Forecasting with Univariate Time Series Models: A Case of Export Demand for Peninsular Malaysia's Moulding and Chipboard

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Abstract

This study determines a suitable method from the univariate time series models to forecast the export demand of moulding and chipboard volume (m^3) from Peninsular Malaysia using the quarterly data from March 1982 to June 2009. Export demand for moulding and chipboard were estimated using univariate time series models including the Holt-Winters Seasonal, ARAR algorithms and the seasonal ARIMA models. The seasonal ARIMA $(1, 0, 4) \times (0, 0, 1, 0)_4$ model produced the best forecast at the lowest forecast errors of MAPE, MAE and RMSE at 18.83%, 32730.8 and 35282.13, respectively. It forecasts the volume (m^3) of moulding and chipboard for export to reach more than 150000 m^3, and it is expected to be within range of 100000 to 250000 m^3 at 95% confidence level. The forecasts assist in decision making process and facilitate a short-term marketing plan to meet the export demand from international market.

Keywords: Forecasting, Moulding and Chipboard, Univariate time series

1. Introduction

Timber industry is one of the growth sectors identified under Malaysia's Industrial Master Plans (IMPs) which is based on export-led growth strategy (ELG). The ELG is a mechanism as the engine of economic growth (Amoah *et al.,* 2008). Therefore, like most of the other export oriented timber products, the export of moulding and chipboard stimulates a dynamic economic growth by creating employment opportunities, channeling technological advancement and providing major foreign investments into the country.

Given its socioeconomics importance, timber industry in Peninsular Malaysia has always aimed at ensuring the export of moulding and chipboard to meet demand from international markets. If the timber industry fails to produce and keep in inventory enough units of moulding and chipboard to meet the export demand, the industry could lose export transaction to many other competitors resulting in financial losses. In order to be certain about the amount of moulding and chipboard for export, the decisions on inventory must depend on the anticipated amount of future export of moulding and chipboard.

Unfortunately, the future export for moulding and chipboard from Peninsular Malaysia is imperfectly known. Thus, the decisions about the inventory of moulding and chipboard must be based on export forecasts. The forecast can anticipate the future trend and pattern of the export of moulding and chipboard and thereby it will help in developing the strategic marketing plan for its export.

By considering the most popular method in obtaining reliable forecasts in forecasting timber products (Hetemaki and Mikkola, 2005; Hetemaki *et al.,* 2004; Buongiorno *et al.,* 1984; Buongiorno and Balsiger, 1977), this study used quantitative analysis of the univariate time series in forecasting the export of moulding and chipboard from Peninsular Malaysia using quarterly volume (m^3) data from March 1982 to June 2009. The univariate time series method is an approach to derive forecasts of a time series solely on the basis of the historical behavior of the series itself (Hoff, 1983). This method is very useful because it can provide reasonable accurate short- to medium-term forecasts and also inexpensive to apply.

We have at least two reasons that justify the need to undertake the application of the univariate time series models in forecasting the export of moulding and chipboard volume (m^3). The first reason is that moulding and chipboard belong to a major group of timber products for which official data exists and they are reasonably compatible over a longer time span. The data is reliable to produce forecasts that determine the amount needed in the future export of moulding and chipboard.

The second reason is that moulding and chipboard belong to a group of key commodities which contribute considerable amount of income to the national economic development. The application of the univariate time series models forecast the future volume (m^3) of moulding and chipboard for export, thus it enables timber industry to keep comprehensive details on the quantity of moulding and chipboard to be exported over a period of time. It avoids financial losses that may result from poor decision makings, improve the efficiency in the planning and ensure the export continue to grow and generates income for the country.

In relevance to the application of the univariate time series, the objectives of the study are twofold: first, to determine a suitable method from the univariate time series models to forecast the export of moulding and chipboard volume (m^3) from Peninsular Malaysia for a specific period of time; and second, to use the forecasts as relevant information in decision making process. The forecasts provide most favorable volume for the future export of moulding and chipboard and identify short term marketing strategy for the export market. On the other hand, this study also contributes to the effort in breaking the limitation in finding evidence of scientific explanations on univariate time series models that associated with the export of timber products from Peninsular Malaysia.

The study is organized as follows. In the next section, the methodology and the data are described. The results and discussion are presented in following section. Finally, concluding remarks are highlighted.

2. Methodology and Data

This section briefly describes the methodology and data used in this study.

