Available online at www.elixirpublishers.com (Elixir International Journal)

Statistics

Elixir Statistics 63 (2013) 18145-18148

ISSN: 2229-712X

Modeling and forecasting export and import of Indian wood based panel using ARIMA models

V.K. Upadhyay

Indian Plywood Industries Research and Training Institute (IPIRTI), HMT Link Road off Tumkur Road, Yeshwantpur, Bangalore-560022

ARTICLE INFO

Article history:
Received: 26 August 2013;
Received in revised form:
29 September 2013;
Accepted: 1 October 2013;

Keywords
ARIMA Model,
BIC,
MAPE,
R-squared,
Wood based panel.

ABSTRACT

The present study is an attempt to find out appropriate ARIMA model by using Box-Jenkins methodology to forecast the export/import of wood based panel in India on time series data for a period of 16 years from 1996-97 to 2011-12. Test criterion like lowest Bayesian Information Criterion (BIC), R^2 value and lowest of mean absolute percentage error (MAPE) are applied to predict the accuracy of the model. This study found ARIMA (0,1,0) with R^2: 0.83 for the export and ARIMA (0,1,1) with R^2: 0.87 for the import to forecast of export/import of wood based panel. The estimated export and import of wood based panels in the year 2020 would be increased by 170% and 127% in respect to 2012.

Introduction

The world forest area in top 10 countries, Russia is in top position share with 20.01% and India is in 10th position accounts 1.69%. India's forest and tree cover of the country is 78.29 million ha., which is 23.81% of total geographical area. India's annual estimated production of wood from forest is 3.175 million m^3 and consumption is 48.0 million m^3 (Country Report, 2010). Uddin (2009) studied that time series behavior of imports and exports of Indonesian trade. Zajac (1998) studied that analysis of the structural changes in export and import of wood and wood based products in Poland. Exponential smoothing method has been applied that estimation of demand for wood panels of Iran in the year 2012 (Mazid *et al*. 2009). In this paper studies have been taken in relation to ARIMA time series forecast model on export and import of wood based panel includes veneers, fiber boards, hard boards and plywood. India plays a dominant role in the production, import, export and consumption of wood based panels globally. The wood based panel industry in India posted a healthy growth during the review period 1996 to 2012 and the trend is expected to continue over the future.

ARIMA model has been applied in various sectors in national and international level. In various sectors like, Dam reservoir inflow forecasting (Mohammad *et al*., 2012), Electricity demand (Mohamad, 2012), Forecasting inflation rate (Olajide *et al*., 2012) and weather forecasting (Mehmet, 2010) etc. Forecasting is a necessary input to planning in research, whether in business, government policy makers. Identifying the trend in export-import as well as predicting the future values of these two sectors, is a major challenge for the national trade policy makers. An approach to the modeling of stationary and non-stationary time series such as commonly occur in economic situations and control problems is discussed by Box and Jenkins (1970), building on the earlier work of several authors beginning with Yule (1927) and Wold (1938) involves iterative use of the three- stage process of identification, estimation, and diagnostic checking.

Alternatively p and q in an ARIMA model may be chosen on the basis of autocorrelation and partial autocorrelation function (ACF and PACF) graphs, in the so-called Box-Jenkins model identification process (Box and Jenkins, 1970). In this approach, the number of lags in the AR process is based on the PACF graph where the choice of p is where the PACF becomes zero (or is close to zero) at (p + 1) lags, and the choice of q lags in the MA process is chosen such that the ACF becomes zero at (q + 1) lags. So based on yearly export and import this study proposes an ARIMA model for forecasting the future value.

Methodology

The data used for this study consists of annual time series data of i) import value, and ii) export value of India during year 1996-1997 to 2011-2012. The wood based panel data for the study were collected from the official website of Ministry of commerce and Industry, Gov. of India, Trade Statistics: Export Import data bank (http://commerce.nic.in/eidb/default.asp). Data are compiled according to trade classification as harmonized system code 4 digits coding on the basis of veneer HS code-4408, Particle board HS code-4410, Fiber board HS code-4411 and Plywood HS code-4412. In this study use Autoregressive Integrated Moving Average (ARIMA) model is referred to as ARIMA (p,d,q) being AR: (p=degree of the autoregressive part); I: (d=degree of the difference involved), and MA: (q=degree of the mean part). The ARIMA model was developed in the 1970's by George Box and Gwilym Jenkins to describe changes on the time series using a mathematical approach also known as a BOX-Jenkins model. The Box –Jenkins refers to the set of procedures for identifying, fitting, and checking ARIMA models with time series data. Forecasts follow from the form of fitted model (Box and Jenkins, 1970).

