Forecasting of purchasing quantity of *Manalagi* apple for apple juice drink production in PT XYZ Malang

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Abstract. Batu City is a city with abundant agricultural and fruit commodities, in particular apple. Apple juice drink is a fruit juice drink prepared from apples with the addition of sugar and citric acid. One producer of apple cider in Batu City is PT XYZ. The effectiveness of the production process in a company has strongly related to the needs of raw materials. The planning activity for raw material requirements can be applied if future sales projections have been obtained. In this case, forecasting demand needs to be done. This study aimed to forecast the quantity of purchasing *Manalagi* apple as the main raw material in apple juice drink production process. Historical data of *Manalagi* apple purchased from January 2016 to December 2018 was used. The forecasting study was carried out for the period of January to December 2019. From the time series plot, it was found that the data for purchasing raw materials for apples was seasonal. Then, the purchasing data of the *Manalagi* apple was transformed twice to fulfill stationary assumptions. The best Seasonal Autoregressive Integrated Moving Average (SARIMA) model obtained was (1,1,0) (1,1,1)$^2$ with the Mean Square Error (MSE) of 0.0106901. The model showed that the average of apple’s purchasing in 2019 was 9786.1 kg/month, with the highest and the lowest value 87950.2 kg (in June) and 249.3 kg (in January), respectively.

1. Introduction

Raw materials are the main factor for companies to support the smooth production process. The determination of raw material inventory varies for each company. In the right quality and quantity, the availability of the raw material will determine to a reasonable extent: the availability, quality and quantity of the resulted outputs [1]. In the end, the results of the calculation will refer to the achievement and allocation of capital requirements for the procurement of raw materials.

*Batu* City is a city that has abundant agricultural products. One of the abundant fruits in *Batu* City is apples. Based on the Central Bureau of Statistics of *Batu* City reports, in 2016 the apple harvest rates in *Batu* City reached 135,526 tons per hectare, therefore the rate was high. Based on data from the *Batu* Agriculture and Forestry Service Office, the number of apple production in *Batu* City in 2016 reached 2,574,852 trees with productivity reaching 15 kg/tree [2]. Apples are fruits with a high total sugar content, with the value of 14.19 ± 1.18 g/100 mL [3]. The large number of apple harvests in *Batu* City encourages the people of *Batu* City to process apples into processed products to increase the selling value of apples. One of the efforts made is making apple juice drinks.

PT XYZ is one of the companies engaged in apple juice drink. The company located in *Batu* City has apple juice products under the *Flamboyan* brand. The production of apple juice in PT XYZ was...
semi-automatic, which is done with the help of machines and also humans. PT XYZ has distributed its products throughout Java. The production process cannot be separated from the needs of raw materials. Procedures and methods for purchasing raw materials that are good and following the conditions of the company will greatly support production activities. Therefore, the company must determine the optimal amount of raw material with the intention that the number of purchases can reach the minimum inventory cost [4].

Raw materials are the main factors that support the smoothness and effectiveness of the production process of a company. Therefore, it is necessary to forecast the raw materials so that the needs of consumers are met. According to Adnan et al. [5], the planning of raw material requirements can be applied if future sales projection data has been obtained, in this case forecasting future demand needs to be done. Demand forecasting is a business that is urgently needed by companies in seeking information about trends in product demand patterns. The company’s problems that occur are the complexity of predicting the number of consumer demand because of its fluctuating nature. A company often experiences problems in purchasing raw materials including the purchase of raw materials that are not following the request. Thus, by forecasting the needs of raw materials, it will help the company in calculating the number of raw materials for apples. Moreover, the evaluation of forecasting the procurement of raw materials can contribute in ensuring the sustainability of the production process, cost efficiency, and increased profits. Hence, this study aimed to forecast apple demand as the main raw material of apple juice drink production.

2. Materials and Method

In the procurement of raw materials for producing the apple juice, the company purchased the main raw materials, namely Manalagi apples from the traditional market in Batu City. In purchasing raw materials, made to order system was used. In this study, data used for forecasting analysis was the amount of apple Manalagi bought by PT XYZ as the calculation results of the amount of apple juice drink ordered by the customer.

