Forecasting of export demand of black tea in PT XYZ Central Java

A Ihwah and R A Putri

Department of Agro-industrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia

E-mail: azimmatul.ihwah@ub.ac.id

Abstract. Tea is one of the agricultural products that has great potential to become a source of foreign exchange. One type of tea developed in Indonesia is the black tea. The market demand for black tea products changes over time and becomes more competitive. A company must have a good production activity plan to exploit opportunities optimally. Effective production planning for both long and short term is influenced by the demand forecasting. The market conditions of black tea are fluid, so forecasting demand helps companies to make decisions in determining the amount of demand for black tea in a period. Demand forecasting results are important to be carried out due to its closely relationship to production planning. This study used quantitative methods to forecast. The most suitable model of the request data is the ARIMA model (p,d,q). Historical data of export demand on black tea in 2016 - 2017 were used. The best model was obtained (1,0,0) combination to produce the most significant model with the smallest Mean Square Error (MSE). The results of forecasting increased from the previous two years with the amount of black tea export demand in 2018 amounted to 3872 tons from 3582 tons in 2017.

1. Introduction

Indonesia is one of the countries that has abundant agro-industrial products from the agriculture, forestry and livestock sectors. One of the most cultivated agricultural commodities is tea. From the web of Directorate General of Plantation, in 2017 Indonesia produced 146,168 m³ tons of tea and exported tea to various countries at 62.00 m³ tons in 2015. Tea is one of the agricultural industry products that has a great potential to become a source of foreign exchange. Tea is Indonesia's flagship commodity that has a variety of benefits that can be used as a refresher, industrial, pharmaceutical, cosmetic and healthy ingredients [1].

One type of tea developed in Indonesia is the black tea. The major active constituents of tea are catechins, and among them, EGCG is the most potent and much of the anticarcinogenic effect of green tea is predominantly credited to it. Some catechins are oxidized or condensed to theaflavins (theaflavin, theaflavin-3-gallate, theaflavin-3′-gallate and theaflavin-3-3′-digallate) (3–6%) and thearubigins (12–18%) during fermentation of fresh tea leaves and are responsible for the bitter taste and dark color of black tea [2]. Black tea is a very useful beverage ingredient, made from tea plants (*Camellia sinensis*). Black tea contains antioxidants and phytonutrients which are useful for cleaning toxins in the body [3]. Black tea is divided into two types, namely orthodox tea and CTC (crushing,
tearing, curling) tea. Both types of black tea are distinguished by the way they are processed. CTC processing is a rolling method that requires very light wilt levels (water content reaches 67-70%) with hard winding properties, while orthodox processing requires heavy wilting (water content 52-58%) with lighter winding properties [4].

Market demand for black tea products is changing over time and more competition is occurring in the black tea processing industry. Because of this, a company must plan a good production activity so that it can take the advantage of opportunities optimally [5]. Effective production planning for both long and short term is influenced by demand forecasting. Market conditions for black tea are changing, so demand forecasting helps companies to make decisions in determining the amount of demand for black tea in a period. Besides, company has to know that prices at world tea auctions are interlinked across different black tea markets. The company will guarantee the availability of products easier so that it can meet market demand in each period [6].

PT. XYZ is a company engaged in plantation, industry, trade, and consultancy. PT. XYZ has 6 production units with core gardens. PT. XYZ is located in Blado District, Batang Regency, Central Java. PT. XYZ can produce up to 40 tons of packs/day for black tea. The analysis of demand forecasting can help PT. XYZ to predict how many market opportunities are available in the future. Demand forecasting has always been a major issue in operations and production management. Many decisional processes, such as inventory management, product development, production and supply chain planning, require forecasts [7]. The results of demand forecasting are used for significant management decisions, such as capacity planning, production, inventory control, etc., so that the company can meet all future consumer demand. One of the biggest challenges of food and beverage manufacturers is adjust the production and the stocks to minimize the loss of products due to its short perishability. Time series analysis is very important in a wide range of applications, especially when it comes to forecasting, and it encloses many different forecasting models [8].

Forecasting can be grouped into three-time horizons, namely long-term forecasting (> 18 months), medium-term forecasting (3-18 months), and short-term forecasting (<3 months) [9]. In forecasting, there are two approaches that can be used namely quantitative and qualitative analysis. Quantitative analysis uses a mathematical model approach using the historical and causal data. While qualitative analysis uses a subjective approach that is related to decision making. Quantitative methods can be done using time series model (decomposition, moving average, exponential smoothing, and exponential smoothing using the trend adjustment) and causal models (trend projection and linear regression causal model) [10].

