Demand forecasting for crude palm oil (CPO) using the time series method

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Abstract. Palm oil is one of the most consumed and produced oils in the world. It can be used as a raw material for various products such as food, cosmetics, as well as a source of biofuel and biodiesel. One of the companies that produces Crude Palm Oil (CPO) is company X. A fundamental mistake that often occurs in making sales decisions for CPO products is inaccuracy in providing sales predictions. So the aim of this study was to evaluate the demand forecasting made by Company X using the Time Series method. Based on the company's historical data from January 2013 to December 2017, CPO sales forecasting for 2018 is carried out using the decomposition method, moving average, exponential smoothing, and trend analysis as part of the Time Series method. The forecasting results showed that the highest sales is in May 2018 amounting to 2,105,952 kg and the lowest forecasting in December 2018 about 766,667 kg.

1. Introduction

Palm oil (**Elaeis guineensis**) is an important industrial plant producing cooking and industrial oil. Indonesia is the largest producer of palm oil in the world who could produce more than 32.5 million tons of oil palm in 2016. Palm oil is one of the most consumed and produced oils in the world. Palm Oil is easy to produce, cheap, and stable production as a raw material for various products such as food, cosmetics, hygiene products, and also as a source of biofuels or biodiesel. In 2016, the production of world palm oil is dominated by Indonesia and Malaysia which produced a total of around 85-90% of the world's total palm oil production amounting 65.6 million tons [1]. Company X is a private plantation company located on Sumatra Island, which is also one of the producers of crude palm oil (CPO) in Indonesia.

The success of Company X is reflected in the ability of management to optimally utilize opportunities to generate sales and profits as expected. Measurement of this opportunity can be done in 2 ways, namely qualitative and quantitative measurements. Qualitative measurements are based on the results of qualitative forecasting from an expert [2]. While quantitative measurements are carried out using statistical methods, one of them is the time series method. This method is carried out to make decisions about demand and evaluate company performance, forecasting results are critical [3].

The demand forecasting function serves many broad managerial goals in organizations that are looking for profit or those who are not looking for profit. The forecasting process will later get the forecasting results used by production or operations management in making decisions regarding process selection, capacity planning, and facility layout, as well as for ongoing decisions regarding
planning, scheduling, and inventory. Demand forecasting is needed to find out basic information about trends and patterns of product consumption. Forecasting can be done both quantitatively and qualitatively. Quantitative measurements used statistical methods, while qualitative measurements based on judgement from those who do forecasting [4]. The aim of this study was to evaluate the demand forecasting made by Company X using the Time Series method.

2. Material and Method

This research was conducted by observing company X and interviewing the managers to acquire the historical data. Data of the historical demand was from January 2013 to December 2017, used to construct the forecasting methods. The Forecasting was analysed quantitatively by using the SPSS 20 program. SPSS is a program for processing statistical data which is quite easy to use [5]. Forecasting is done to find out how much the volume of demand for CPO products in the future or one year ahead, from January to December 2018.

Period of the forecasting was about 12 months so this forecast is included in the medium-term forecast. The forecast error of this method in time series measured and processed by using SPSS 20 Program with mean absolute deviation (MAD), and mean absolute percentage of error (MAPE) as a basic error measurement used in forecasting area. MAD is an error forecasting the actual value of each period. This MAD value then used as an absolute error. MAPE is the average absolute percentage of forecast error by calculating the absolute error for each period. This error is then divided by the number of periods measured.

3. Results and Discussion

3.1 Forecasting CPO Production Demand

This study revealed that Company X carried out the forecasting for production demand using qualitative methods, in particular using the delivery order (OD) system. This system was applied due to the absence of marketing department. Therefore, the production capacity for each period in Company X was solely based on the order from the marketing department at the head office.

Forecasting can be interpreted as an estimate of future events beyond the control of the organization as a basis for managerial planning [6]. Changes in the level of demand, competition for raw material prices, or producing products with seasonal raw materials require precise demand forecasting [7]. There are three terms in systematics component which is tried to be measured, there are trends, cycles and random variations.

