Analysis Monthly Import of Palm Oil Products Using Box-Jenkins Model

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Abstract. The palm oil industry has been an important component of the national economy especially the agriculture sector. The aim of this study is to identify the pattern of import of palm oil products, to model the time series using Box-Jenkins model and to forecast the monthly import of palm oil products. The method approach is included in the statistical test for verifying the equivalence model and statistical measurement of three models, namely Autoregressive (AR) model, Moving Average (MA) model and Autoregressive Moving Average (ARMA) model. The model identification of all product import palm oil is different in which the AR(1) was found to be the best model for product import palm oil while MA(3) was found to be the best model for products import palm kernel oil. For the palm kernel, MA(4) was found to be the best model. The results forecast for the next four months for products import palm oil, palm kernel oil and palm kernel showed the most significant decrease compared to the actual data.

1. Introduction
The objectives of this study are to identify the pattern of import of palm oil products, to model the time series and to forecast the monthly import of palm oil products. The most important tropical vegetable oils in the global market for oils and fats markets is palm oil [4]. In order to fill the gap and the demand, Malaysia has to imports crude palm oil mostly from Indonesia. The import of palm oil has increased to 1.1 million from 2010 compared to the previous year [4, 8]. Due to insufficient crude palm oil for local activities, Malaysia has to import crude palm oil [1, 11]. The way to support local supply of palm oil, Malaysia has to import products of palm oil [3]. About 80% of palm oil and palm kernel oil are used in food applications [5].

2. Method
The stationary of time series data could be determined by plotting the time series plot or autocorrelation function (ACF) plot. The series is considered to be stationary if the ACF plot of the time series value dies down quickly and then the series considered to be non stationary if the ACF plot of the time series value dies down extremely slowly [1,7].

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There are three basic models which are autoregressive (AR) model, moving average (MA) model and autoregressive moving average model (ARMA). There are 4 phases in Box-Jenkins methodology which are model identification, parameter estimation, diagnostic checking and forecasting [6, 12]. There are few studies that use forecasting as a stepping stone in order to get preliminary results and use it with other mathematical or statistical methods [9, 10]. There are other quite considerable studies were carried out to use statistical techniques in Malaysia and other countries [13, 14, 15]. Whereas the concept of time series have been studied by [16] and [17].

| Model                          | ACF                  | PACF                      |
|-------------------------------|----------------------|---------------------------|
| MA (q): moving average of order q | Cuts off after lag q | Dies Down                 |
| AR (p): autoregressive of order p | Dies Down            | Cuts off after lag p       |
| ARMA (p,q): mixed autoregressive moving average of order (p,q) | Dies Down            | Dies Down                 |

The study will forecast the variable of interest using a linear combination of past values of the variable in an autoregressive (AR) model [2, 12].

\[ y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_p y_{t-p} + e_t \]  

(1)

Moving average (MA) uses past forecast errors in a regression-like model.

\[ y_t = c + e_t + \theta_1 e_{t-1} + \theta_2 e_{t-2} + ... + \theta_q e_{t-q} \]  

(2)

The order of the ARMA model is found by examining the autocorrelations and partial correlations of the stationary series.

\[ y_t = \Phi_1 y_{t-1} + ... + \Phi_p y_{t-p} + e_t - e_{t-1} - ... - \theta_q e_{t-q} \]  

(3)

The Box-Ljung test was used to test the lack of fit of a time series model. If the p-value associated with the \( Q \) statistic is small (p-value < 0.05), the model considered inadequate [2]. If the model is inadequate, the analysis continued until the level of satisfactory for model achieved. Once an adequate model has been selected, it was used to forecast for one period or several periods into the future. Once the best model is obtained, the next step is forecast using estimated model equation.

3. Result & Discussion

The results obtained by analyzing the import of palm oil products data using the Box-Jenkins approached.
3.1 Model Identification and Forecasting for Palm Oil

![Time Series Plot of Products Import Palm Oil](image1)

**Figure 1.** The Time Series Plot of Products Import Palm Oil.

The stationary mean is 81650. To identify whether the graph is stationary or non-stationary, it can be determined by the autocorrelation function (ACF) and partial autocorrelation function (PACF).

