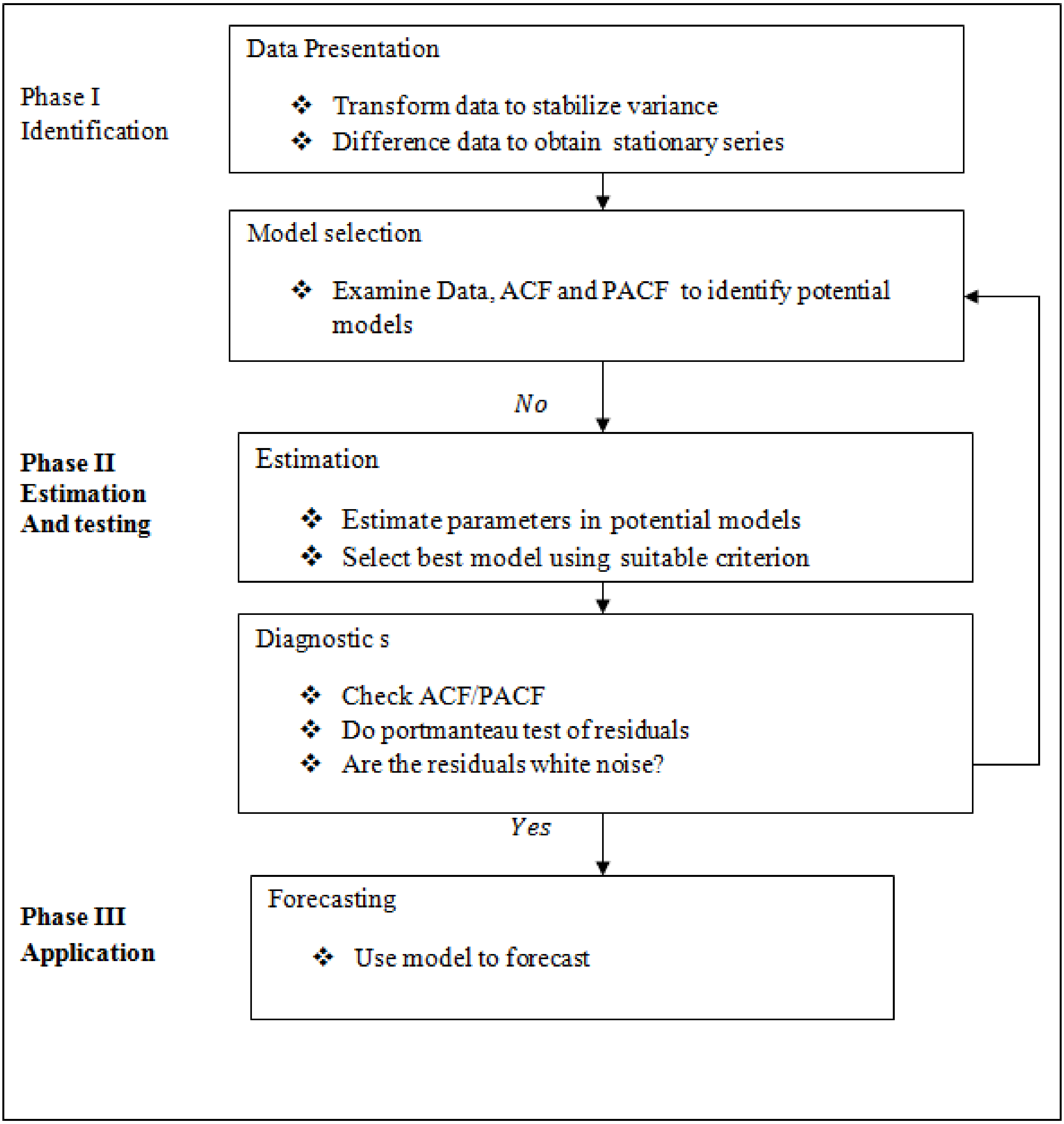

Figure 1.1 : Schematic representation of the Box-Jenkins methodology for time series modeling

Assessment Approach: The validity of the forecasting in time series analysis can be assessedvia couples of approaches such as Mean error (ME), root mean square error (RMSE), mean absolute error (MAE), mean percentage error (MPE), mean absolute percentage error (MAPE), mean square error (MSE), Mean absolute scaled error (MASE) and The il's U statistic.