3.2. Forecasting Demand Using the SPSS Program

Time series forecasting use the historical data for the main data to predict the future that assume the past pattern [8]. The historical data on the CPO demand from January 2013 to December 2017 can be seen in Table 1. Table 1 shows that the data in almost every year have the same trend, with the highest average value in every May in the amount of 2,050,490 kg and the lowest average every years is in December in the amount of 596,721 kg. The demand forecasting data needs to be made into a scatter diagram. This scatter diagram is used to find out whether there is a relationship between sales volume and sales period. Then this scatter diagram can know the pattern of sales data so that it can determine the right forecasting method (Figure 1).

The diagram above showed that the data pattern tends to be stationary but there is still a little element of trend. Stationary data patterns occur if there is data that fluctuates around a constant average value. In the statistical data forecasting phase, data normality tests, and stationary tests can be carried out. Normality test is needed to find out whether the data distribution has been done follows or approaches the normal distribution, in the form of bell-shaped data. The Good data is data that has a pattern like a normal distribution, not uniformly distribution, the pattern of data is in the middle and balanced [9]. Stationary test is the most important stage in time series method, which is used to determine the validity of the data.
### Table 1. Historical data for CPO demand from January 2013 to December 2017

| Month | 2013        | 2014        | 2015        | 2016        | 2017        | Average    |
|-------|-------------|-------------|-------------|-------------|-------------|------------|
| Jan   | 1,576,690   | 1,257,490   | 545,310     | 363,810     | 585,120     | 613,154    |
| Feb   | 1,536,890   | 1,059,000   | 750,920     | 1,109,350   | 740,730     | 770,881    |
| Mar   | 159,540     | 1,763,920   | 1,366,180   | 1,549,920   | 1,414,110   | 1,222,017  |
| Apr   | 1,833,070   | 1,836,550   | 2,100,000   | 1,819,580   | 1,859,360   | 1,889,712  |
| May   | 1,859,450   | 1,761,500   | 1,950,000   | 1,988,730   | 2,692,770   | 2,050,490  |
| Jun   | 1,570,870   | 1,565,230   | 2,170,120   | 1,971,400   | 1,413,860   | 1,738,296  |
| Jul   | 1,598,460   | 1,272,840   | 1,688,150   | 854,950     | 1,851,680   | 1,070,214  |
| Oct   | 1,150,010   | 1,776,510   | 1,741,730   | 1,029,520   | 1,047,920   | 1,349,138  |
| Nov   | 1,157,670   | 1,071,040   | 1,270,730   | 505,170     | 718,640     | 724,364    |
| Dec   | 1,445,840   | 1,376,900   | 991,540     | 452,450     | 986,320     | 596,721    |

**Figure 1.** The diagram of the sale of CPO products in Company X from January 2013 - December 2017

3.3. Result forecasting demand using the SPSS program

From the pattern of data that has been plotted, the right method can be determined to do the forecasting. Stationary data patterns can be forecasted by using the ARIMA (Autoregressive Integrated Moving Average) method. With the development of technology, some statistical software has been able to answer the complexity of mathematical calculations and statistics in this forecasting analysis. One popular statistical software, the SPSS 20, has provided the Expert Modeler feature on the Analyze Time Series menu to simplify the forecast analysis process. Expert Modeler can estimate the univariate ARIMA model, and the ARIMA multivariate model for time series data and then generate forecasts for the time series data. The forecasting results for CPO demand in 2018 is shown in Table 2. Forecasting result by using SPP also showed the graph of demand forecasting from the historical data from January 2013 to December 2017 and the demand forecasting result in 2018 by SPSS is shown in Figure 2.