![Autocorrelation Function for Products Import Palm Oil](image2)

**Figure 2.** The Autocorrelation Function (ACF) for Product Imports Palm Oil.

The time series value dies down exponentially fast in Figure 2. The ACF plot shows the data was stationary. Hence, differencing is not necessary.
The model identified by reading the plot of ACF and PACF to determine whether the model is AR, MA or ARMA. Figure 3, shows there are three different model to be selected which are AR(1), MA(2) and ARMA(2,1). We determined the best parameter by testing the parameter significant and Ljung-Box Chi Square statistic. Next, to determine the best model we choose the smallest value of mean square error (MSE). Therefore, the model that satisfied all the test is AR(1). The model can be estimated as in equation (4).

\[ y_t = 0.9548 \, y_{t-1} + \varepsilon_t \]  

Figure 3. The ACF and PACF plot for Product Import Palm Oil.

Figure 4. Forecasting for Products Import Palm Oil.

Figure 4, shows the result of forecast for four months. From the figure above, it started drastically decrease at second month until fourth month. The result will be not completely accurate because sometimes forecasts will deviate from the actual demand.

| Month     | Forecasting Value |
|-----------|-------------------|
| January 2016 | 79715.7           |
| February 2016 | 76115.7           |
| March 2016   | 72678.3           |
| April 2016   | 69396.2           |

Table 2. Forecasting Value.
3.2 Model Identification and Forecasting for Palm Kernel Oil

![Time Series Plot of Products Import Palm Kernel Oil](image1)

**Figure 5.** The Time Series Plot of Products Import Palm Kernel Oil.

The stationary mean is 23712. To identify whether the graph is stationary or non-stationary, it can be determined by the autocorrelation function (ACF) and partial autocorrelation function (PACF).

![Autocorrelation Function for Products Import Palm Kernel Oil](image2)

**Figure 6.** The Autocorrelation Function (ACF) for Product Imports Palm Kernel Oil.

The time series value dies down exponentially fast in Figure 6. The ACF plot shows the data was stationary. Hence, differencing is not necessary.
The model identified by reading the plot of ACF and PACF to determine whether the model is AR, MA or ARMA. Figure 7, shows there are three different model to be selected which are AR(1), MA(3) and ARMA(1,3). We determined the best parameter by testing the parameter significant and Ljung-Box Chi Square statistic. Next, to determine the best model we choose the smallest value of mean square error (MSE). Therefore, the model that satisfied all the test is MA(3). The model can be estimated as in equation (5).

\[ y_t = \varepsilon_t - 0.3734\varepsilon_{t-1} - 0.4745\varepsilon_{t-2} - 0.8617\varepsilon_{t-3} \]  

(5)

Figure 8. Forecasting for Products Import Palm Kernel Oil.

Figure 8, shows the result of forecast for four months. From the figure above, it started drastically decrease at second month until fourth month. The result will be not completely accurate because sometimes forecasts will deviate from the actual demand.

| Table 3. Forecasting Value. |
|----------------------------|
| Month                      | Forecasting Value |
|----------------------------|--------------------|
| January 2016               | 2540.393           |
| February 2016              | -1832.54           |
| March 2016                 | -2913.11           |
| April 2016                 | 0                  |
3.3 Model Identification and Forecasting for Palm Kernel

![Time Series Plot of Products Import Palm Kernel](image1)

**Figure 9.** The Time Series Plot of Products Import Palm Kernel.

The stationary mean is 2549. To identify whether the graph is stationary or non-stationary, it can be determined by the autocorrelation function (ACF) and partial autocorrelation function (PACF).

![Autocorrelation Function for Products Import Palm Kernel](image2)

**Figure 10.** The Autocorrelation Function (ACF) for Product Imports Palm Kernel.

The time series value dies down exponentially fast in Figure 10. The ACF plot shows the data was stationary. Hence, differencing is not necessary.
The model identified by reading the plot of ACF and PACF to determine whether the model is AR, MA or ARMA. Figure 11, shows there are three different model to be selected which are AR(2), MA(4) and ARMA(2,4). We determined the best parameter by testing the parameter significant and Ljung-Box Chi Square statistic. Next, to determine the best model we choose the smallest value of mean square error (MSE). Therefore, the model that satisfied all the test is MA(4). The model can be estimated as in equation (6).

\[ y_t = \varepsilon_t - 0.4673 - 0.8316\varepsilon_{t-2} - 0.3986\varepsilon_{t-3} - 0.6504\varepsilon_{t-4} \] (6)

Figure 12. Forecasting for Products Import Palm Kernel.

Figure 12, shows the result of forecast for four months. The figure shows fluctuating graph starting January till April. The result will be not completely accurate because sometimes forecasts will deviate from the actual demand.