This paper investigates the approach to determine the revenue demand forecasting of black tea based on the Autoregressive Integrated Moving Average (ARIMA) models. This time series technique makes very few assumptions and is very flexible. It is theoretically and statistically sound in its foundation and no a priori postulation of models is required when analysing failure data. ARIMA models are, in theory, the most general class of models for forecasting a time series which can be made to be “stationary” by differencing (if necessary), perhaps in conjunction with nonlinear transformations such as logging or deflating (if necessary). A random variable that is a time series is stationary if its statistical properties are all constant over time [11].

2. Materials and Methods

The raw material for making black tea is a fresh shoot of tea plants. The top quality of the tea is determined by the physical condition and chemical content of tea shoots. The specifications of the ingredients processed at PT XYZ are sought high quality with the characteristics of the base material of young leaves that are intact, fresh and green.

This study uses forecasting quantitative methods. The data used were past sales data namely black tea export data from January 2016 - December 2017. The past sale data were obtained from PPIC (Production Planning and Inventory Control) department of PT XYZ. ARIMA model was used to determine the revenue demand forecasting of black tea. To determine the best ARIMA model, the stationary test should be done first. There were stationary test in average and stationary test in
variance. The best-significant ARIMA model is a (p, d, q) combination with the smallest Mean Square Error (MSE). The forecasting to be carried out was in the period of January - December 2018. The forecast period is 12 months so this forecast is included in the medium-term forecasting. The software that used was Minitab.

3. Results and Discussion
One of the problems faced in forecasting analysis is the problem of complexity in terms of mathematical calculations and statistics to form the best forecasting model. Before testing the stationary data, it is necessary to identify the data type pattern by plotting the data in order to produce a time series plot graph. This time series plot graph is used to determine the relationship between sales volume and sales period. The times series plot graph produced also provides an overview of the sales data pattern so that it can determine the right forecasting method to use. Figure 1 shows the times series plot graph of sales (exports) from January 2016 to December 2017.

![Figure 1. Times series plot of export demand of black tea.](image)

The time series plot graph of the export demand of black tea in January 2016 - December 2017 shows a stationary data pattern with the non-seasonal data types. Data types are non-seasonal because the pattern of increase and decrease has fluctuating in a certain period of time. Thus, the ARIMA model is non-seasonal. Then we just have to make it blank in seasonal box of the software Minitab.

3.1 Stationary test of a variety
The data are stationary to a variety if the rounded value is equal to one. If the rounded value displayed on the box-cox plot graph is not equal to one, then the data must be transformed first, then the stationary test is performed on the result data until the rounded value equals to one. Rounded value/lambda equals to one means that the data are stationary against the variance (has the smallest standard deviation value) and no transformation is done [12]. Based on the data, do the transformation twice since we obtain lambda equals 1.07 for the first transformation.
Figure 2. Original box-cox graphic of export demand of black tea.

Figure 3. Box-Cox graphic of transformation 1 of export demand of black tea.

Figure 4. Box-Cox of transformation 2 of export demand of black tea.
3.2. Stationary test of average

Data are stationary to the average if there are no data coming out of the upper and lower limits (confidence interval) which can be seen in the graph of the autocorrelation function (ACF) plot test. Based on the stationary test on the average shows the average number of sales (exports) of black tea is stationary to the average. This is indicated by the absence of data that come out of the limit of each lag on the graph of the ACF plot test. Lag is a difference. Lags formed amounted to 6 of the 24 data used. After a stationary test on average with the ACF plot test, the transformation data 2 is again used for the partial autocorrelation function (PACF) plot test which also included the stationary test to the average. The PACF plot test is carried out as a follow-up test to prove that the average amount of consumption data have been stationary to the average or not. The ACF and PACF plot can be seen in Figure 3. Since both of the stationary test results said that the data were stationary, the ARIMA model of forecasting could be developed.

![ACF and PACF Plot](image)

Figure 5. ACF and PACF Plot of export demand black tea.

3.3. Forecasting of export demand of black tea

Black tea export demand forecasting can use the ARIMA (Autoregressive Integrated Moving Average) model because the data pattern is stationary. ARIMA model is classified as an "ARIMA(p,d,q)" model, which are p is number autoregressive terms, d is number of non-seasonal differences needed for stationarity, and q is the number of lagged forecast errors in the prediction equation [13]. Combined notations that can be used for the analysis are (1,0,1), (1,0,0), and (0,0,1). The value of p equals 1 means that we examined whether the autoregressive model fits with the data or not, then the value of p equals 0 means that we did not examined. The value of d for all combination equals 0 because we did not need to extinguish if the data were stationary to the average. The value of q equals 1 means that we examined whether the value of moving average fits with the data or not.