Tele:
E-mail addresses: vinodup78@gmail.com

Autoregressive model: AR (p) is the general form:

$Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} +----------+ \Phi_p Y_{t-p} + \varepsilon_t$

Where, Y_t = Response (dependent) variable at time t

$Y_{t-1}, Y_{t-2}, Y_{t-3}--------, Y_{t-p}$ = Response variable at time lags t-1, t-2,-----,t-p respectively

Φ_0, Φ_1, Φ_2 ----------Φ_p= Coefficients to be estimated

ε_t =Error term at time t

Moving average model: MA (q) which has the general form

$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2}$ ----------$- \theta_q \varepsilon_{t-q}$

Where, Y_t = Response (dependent) variable at time t

μ= Constant mean of the process

$\theta_1, \theta_2,$ ---------- θ_q= Coefficients to be estimated

ε_t =Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2},$--------$\varepsilon_{t-q}$= Errors in previous time periods that are incorporated in the response Y_t

Mixed Autoregressive Integrated Moving Average (ARIMA) model: ARIMA (p,d,q) which has the general form:

$Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} +----------+ \Phi_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2}$ ----------$- \theta_q \varepsilon_{t-q}$

Determine whether the series is stationary or not by considering the graph of ACF. If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series should be considered stationary. If a graph of ACF dies down extremely slowly then the time series is non-stationary. If the series is not stationary, it can be transformed data to a stationary series by differencing. The graph of the autocorrelation function (ACF) and the Partial correlation function (PACF) to determine the model which process can be summarized as follows:

Model	ACF	PAC
AR(p)	Dies down	Cut off after lag q
MA(q)	Cut off after lag p	Dies down
ARMA(p,q)	Dies down	Dies down

Results and Discussion

Indian wood based panels feature of trade was a declining since 2000 to 2002, and the continuous sharp increase and annual growth of 73% from 2003 to 2012. During 1996-97 to 2011-12 total exports accounted for 28% of total trade of wood based panel and in 2011-12 accounted for 12% (22731 lakh INR). On the import side, total imports accounted for 72% of trade of wood based panel and in 2011-12 accounted for 88% i.e. 159800 lakh INR (Upadhyay, 2013). The export and import of wood based panel data are analysed by using SPSS a statistics computer package. The selection of ARIMA model with minimum value of BIC, non-significance B-J Q statistic, R^2 value and with minimum MAPE is considered an appropriate model for the purpose of forecasting. The forecast export and import values of wood based panel on the basis of period 16 years, from 1996-97 to 2011-12. The time series, ACF and PACF plots of the first-difference time series are shown in Figure 1&2 and Table 1&2 of the export and import respectively. It is clear from the time series plot that this first-difference time series is stationary (constant mean and approximately constant variance). There is evidence of decay on the PACF plot. These plots indicate that an export without order of AR and MA model would be appropriate model ARIMA (0,1,0) for the first differenced data. In the import case ACF and PACF plot shows that MA(1) model would be appropriate for the first-differenced data. Following this an ARIMA(0,1,1) model is suitable to the original time series.

Table 1. ACF and PACF of export of wood based panel at first difference

Lag	Autocorrelation	Std. Error[a]	Partial Autocorrelation	Box-Ljung Statistic	
				Value	Sig.[b]
1	.287	.234	.287	1.495	.221
2	.118	.226	.039	1.768	.413
3	-.124	.217	-.183	2.095	.553
4	-.193	.208	-.131	2.954	.565
5	-.203	.198	-.099	4.006	.549
6	-.384	.188	-.341	8.192	.224
7	-.117	.177	.039	8.628	.280
8	-.157	.166	-.174	9.523	.300
9	-.018	.153	-.108	9.536	.389
10	-.022	.140	-.137	9.562	.480
11	.100	.125	-.008	10.201	.512
12	.240	.108	.045	15.083	.237
13	.048	.089	-.152	15.379	.284

The underlying process assumed is independence (white noise).
b. Based on the asymptotic chi-square approximation.