From the graph, it can be seen that the red graph shows the historical data on CPO sales from January 2013 to December 2017, then the forecasting results are shown in blue. The lowest forecasting data in December 2018 is 766,667 kg. While the highest sales forecasting was in May 2018 with the value of 2,105,952 kg. Accuracy in sales estimates will increase the competitive ability of the products [10]. From the graph shown that the historical data pattern not significantly different with the forecast
result, so the forecasting is can be said to be accurate, and supported by data error measurement can be seen in Table 3.

Table 2. Forecasting results in 2018

| Month    | CPO Forecasting 2018 (kg) |
|----------|---------------------------|
| January  | 921,145                   |
| February | 1,094,768                 |
| March    | 1,593,368                 |
| April    | 1,941,214                 |
| May      | 2,105,952                 |
| June     | 1,793,758                 |
| July     | 1,508,684                 |
| August   | 1,404,600                 |
| September| 1,000,112                 |
| October  | 1,106,072                 |
| November | 968,822                   |
| December | 766,667                   |

Figure 2. Graph of the forecasting results in 2018

Table 3. The 2018 model’s forecast

| Model                | Jan-18 | Feb-18 | Mar-18 | Apr-18 | May-18 | Jun-18 | Jul-18 | Aug-18 | Sep-18 | Oct-18 | Nov-18 | Dec-18 |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Demand modelling_1   |        |        |        |        |        |        |        |        |        |        |        |        |
| Forecast             | 921145 | 1094768| 1593368| 1941214| 2105952| 1793758|        |        |        |        |        |        |
| Upper Control Limit (UCL) | 1514426| 1733758| 2275009| 2662991| 2865748| 2589758|        |        |        |        |        |        |
| Lower Control Limit (LCL) | 327865 | 455777 | 911226 | 1219436| 1346156| 97757  |        |        |        |        |        |        |
| Model                |        |        |        |        |        |        |        |        |        |        |        |        |
| Demand modelling_1   |        |        |        |        |        |        |        |        |        |        |        |        |
| Forecast             | 1508684| 1204600| 1000112| 1106072| 968822 | 76667 |        |        |        |        |        |        |
| Upper Control Limit (UCL) | 2339312| 2268470| 1895990| 2032854| 1925510| 1752354|        |        |        |        |        |        |
| Lower Control Limit (LCL) | 678055 | 540730 | 104234 | 179290 | 12134 | -219020 |        |        |        |        |        |        |
For each model in Table 4, forecasts start after the last non-missing in the range of the requested estimation period, and end at the last period for which non-missing values of all the predictors are available or at the end date of the requested forecast period, whichever is earlier.

| Model            | Number of Predictor | Model Fit statistics | Ljung-Box Q(18) | Number of Outliers |
|------------------|---------------------|----------------------|-----------------|-------------------|
|                  | Stationary R^2      | R^2                  | RMSE            | MAPE              | MAE               | Statistics | DF | Sig. |
| Demand modelling | 0                   | .643                 | .681            | 330242.4          | 21.9              | 235592.9    | 37.9| 16   | .002 | 0    |

A model’s forecast is never 100% accurate and always finds a deviation from the actual demand. A forecast is said to be good if the deviation between the forecast results and actual demand is as small as possible. Large deviations between the results of forecast and actual demand can be caused by two, namely the forecast method used is not suitable, or there are errors in certain weights or constants. There are several analyses to determine the accuracy of a forecast, such as Mean Absolute Definition (MAD), Mean Absolute Percent Definition (MAPE), Acumulative Error, Average Error or Bias, Mean Square Error (MAE), Percent of Acuration (POA) etc. MAD is the error of the forecast results with respect to the actual value of each period. MAPE is the absolute percentage average of the error error by calculating absolute errors per period. MSE is the absolute average of error forecasting squares [11].