To get the best combination notation, we can see the mean square of residual which one is the lowest and p-value which one is less than significance value (we use significance value equals 0.05) for each combination of notations. The best ARIMA model is indicated by a notation combination (1,0,0) where the mean square of residual is 0 and the auto regression (AR) model is equal to 0 or significant (p-value<0.05). The data from forecasting demand for black tea exports from January to December 2018 are shown in Table 1.
Table 1. Revenue forecast data of black tea for export from PT XYZ.

| Period 2018 | Forecast Result (kg) |
|-------------|----------------------|
| January     | 227,410.5451         |
| February    | 241,414.7090         |
| March       | 256,281.2630         |
| April       | 272,063.3139         |
| May         | 288,817.2390         |
| June        | 306,602.8872         |
| July        | 325,483.7930         |
| August      | 345,527.4035         |
| September   | 366,805.3191         |
| October     | 389,393.5495         |
| November    | 413,372.7853         |
| December    | 438,828.6859         |
| Total       | 3,872,001.49         |

Based on the forecast result, the interim demand for black tea products has increased every month during 2018. The lowest demand is in January 2018 with the amount of 227,410.54 kg (or 227.41 tons) and the highest demand is in December 2018 with the amount of 438,828.68 kg (or 438.828 tons). The average of export demand of black tea in 2018 is 322,666.791 kg/month or 323 tons/month. It means that PT XYZ has to provide 323 tons/month approximately to fulfill the export demand of black tea. Black tea export demand from Indonesia has been increasing year by year. This is because Indonesia being the main tea producing countries in Asia, together with Bangladesh, India, China, Sri Lanka, and Taiwan which export 80% of world tea [14]. Moreover, from the latest study in Japan said that black tea is at the second place of necessities in the Japanese household [15].

4. Conclusion

Based on the discussion, there are several points of conclusion, namely the times series plot graph of the Export Demand of Black Tea from January 2016 to December 2017 shows a stationary data pattern with non-seasonal data types. The data has been stationary to the average and variance. The best ARIMA model is indicated by a notation combination (1,0,0). Based on the forecast result, the interim demand for black tea products has increased every month during the year of 2018. The total black tea export demand in 2018 is 3,872 tons. Research can be continued by examining the quantity of black tea in order to fulfill the export demand effectively by using Economic Quantity Order (EOQ) Method.

References

[1] Anjarsari I R D 2016 The effect of concentration of benzyl amino purine on the growth of several tea plants (Camellia sinensis L.) has hot produced in the low flat J. Kultivasi 15 2 99-106. [In Indonesian]
[2] Khan N, Mukhtar H 2013 Tea and health: study in humans J. Current Pharmaceutical Design 19 34 6141-6147.
[3] Somantri R, Tanti K 2011 Story and Efficacy of Tea Gramedia Pustaka Utama Jakarta Indonesia. [In Indonesian]
[4] Setiawati I, Nasikun 2008 Tea: Socio-economics Study Aditya Media Yogyakarta Indonesia. [In Indonesian]
[5] Render B, Heizer J 2009 Operation management Salemba Empat Jakarta Indonesia. [In Indonesian]

[6] Tanui J K, Fang W, Feng W, Zhuang P, Xinghui L 2012 World black tea markets: relationships and implications for the global tea industry Int. J. Food Agri. Market. 24 2 148-168.

[7] Kalchshmidt M 2013 The effect of global supply chain configuration on the relationship between supply chain improvement programs and performance Int. J. Oper. Prod. Manag. 26 6 619-638.

[8] Barbosa N de P, Christo E da S, Costa K A 2015 Demand forecasting for production planning in food company J. Eng. Appl. Sci. 10 16 7137-7141.

[9] Herjanto E 2007 Operation and production management PT Gramedia Jakarta Indonesia. [In Indonesian]

[10] Rangkuti F 2006 SWOT analysis: techniques for dissecting business cases Gramedia Pustaka Jakarta Indonesia. [In Indonesian]

[11] Ho S L, Xie M 1998 The use of ARIMA models for reliability forecasting and analysis J. Comput. Ind. Eng. 35 1-2 213-216.

[12] Wei X and Heywood J S 2006 Performance pay and job satisfaction J. Ind. Relations 48 4 523-540.

[13] Anonym Introduction to ARIMA: non-seasonal model. Retrieved from https://people.duke.edu/~rmau/411arim.htm. [Accessed on 19 November 2018]

[14] Khan R E A, Hussain T 2011 Employee work satisfaction and work-life balance: a Pakistani persperctive J. Contem. Res. Bus. 2 11 606-617.

[15] Yohannes M, Matsuda T 2015 Demand analysis of non-alcoholic beverage in Japan 2015 J. Agric. Sci. 7 5 143-153.