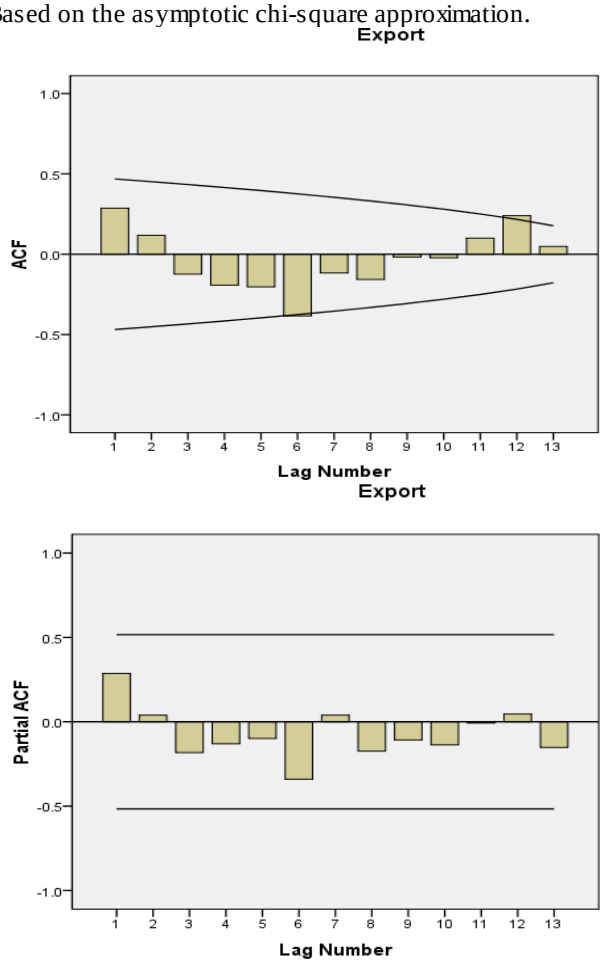

Fig. 1. ACF and PACF export of wood based panel at first difference

Wood based panel ARIMA models for the prediction of export and import of wood based panel with their statistics are described in Table 3. Higher values of R^2 value, minimum MAPE and minimum BIC of models for export and import show better accuracy of prediction and can be used in forecasting export and import. From the Table 3, we found that ARIMA (0,1,0) model initially selected the lowest BIC value for the export. Whereas, ARIMA (0,1,1) have almost lowest BIC values for the import, So we have considered all of them in our diagnostic checking. Although all the spikes depicts in both the ACF and PACF graphs are within the 95% confidence bands.

Table 2. ACF and PACF of import of wood based panel at first difference

Lag	Autocorrelation	Std. Error[a]	Partial Autocorrelation	Box-Ljung Statistic	
				Value	Sig.[b]
1	.461	.234	.461	3.865	.049
2	.023	.226	-.240	3.876	.144
3	.073	.217	.229	3.989	.263
4	.162	.208	.028	4.597	.331
5	.057	.198	-.049	4.681	.456
6	.006	.188	.048	4.682	.585
7	-.109	.177	-.213	5.063	.652
8	-.169	.166	-.034	6.108	.635
9	-.187	.153	-.145	7.594	.576
10	-.170	.140	-.057	9.064	.526
11	-.225	.125	-.144	12.294	.342
12	-.230	.108	-.069	16.807	.157
13	-.130	.089	.033	18.973	.124

a. The underlying process assumed is independence (white noise). b. Based on the asymptotic chi-square approximation.