This study used the secondary data which represented the whole Peninsular Malaysia. One hundred and ten (110) quarterly data on the export of moulding and chipboard volume (m^3) from March 1982 to June 2009 were obtained from the *Report on Timber Export Statistics*, Malaysia Timber Industry Board (MTIB). Figure 1 shows the time series plot for the export of moulding and chipboard volume (m^3) from March 1982 to June 2009.

One hundred (100) within-sample data (March 1982 to December 2006) were used in modelling process while ten (10) remaining data (March 2007 to June 2009) were applied to assess the out-of-sample forecasting abilities. Since the data has a seasonal period 4, we differenced the time series once at lag 4 and the mean was subtracted. We then proceeded to fit a zero-mean ARMA model to the *transformed* data. A zero mean ARMA (*p, q*) model is defined as a sequence of random variables $\{X_t\}$ given by,

$$X_t - \phi_1 X_{t-1} - \ldots - \phi_p X_{t-p} = Z_t + \theta_1 Z_{t-1} + \ldots + \theta_q Z_{t-q},$$

where $\{Z_t\}$ is a sequence of uncorrelated random variables with zero mean and constant variance, denoted as $\{Z_t\} \sim WN(0, \sigma^2)$. We define $\{X_t\}$ to be an ARMA (*p, q*) with mean μ if $\{X_t - \mu\}$ is a zero mean ARMA (*p, q*) process.

The time series $\{Y_t\}$ is a seasonal ARIMA (*p, d, q*) X (*P, D, Q)s* model with period *s* if the differenced series $X_t = (1-B)^d (1-B^s)^D Y_t$ is an ARMA process.

The other method used in this study was the Holt-Winters Seasonal algorithm. The Holt-Winters Seasonal algorithm is commonly used for time series data that contain both trend and seasonality. It is based on three smoothing equations of the level, trend, and seasonality. We applied the Holt-Winters Seasonal algorithm to the time series data to produce the forecast.

The ARAR is another forecasting algorithm that have used in the study and it consists of three important steps. The initial step is to decide whether the underlying process is "long-memory" and if so to apply a memory-shortening transformation before attempting to fit an autoregressive (AR) model. The next step involves an autoregressive (AR) model fitted to the memory short-term series. Details on the explanation whether the time series is long or short memory are explained in Brockwell and Davis (2002). The forecasting analysis is the final step for the application of ARAR algorithm. For the complete and detailed explanation on all methods, please refer to Brockwell and Davis (2002).

Computer software called the Interactive Time Series Modelling (ITSM) was used in the process of fitting time series model. ITSM is interactive Windows based menu-driven software for univariate and multivariate time series modelling and forecasting. The ITSM software is designed for the user engaged in time series analysis and forecasting with exceptional user-friendly tools (Lee and Strazicich, 2002).

The accuracy of the forecasts is measured using the mean absolute error (MAE), the root mean square error (RMSE) and the mean absolute percentage error (MAPE). The following equations are respective formulas used in computing the MAE, RMSE and MAPE.

$$\text{MAE} = \frac{\sum_{i=1}^{n}|y_i - \hat{y}_i|}{n}, \text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n}}, \text{MAPE} = \frac{\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right|}{n} \text{X } 100\%,$$

where y_i and $\hat{y}_i$ are the actual observed values and the predicted values respectively while n is the number of the predicted values.

The accuracy of forecast is evaluated based on the estimation of error, thus the smaller the value of MAE, RMSE and MAPE, the better the forecast is. The criterion of MAPE is the decisive factor because it is expressed in easy generic percentage term. Table 1 shows the criteria of MAPE for model evaluation based on Lewis (1982).

3. Results and Discussions

In this section, the results are presented and discussed.

The best fitted model (based on the Akaike Information Corrected Criterion, AICC) to the *transformed* data $\{X_t\}$ is ARMA (1, 4) model given as,

$X_t = -0.1905X_{t-1} + Z_t + 0.6668Z_{t-1} + 0.5521Z_{t-2} + 0.5978Z_{t-3} - 0.2875Z_{t-4}$

where $\{Z_t\} \sim$WN (0, 3894000).

Note that the original (untransformed) time series follow a seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model. Thus, among the forecasting methods that considered in this study, the seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model produce the best forecast, in the sense of having the lowest forecast errors. This model has the lowest MAPE of 18.83% (see Table 2) and it is classified as a good forecasting model because the MAPE is in the ranges of 10% to 20% (see Table 1). The plot of time series for the application of seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model is shown in Figure 2.