In the results of forecasting using SPSS 20 there are several methods to measure the accuracy of the method including Root Mean Square Error (RMSE), MAPE, and MAE. These are not specifically used for each indicator in the forecast method. The method that has the lowest value, is the best. Accordance with other studies that show that the value of RMSE, MAE and MAPE can determine the performance of the resulting model. Simpler models tend to be more accurate and easily accepted [12]. The output of the error calculation for the MAPE and MAE values can be seen in Table 5.

| Model            | Number of Predictor | Model Fit statistics | Ljung-Box Q(18) | Number of Outliers |
|------------------|---------------------|----------------------|-----------------|-------------------|
|                  | Stationary R^2      | R^2                  | RMSE            | MAPE              | MAE               | Statistics | DF | Sig. |
| Delivery-Model_1 | 0                   | .643                 | .681            | 296385.6          | 21.9              | 235592.9    | 37.9| 16   | .002 | 0    |

Forecasting results of CPO in Company X used the expert modeler method. In this method, the RMSE value is 296385,597 MAPE of 21,932 and MAE of 235592,970. In the results of forecasting using SPSS 20 there are several measures in assessing the accuracy of forecasting methods including Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE). There are no specific rules regarding the value of each indicator in each forecasting period. The method that has the lowest value, the method is the best method.

From these results the Expert Model method is the best forecasting result with a confidence level of 95% or in other words it is believed that 95% of rejecting the wrong hypothesis is correct. Whereas a significant level of 5% again is the risk of being wrong to reject the correct hypothesis. P-value or probability can be interpreted as the probability of making a mistake if decide to reject the hypothesis.

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In general, p-value is compared to a certain level of $\alpha$, usually 0.05 or 5%. The real level $\alpha$ is interpreted as an opportunity to make a mistake to conclude that the hypothesis is wrong. On the forecasting output above, $R^2$ and p-value are obtained. $R^2$ value is obtained at 0.681 which means that the ability of demand data in explaining the results of future data is 68.1%. The p-value obtained is 0.002. If the alpha value is set at 5% or 0.05 then the p-value is less than the alpha value. If the p-value is less than the alpha value, the model used is correct.

3.4. Forecasting value evaluation
Demand forecasting results are closely related to production planning. Forecasting is an activity process to determine the number of production plans for the coming year that are appropriate for the time and number of product. The forecasting value evaluation from January to March 2018 is shown in Table 6.

The table 6 shows that between the demand data and the forecasting data are not too different. So, the forecasting method using time series can be applied to company X. Sometimes managers want to remember if their forecast results are very inaccurate, but the company needs to determine why the actual demand (the tested variable) is significantly different from the projected one. This is very influential on the company's production planning. Following another study, that Sales prediction is another area in which forecasting is utilised intensively. Sales forecasts refer to an estimate of company sales for a specified future period [13]. Sales forecasting is the most important planning task within any company-large or small and the sales forecast should be one of the company’s most important documents [14]. Good forecasting is very important in all aspects of business because it is the only prediction on demand until the actual demand is known. Demand forecasting controls decisions in many fields. Inaccurate forecasting will have an impact on company employees consisting of production and financial section managers.

| Month   | Demand Data (kg) | Forecasting Data (kg) |
|---------|-----------------|-----------------------|
| January | 946,770         | 921,145               |
| February| 1,102,231       | 1,094,768             |
| March   | 1,619,570       | 1,593,368             |

4. Conclusions
Company X performs forecasting with qualitative methods or only based on the opinion of the leader. While quantitative forecasting s carried out by the Marketing Department and Production Department at the headquarters of Head office. Forecasting was done based on historical data from January 2013 to December 2017. Forecasting results was done by the time series method for 2018 to simplify the process and get better forecasting results. From the forecasting value evaluation shown that between the demand data and the forecasting data are not too different. Data in January shown that the demand data is about 946,770 kg and the forecasting value about 921,145 kg, in February the demand data is about 1,102,231 and the forecasting data about 1,094,768. And the highest data in March for the demand is about 1,619,570 and the Forecasting data about 1,593,368. So, the forecasting method using time series can be applied to company X. The findings in this study confirmed that time series method was better applied for Company X. The forecasting results in 2018 have shown similarity with the historical data of demand.

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