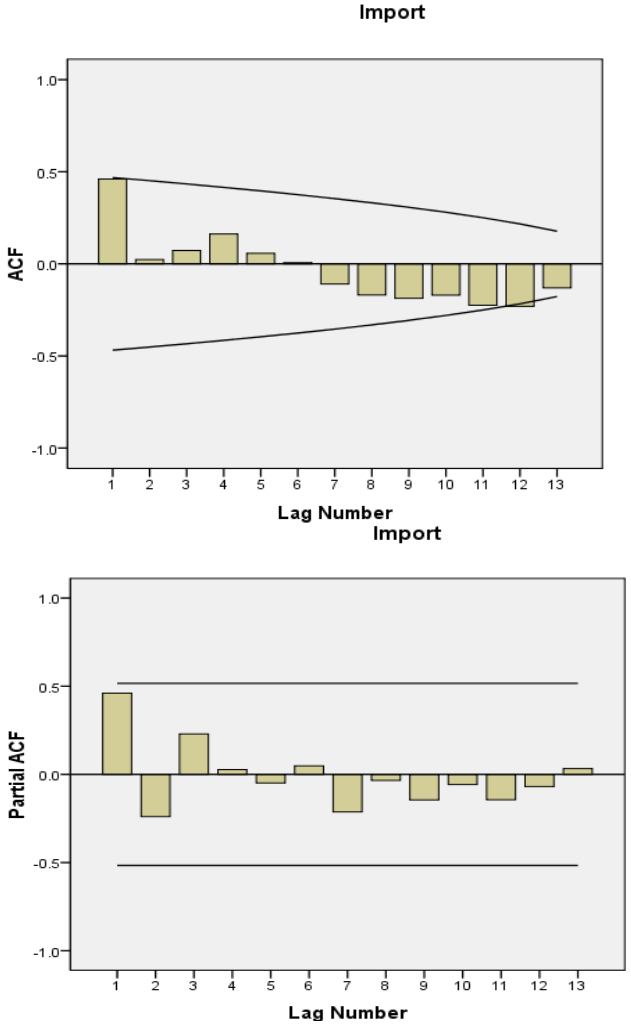

Fig. 2. ACF and PACF import of wood based panel at first difference

The estimate of the coefficient is reported in Table 4 alongside the standard error and 95% confidence interval of the estimate ARIMA(0,1,0) for export and ARIMA(0,1,1) for import of wood based panels.

Table 3. Model Statistics

WBP	Model	R-squared	RMSE	MAPE	MAE	Max APE	Max AE	Normalized BIC
Export	ARIMA(0,1,0)	0.832	3367	19.091	2663	58.472	5778	16.424
Import	ARIMA(0,1,1)	0.931	11830	32.973	8825	107.471	26140	19.118

Table 4. Coefficients for the ARIMA model

WBP	Model		Estimate	SE	t	Sig.
Export	ARIMA(0,1,0)	Constant	773.87	869.29	0.89	0.38
Import	ARIMA(0,1,1)	Constant	11462.84	5206.20	2.20	0.04
		MA1	-0.763	0.27	-2.81	0.01

Residual Diagnostics

First, we consider the residuals of the model. Figure 3&4 shows four diagnostic plots that are useful here. Firstly, the time series plot of the model residuals allow us to look for trends and heteroscedasticity in the residuals. It is clear from the time series plot shown in Figure 3&4 that the series of residuals are a stationary series (with constant mean and variance). Here we see that the ACF values are all within the 95% zero-bound - indicating that there is no correlation amongst the residuals. This plot is used as an indicator of the independence of the residual terms. This ACF and PACF residuals graph confirm that the residuals of the ARIMA(0,1,0) model for the export (figure 3) and ARIMA(0,1,1) model for the import (figure 4) are distributed as white noise indicating that the model fit well for the export of wood based panels.

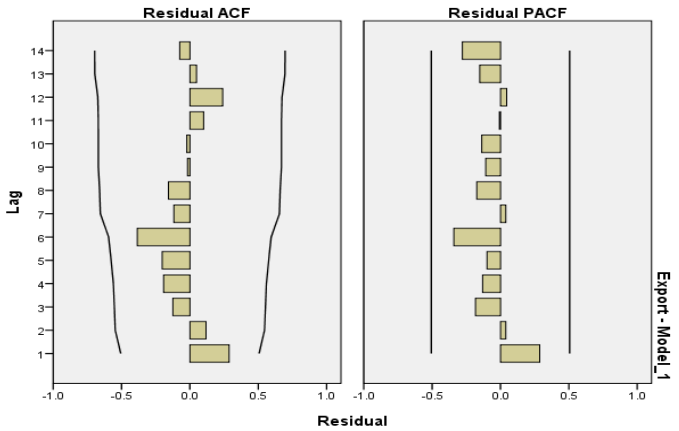

Fig. 3. Residuals plots of ACF and PACF for the export of wood based panels.