Percentage Error: If Y_t is the actual observation for time period t and F_t is the forecast for the same period, then the percentage error is defined as

$$PE_t = (\frac{Y_t - F_t}{Y_t}) \times 100$$

Mean Percentage Error (MPE):

$$MPE = \frac{1}{n}\sum_{t=1}^{n} PE_t$$

Mean Absolute Percentage Error:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} |PE_t|$$

If smaller the any above index is considered the better forecasting technique.

Theil's U Statistic: It is defined as follows:

$$U = \sqrt{\frac{\sum_{t=1}^{n-1}(FPE_{t+1} - APE_{t+1})^2}{\sum_{t=1}^{n-1}(APE_{t+1})^2}}$$

Where $FPE_{t+1} = \frac{F_{t+1} - Y_t}{Y_t}$ (forecast relative change)

And $APE_{t+1} = \frac{Y_{t+1} - Y_t}{Y_t}$ (actual relative change)

If $U < 1$: the forecasting technique being used is better than the naïve method. The smaller the U statistic is considered the better forecasting technique.

II. Empirical Results

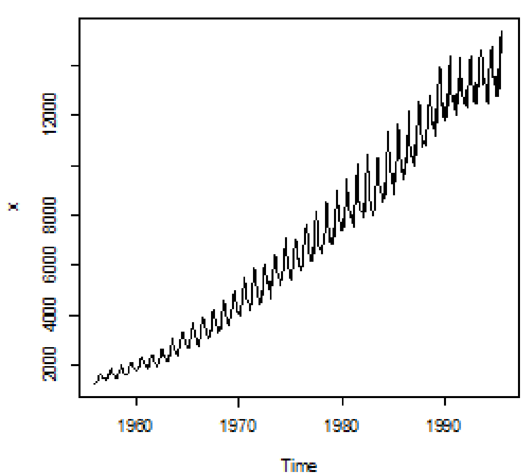

Fig: 1. 2 : Australian monthly electricity productions from January, 1980 to August, 1995

Now, it is revealed to us that the above figure of monthly Australian electricity production exhibits an additive seasonal and steadily increasing trend pattern. Obviously the data series is non-stationary.

Before model building first and foremost task is to differentiate the original data first difference as well as seasonal first difference.

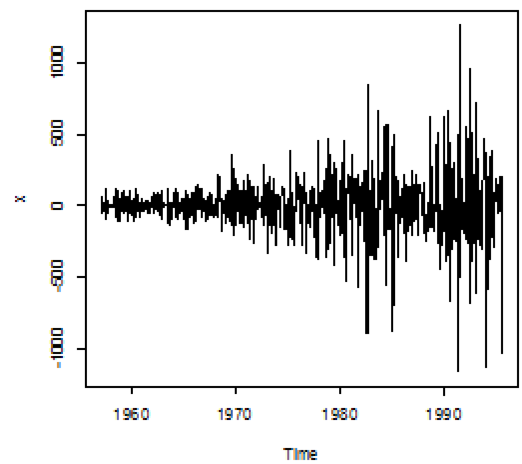

Figure: Time series plot of first difference of the original data

Obviously, first difference of original time series data is now of stationary.

The model SARIMA (0, 1, 1) (0, 1, 2) [12] has chosen on the basis AIC & BIC criterion. The minimum of AIC & BIC that model is taken as the ultimate model for forecasting.

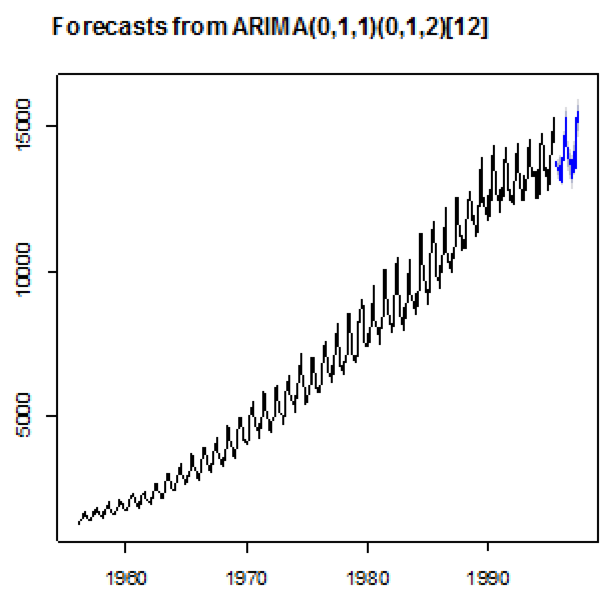

Figure: 1.3 : Forecasting the electricity production of Australia

Diagnostic Checking: we want to compare the performance of the SARIMA with Holt's-Winter trend and additive smoothing approach.