The forecasting method used in this study was quantitative method. Quantitative forecasting was carried out by using historical data of Manalagi apple purchased from January 2016 to December 2018. The past data of Manalagi apple purchased was obtained from Department of Production Planning and Inventory Control (PPIC) in PT XYZ.

The quantitative forecasting method used for this research was the Seasonal Autoregressive Integrated Moving Average (SARIMA) forecasting method to obtain the number of raw materials needed by the company from January 2019 to December 2019. SARIMA is used to handle seasonal periodical aspects of the series. According to Chang et al. [6], the seasonal pattern is a fluctuation of data that occurs periodically within one year, such as quarterly, quarterly, monthly, weekly, or daily. The Seasonal ARIMA Model is an ARIMA model used to complete a seasonal time series consisting of two parts, namely non-seasonal parts and seasonal parts. The SARIMA model is defined as ARIMA (p, d, q) (P, D, Q) where p is the number of non-autoregressive federal, d is the number of non-communal differencing, q is the number of errors left in the equation prediction. Then P is the seasonal autoregressive number, D is the number of differencing seasonal, and Q is the number of seasonal errors left behind [7]. Before determining the forecasting model, the time series plot should be analysed. After that, a stationary test was conducted. This forecast is included in the medium-term forecasting because the period is 12 months. Minitab software used for data analyse.

3. Results and Discussion

Forecasting analysis faced one of critical problems that is the complexity of mathematical calculations and statistics to determine the best forecasting model. Before the stationary test data was carried out, the time series plot is necessary to identify the data type pattern. The time series plot of the final Manalagi apple purchase quantity can be seen in Figure 1. The figure shows that there was a clear relationship between month and number of purchasing quantity of Manalagi apple.
Figure 1 shows the quantity of purchase of the apple obtained from historical data from January 2016–December 2018. From the graph, it can be seen that the graph has a seasonal pattern. This was because there are patterns of increase that have similarities in a certain period. The seasonal pattern is influenced by seasonal factors which can be seen from around May to June experiencing a high increase because around May to June is high season. A seasonal pattern occurs when a time series is affected by seasonal factors such as the time of the year or the day of the week. Seasonality is always of a fixed and known frequency [8]. This seasonal pattern was because around May to June there are Eid Mubarak Day in 2018 where demand is very high which results in increased raw material purchases. Next discussion focused on whether each data has been stationary towards the average and variance.

3.1. Stationary test of variance

A data is said to be stationary concerning variance if the rounded value of lambda ($\lambda$) was equal to one. If the lambda obtained is not equal to one, then the data transformation must be done. The lambda value obtained in the Box-Cox graph affects the transformation formula used to convert the original data into transformation data so that the lambda value ($\lambda$) = 1. Based on the data, it is necessary to do twice transformations to get a lambda value = 1 [9]. Thus, by 2 times transformation, lambda equal to one was obtained.

Based on Figure 2, the Lower Control Limit and Upper Control Limit of lambda ($\lambda$), in which these values were confidence intervals for the Box-Cox transformation. Those can be asymptotically constructed using Wilks's theorem on the profile likelihood function to find all the possible values of lambda ($\lambda$) and showed in the graph by using vertical lines. Rounded value of lambda was more considered to be used for data transformation than estimate value because the rounded value was found to be the optimum value of lambda ($\lambda$) [10].
3.2. Stationary test of average
A data is said to be stationary to the average if there is no data coming out of the confidence interval. This study found that there was 1 lag out of the boundary (Figure 3a), in which data can be considered as stationary [11]. However, the data was not stationary to the average. Furthermore, by using differencing value 1, the data meets the requirements of stationary on average (Figure 3b).

![ACF plot](image1)

(a) ACF plot
(b) ACF plot after differencing

**Figure 3.** ACF plot of data quantity purchase of Manalagi apple

After stationary testing of on average, data after differencing is carried out to see a graph partial autocorrelation function (PACF) [12]. Assuming that the data is seasonal, a PACF plot result has been compared with the results of the ACF plot that has been obtained previously. The graph of the PACF plot after differencing can be seen in Figure 4. The figure shows that there are 3 lags which came out, namely in the second period, the ninth period, and the seventeenth period.