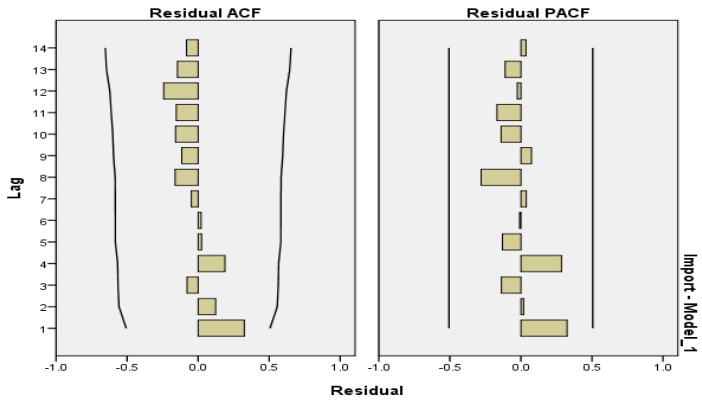

Fig. 4. Residuals plots of ACF and PACF for the import of wood based panels

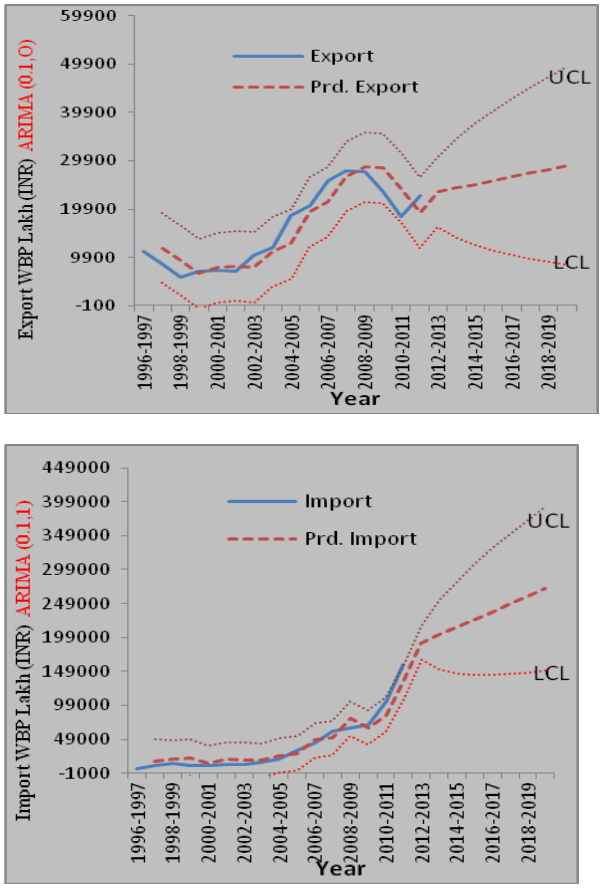

Fig. 5. Actual and forecasted value of export ARIMA (0,1,0) and import ARIMA (0,1,1) of Indian wood based panels.

Forecast for the Period 2013-2020

Now to see the performance of this model in the out-of-export forecasting, the forecasted value of the yearly export data for the period 1996-97 to 2019-20 will be derived using this model. Then we compare the forecasted value with the actual value, which is available from 2012-13 to 2019-20. The Figure 5 shows the forecast value obtained by models ARIMA(0,1,0) for the export and ARIMA(0,1,1) for the import along with the actual data respectively. We clearly see that the forecasted values are most close to the actual values for our finally suggested model. As the forecasted values go upward then go downward and then again go upward as compared to the actual value, which indicates that forecasting model weights all the observations equally. The basic aim of the study is to select models for forecasting export and import of Indian wood based panels. In this context we took our interest on ARIMA with respect to our data. It is found that BIC, MAPE and R^2 value based model selection procedures give ARIMA models with order (0,1,0) and order (0,1,1) for export and import respectively are appropriate for the data. It shows that the forecasting performance of ARIMA (0,1,0) and ARIMA (0,1,1) models are better.

Conclusion

On the basis of the above discussion, we can conclude that, to forecast export and import of wood based panel data, one can easily use ARIMA model. From the pattern of the graphical representation of the models we can conclude that on the whole the trend of export and import rose through all around the years. ARIMA (0,1,0) and ARIMA (0,1,1) are the most appropriate model to forecast for the export and import of wood based panel to India. The forecasted value of export and import of Indian WBP will be 28922 lakh (INR) and 242209 lakh (INR) respectively in the year 2020, which will be increasing more than 170% and 127% as compared to 2011-12.

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