Method	RMSE	MAE	MAPE	MASE	Theil's U
SARIMA*	163.8559	115.0209	1.7778	0.3446	0.368217*
SES	457.0500	334.7208	4.9454	1.0029	--------
HOLT's	456.1791	342.0339	5.1885	1.0248	--------
SNAIVE	394.9866	330.5348	5.6245	0.9903	--------
HOLT - WINTER*	167.4026	119.0757	1.8704	0.3567	0.6557*

We may say from the above accuracy measurement table that the performance of SARIMA (0, 1, 1) (0, 1, 2) [12] model is better than Holt's-Winter method.

Now, we want to represent the histogram of the respective method sequentially

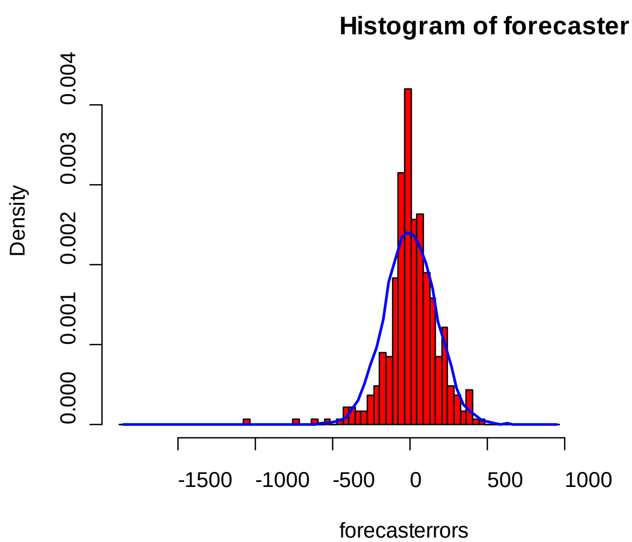

Figure: Histogram of forecast error of SARIMA (0,1,1)(0,1,2)[12] model

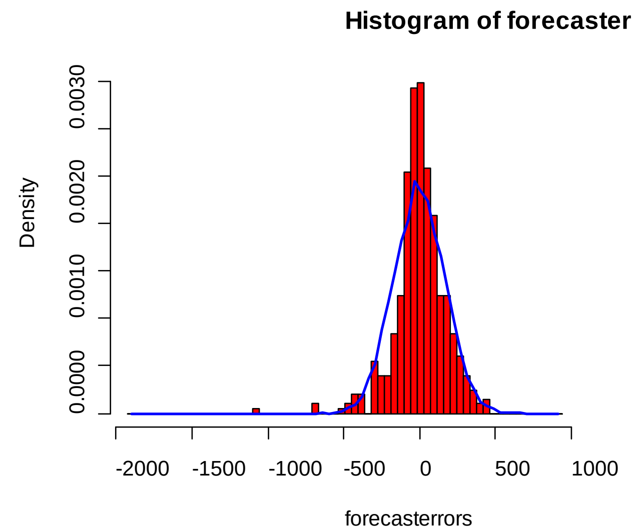

Figure: Histogram forecast error of Holt-winter's trend and additive seasonality model

Comment: On the basis of above two histogram of forecast error, it is revealed that the both of two error terms shape is approximately normal distribution. So, the both of the error term represent white-noise. But the SARIMA (0, 1, 1) (0, 1, 2) [12] model exhibits better normality of forecast error than counterpart.

White Noise Test: The following Table represents the white noise assessment of the error term of the fitted model

Test	P-value	H_0	Decision
Ljung-Box	0.7863	accept	stationary
KPSS	0.1	accept	Stationary
ADF	0.01	Do not accept	Stationary

Above white noise testing approach suggests there is lack of correlation in error term. So, the model is well fitted.

III. Conclusion

The main goal of this paper was the performance assessment between seasonal ARIMA modeling with Holt–Winters' exponential smoothing approach. The empirical analysis revealed that SARIMA (0, 1, 1) (0, 1, 2) [12] were the better model than counterpart

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