It provides the forecasts for a period of six quarters at 95% confidence intervals as shown in Table 3 and Figure 3. The forecasts show the least volume (m^3) for the export of moulding and chipboard is in December 2009 at 158760 m^3 while the most anticipated volumes is in June 2010 at 194760 m^3. These anticipated volumes are relevant to assist timber industry from over- or underestimate the volume that required in the future export of moulding and chipboard. For the period of six quarters and at 95% confidence level, the volume (m^3) of moulding and chipboard that needed for export is expected to be within ranges of 100000 to 250000 m^3.

As one of the industries that have a large scale of operation and process products from raw timber materials, it is important for timber industry to know the expected volume in the future export of moulding and chipboard. In this case, these forecasts provide in advance information that facilitates the preparation in the inventory for the export of moulding and chipboard. The forecasts help timber industry to be able to utilize the most favorable amount of raw timber materials and avoids the unnecessary exploitation of timber resources; pacifying the challenges from the depletion rate in supplies of timber raw material. At the same time, the forecasts anticipate the future trend and pattern of the export of moulding and chipboard; thereby it will help in developing a strategic marketing plan for a specific period of time.

On the contrary, if timber industry is not precisely know the volume that required in the future export of moulding and chipboard; it may put timber resources under the threat of exploitation which further facilitates the depletion rate in raw timber materials supplies. From the economic point of view, it will put timber industry to face the failures in meeting export demand from international markets and lose export transactions to many other competitors. The failures would cause financial losses and marketing blunders as well as hinder the industry to gain lucrative profit and revenues from the export of moulding and chipboard.

4. Conclusions

This study indicates that the proposed model produces a good forecasting in the export of moulding and chipboard volume (m^3) from Peninsular Malaysia to international market. It presents forecast that determine the most favorable volume (m^3) for the future export of moulding and chipboard. These forecasts can be used in decision making process and further be implemented in short term marketing strategy for the export market. Therefore, the export will continuously contribute to stimulate a vigorous economic development and at the same time, utilize timber resources in an efficient manner.

This study of course is based on the assumption that related events will not drastically change the statistics. However, it is reasonable to do further research in order to understand more on the trend of the export of timber products and efficient use of timber resources.

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Table 1. Typical MAPE Values for Model Evaluation

MAPE (%)	Evaluation
MAPE ≤ 10%	High Accuracy Forecasting
10% < MAPE ≤ 20%	Good Forecasting
20% < MAPE ≤ 50%	Reasonable Forecasting
MAPE > 50%	Inaccurate Forecasting

Source: Lewis (1982).

Table 2. MAE, RMSE and MAPE Values for Holt-Winters Seasonal, ARAR algorithms and Seasonal ARIMA $(1, 0, 4) X (0, 0, 1, 0)_4$ model for the Quarterly Export of Moulding and Chipboard Volume (m^3)

Model/Criteria	MAE	RMSE	MAPE
Holt-Winters Seasonal algorithm	44418.8	46307.01	25.08 %
ARAR algorithm	46242.8	47295.17	25.71 %
Seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model	32730.8	35282.13	18.83 %

Table 3. Forecasts for the Quarterly Export of Moulding and Chipboard Volume (m^3) using Seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model at 95% confidence level.

Quarter	Forecasts (Volume, m^3)	95% Confident Intervals	
		Lower (Volume, m^3)	Upper (Volume, m^3)
Sep-09	170460	131780	209150
Dec-09	158760	115920	201600
Mar-10	171440	125030	217850
Jun-10	194760	144330	245190
Sep-10	176400	120630	232170
Dec-10	163490	103810	223170