**Table 4.** Forecasting Value.

| Month       | Forecasting Value |
|-------------|-------------------|
| January 2016| 1066.959          |
| February 2016| 1073.761         |
| March 2016  | 137.0658          |
| April 2016  | 348.829           |
4. Conclusion
In conclusion, all the three products import of palm oil, palm kernel oil and palm kernel shows trend pattern and non-seasonal. The differencing is not necessary in our data for all three products import since it already in stationary state. The best model for product import palm oil was AR(1) while for products import palm kernel oil the best model was MA(3). Lastly, the best model for products import palm kernel was MA(4). Lastly, all the three of the model was forecasted for four month starting from January 2016 until April 2016 and the trend of the forecasted data was obtained.

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Reference
[1] Abhishek S and Mishra G C 2015 Application of Box-Jenkins Method and Artificial Neural Network Procedure for Time Series Forecasting of Prices Statistics in Transition new series 16(1) 23-25.
[2] Ljung G M and Box G E P 1978 On A Measure of Lack of Fit in Time Series Models Biometrika 65 297-303.
[3] Mohammad H A 1999 Interactions Between Malaysian And Indonesian Palm Oil Industries: Simulating The Impact of Liberalization of Imports of CPO from Indonesia Journal of Oil Palm Research 11(2) 46-56.
[4] World Growth 2011 The Economic Benefit of palm oil to Indonesia acessible at: http://www.worldgrowth.org/assets/
[5] Salmiah A 2000 Non-food Uses of Palm Oil and Palm Kernel Oil MPOPC Palm 24 12-15
[6] Sufahani S, Che-Him N, Khamis, A, Rusiman M S, Arbin N, Yee C K, Ramli I N, Suhaimi N A, Jing S S and Azmi Z A 2017 Descriptive Statistics with Box-Jenkins and Marketing Research for Jewellery Company in Malaysia Far East Journal of Mathematical Sciences 101(10) 2151-2161
[7] Nor M E, Khamis A, Saharan S, Abdullah M A A, Salleh R M, Asrah N M, Khalid K, Aman F, Rusiman M S, Halim H, Lee M H and Nor E 2016 Malaysia Tourism Demand Forecasting by Using Time Series Approaches Social Science (Pakistan) 11(12) 2938-2945
[8] Sufahani S F and Ahmad A 2012 A Comparison Between Normal and Non-Normal Data in Bootstrap Applied Mathematical Sciences 6 (89-92) 4547-4560
[9] Ismail Z, Abu N and Sufahani S 2016 New Product Forecasting with Limited or No Data AIP Conference Proceedings 1782 050009
[10] Sufahani S and Ismail Z 2014 The Statistical Analysis of the Prevalence of Pneumonia for Children Age 12 in West Malaysian Hospital Applied Mathematical Sciences 8(113-116) 5673-5680 Sufahani S and Ismail Z 2014 A New Menu Planning Model for Malaysian Secondary Schools using Optimization Approach Applied Mathematical Sciences 8(49-152) 7511-7518
[11] Jayeola D, Ismail Z, Sufahani S F and Manliura D P 2017 Optimal Method for Investing on Assets using Black Litterman Model Far East Journal of Mathematical Sciences 101(5) 1123-1131
[12] Rusiman M S, Hau O C, Abdullah A W, Sufahani S F, Azmi N A 2017 An Analysis of Time Series for the Prediction of Barramundi (Ikan Siakap) Price in Malaysia Far East Journal of Mathematical Sciences 102(9) 2081-2093
[13] Bin Shafi M A, Bin Rusiman M S and Che Yusof N S H 2014 Determinants Status of Patient After Receiving Treatment at Intensive Care Unit: A Case Study in Johor Bahru. 1st International Conference on Computer, Communications, and Control Technology.
Proceedings 30 September 2014, 6914150, 80 – 82.

[14] Rusiman M S, Nasibov E and Adnan R 2011 The Optimal Fuzzy C-regression Models (OFCRM) in Miles per Gallon of Cars Prediction, Proceedings – 2011 IEEE Student Conference on Research and Development, SCORcD 2011, 6148760 333-338

[15] Shafi M A and Rusiman M S 2015 The Use of Fuzzy Linear Regression Models for Tumor Size in Colorectal Cancer in Hospital of Malaysia Applied Mathematical Sciences 9 (56) 2749-2759

[16] Khalid K, Mohamed I and Abdullah N A 2015 An Additive Outlier Detection Procedure in Random Coefficient Autoregressive Models AIP Conference Proceedings 1682 050017

[17] Mohamed I, Khalid K And Yahya M S 2016 Combined Estimating Function for Random Coefficient Models with Correlated Errors Communications In Statistics—Theory And Methods 45(4) 967-975