![PACF plot](image2)

**Figure 4.** PACF plot

3.3. Forecasting quantity of purchasing Manalagi apples
Periodic series are series that have recurring properties after a certain period, for example, one year, one month, and quarterly. Therefore, the periodic series has characteristics that indicate a strong correlation. SARIMA model is an extension of the ARIMA class to include seasonal behaviour. Seasonal patterns exist when data is influenced by seasonal factors.

The combination of notation of the SARIMA model used for this forecasting analysis was (1,1,1) (1,1,1)², (0,1,1) (1,1,1)², (1,1,0) (1,1,1)². However, there were two significant SARIMA models, namely (1,1,0) (1,1,1)² and (0,1,0) (1,1,1)². Then, SARIMA model chosen for forecasting was (1,1,0) (1,1,1)² because it has the smallest value of Mean Square Error (MSE), which is 0.0106901, while the model
(0,1,0) (1,1,1)^2 has MSE of 0.127822. Hence the model (1,1,0) (1,1,1)^2 was feasible to be used for forecasting the quantity of purchasing raw materials for Manalagi apples.

Forecasting the purchase of apple raw materials is done for the next 12 months. Forecasting is done using model notation (1,1,0) (0,1,1)^2. The results of the forecasting obtained must be transformed back. The results of forecasting the purchase of apple raw materials can be seen in Table 1.

| Table 1. Forecasting the quantity of purchasing Manalagi apple from PT XYZ |
|---------------------|--------------------------|
| Period 2019         | Forecasting Results (kg) |
| January             | 249.3                    |
| February            | 607.3                    |
| March               | 413.4                    |
| April               | 619.1                    |
| May                 | 291.4                    |
| June                | 87950.2                  |
| July                | 340.5                    |
| August              | 2144.8                   |
| September           | 311.2                    |
| October             | 19052.6                  |
| November            | 337.4                    |
| December            | 5116.0                   |
| **Total**           | **117433.2**             |

From the forecasting results for the next 12 months, the results obtained were the highest in June at 87950.2 kg and the lowest in January, which amounted to 249.3 kg. According to historical data, the level of demand from consumers has increased dramatically during the Eid season or celebration season, which is Eid Mubarak Day in June 2019. This is appropriate with the seasonal pattern because the forecasting results have increased dramatically from January to May 2019 and declined again from July to December 2019. Such fluctuation has indicated that the data is seasonal.

### 3.4. Statistical data of apple production quantity in Batu City from Central Bureau of Statistics

Apples are fruits that are harvested continuously in one season. Data on apple crop production in Batu City, according to the Central Bureau of Statistics in Batu City data in 2018 can be seen in Table 2.

| Table 2. Quantity of apple that used for production of Batu City [12] |
|-----------------------------|---------------------|
| Month                       | Quantity (kg)        |
| January – March             | 163012              |
| April – June                | 105656              |
| July – September            | 127076              |
| October – November          | 146362              |
| **Total**                   | **542106**          |

Table 2 indicates that the production of apple was fluctuated throughout the year, in which the highest production was from January to March 2018. According to Sa’adah [13], most of the communities in Batu City, use apple for producing apple juice beverages. There are 20 apple juice business units, 15 apple chips business units and 14 apple jams business units existed in 2018, which required approximately 1600 tons, 180 tons and 324 tons of apples respectively per year.

Some factors influence the production of apples in Batu City which tend to fluctuate. According to Marthur [14], apple farmers consider that the failure of fruit harvest can be caused by climate change.
Among the environmental factors, temperature plays a crucial role in the growth of tomato plants and development of fruits. At suboptimal air temperature for the vegetative stage, tropical fruits seedlings tend to produce larger cells to store more starch, indicating thicker leaves and a relatively lower growth rate [15]. However, plants that thrive do not necessarily produce optimal fruit. Therefore, according to Oren et al. [16], it is necessary to do good care such as giving fertilizer regularly, trimming damaged branches, stems, and leaves to produce optimal apples.

4. Conclusions
The findings confirmed that the times series plot of Manalagi apple purchased from January 2016 to December 2018 showed seasonal data pattern. The data has been stationary to the average after first differencing and stationary to the variance after twice data transformation. The best SARIMA model is indicated by a notation combination (1,1,0) (0,1,1)². From the forecasting result, the peak of the purchasing quantity of Manalagi apple happened in June 2019 with an amount of 87950.2 kg. The total quantity of purchasing Manalagi apple in 2019 is 117433.2 kg.

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