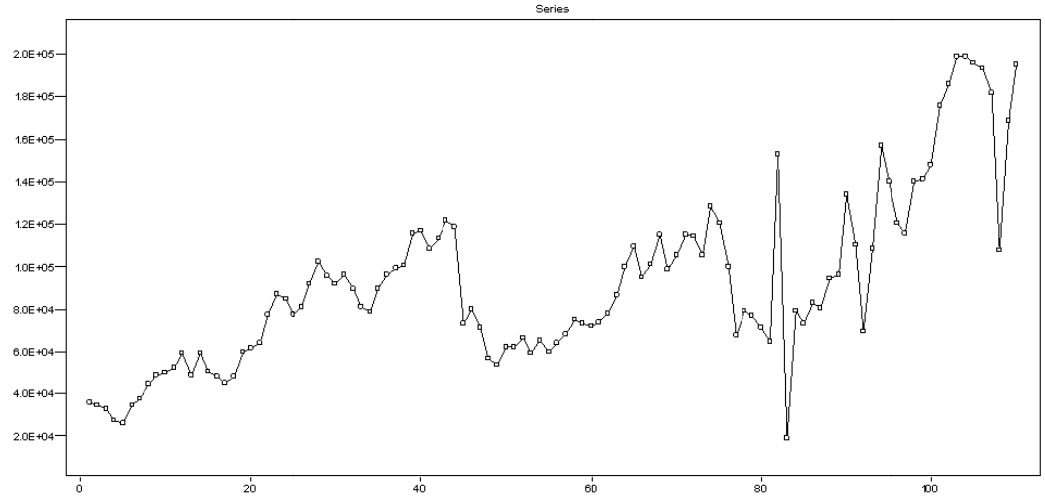

Figure 1. Time Plot for the Quarterly Export of Moulding and Chipboard Volume (m^3) from March 1982 to June 2009

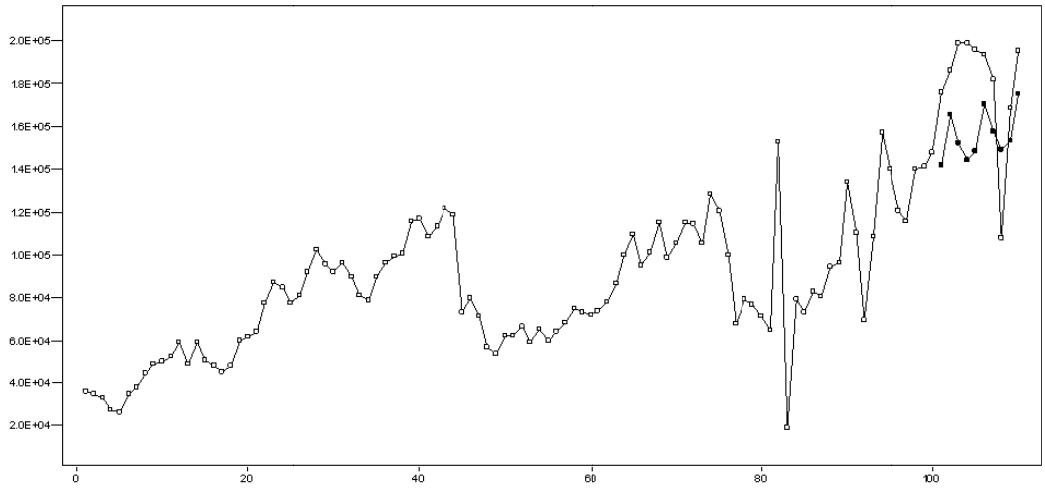

Figure 2. Time Plot for the Actual and Forecasts of the Quarterly Export of Moulding and Chipboard Volume (m^3) using Seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model

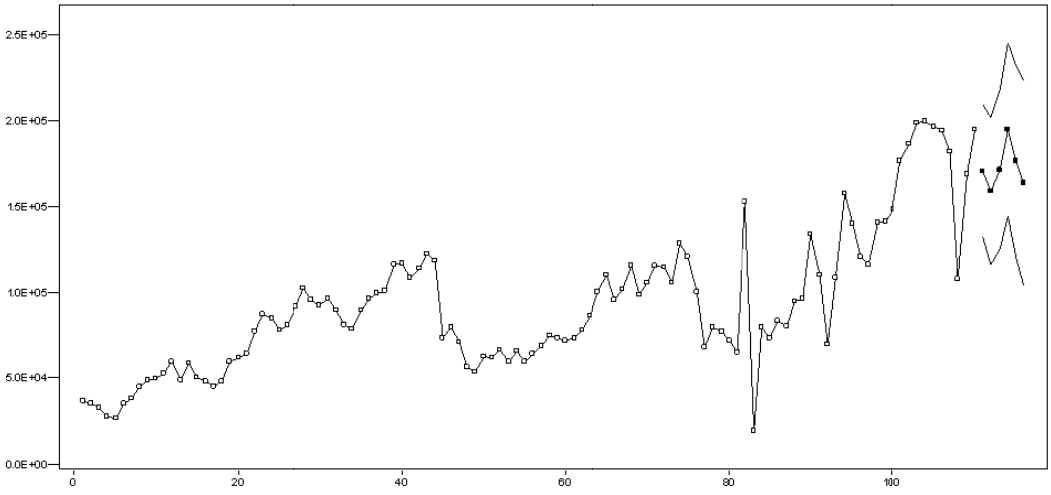

Figure 3. Time Plot for the Forecasts of the Quarterly Export of Moulding and Chipboard Volume (m^3) using Seasonal ARIMA (1, 0, 4) X $(0, 0, 1, 0)_4$ model at 95% confidence level.