Identification of production planning and supply of glass bottles at the bottled tea company

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Abstract. Sinar Sosro Limited (SS Ltd) is a company that produces a variety of packaged teas with superior products of bottled tea with 220 ml glass bottles. Based on the preliminary research, the glass bottles still can meet the production but with the demand. In their production planning, the company applies a method of estimating or predicting so that production results cannot meet production demand. This is the background of the researchers to make production planning based on forecasting methods and determine the quantity of glass bottle orders to meet demand. In forecasting the demand for production of the 220 ml glass bottle packaging, the methods used are Moving Average, Exponential Smoothing, and Linear Regression by comparing the size of forecasting errors using Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE). To determine the supply of glass bottles used the EOQ (Economy Order Quantity) method to determine the purchase of the most economical glass bottles. Base on the data, the Moving Average method (n=9) was the best forecasting used to predict the 220 ml glass bottle packaging demand for the next period of 233,862 crates with MAD forecasting error of 13,680, MSE of 561,420,907, and MAPE 5.49% which is the smallest value of the three methods. The application of the EOQ method results in the most economical order of glass bottles that is 136,234 crates for one message with a total repurchase frequency of 21 times a year.

1. Introduction

Economic growth in the era of globalization requires every company to compete in the industry or service. One of them is the beverage industry which has very fierce competition because drinks are a daily necessity, especially of packaged tea [1][2].

Sinar Sosro Limited (SS Ltd) is a company engaged in the beverage industry as a market leader who controls the market share with the mainstay product namely Sosro Tea Bottles packaging 220 ml glass bottles. However, in the production of sosro bottled tea, the 220 ml glass bottles do not match the number of requests. This can be seen from the market demand data of 2,967,644 crates in 2018 while the company was only able to cover the demand of 1,692,046 crates for 2018.

From this issue arises the problem of inaccurate demand forecasting which has an impact on production planning. Even though the company has forecasted the production demand, the amount produced is still unable to meet the actual demand [3].

Forecasting is generally done based on past data and analyzed using certain methods to get the smallest forecast error value. Several methods can be used to solve these problems, including the method of forecasting Linear Regression, Moving Average, and Exponential Smoothing [4]. These three methods are used to predict future demand using past data.
Then to avoid any shortage or excess supply of glass bottles, it is also necessary to control the supply of glass bottles. Inventory control is intended to predict the amount of supply of glass bottles needed in the production process in the coming period so as not to experience shortages or excess. This inventory is also to avoid deficiency or excess glass bottles intended to anticipate an increase in demand resulting in shortages of inventory.

Economic Order Quantity (EOQ) is one of the inventory control methods that aims to determine the optimum amount of ordering the most economical goods or materials for each order. This method can determine the optimal frequency of ordering to minimize production costs without reducing the target or profit to be achieved [5][6].

2. Methods

The data obtained is then observed and processed to obtain the desired results, and the data processing analysis stages are [7][4]:

1. Forecasting of the production requests for 220 ml glass bottle size packaging using forecasting models as follows:
   a. Linear regression

   \[ \hat{y} = a + bx \]
   \[ b = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{n \cdot \Sigma x^2 - (\Sigma x)^2} \]
   \[ a = \frac{\Sigma y - b \cdot \Sigma x}{n} \]

   b. Exponential Smoothing

   \[ F_t = F_{t-1} + \alpha (A_{t-1} - F_{t-1}) \]

   c. Moving Average

   \[ \text{Moving Average} = \frac{\Sigma \text{Previous periods request}}{s} \]

2. Calculation of the forecast error from the production of 220 ml glass bottles:
   a. Mean Absolute Deviation (MAD)

   \[ \text{MAD} = \frac{\Sigma |\text{actual} - \text{forecasting}|}{n} \]

   b. Mean Square Error (MSE)

   \[ \text{MSE} = \frac{\Sigma (\text{actual} - \text{forecasting})^2}{n} \]

   c. Mean Absolute Percentage Error (MAPE)

   \[ \text{MAPE} = \frac{100}{n} \cdot \Sigma \frac{|\text{actual}_i - \text{forecasting}_i|}{\text{actual}_i} \]
3. Determination of the best method to predict demand for the production of the 220 ml glass bottle size by comparing the smallest error value.

4. Calculation of the number of orders in a single message by using the EOQ method

\[ EOQ = \sqrt{\frac{2 \cdot D \cdot S}{H}} \]

5. Calculation of order frequencies based on the EOQ method

\[ F = \frac{D}{EOQ} \]

6. Calculation of the total cost (TIC) of inventory based on the EOQ method

\[ TIC = S \times \frac{D}{Q} + H \times \frac{Q}{2} \]

7. Calculation of Safety Stock

\[ SS = SD \times Z \]

8. Calculation of the point of reordering inventory (ROP / Reorder Point)

\[ ROP = (d \times L) + SS \]

3. Result
Following the formulation of the problem, the data collected from the company include data on the demand for production of 220 ml bottles of sosro tea bottles with glass bottles from January 2018 to December 2018, data on the inventory of glass bottles, ordering costs, and storage costs. Table 1 was obtained from the production and logistics department of SS Ltd.

| Period   | Production (crate) | Demand (crate) | Bottle Supplies (crate) |
|----------|--------------------|----------------|-------------------------|
| January  | 130.115            | 150.183        | 140.152                 |
| February | 150.755            | 184.952        | 160.246                 |
| March    | 140.456            | 257.755        | 150.457                 |
| April    | 150.286            | 214.589        | 160.429                 |
| May      | 150.655            | 255.435        | 160.289                 |
| June     | 180.522            | 230.187        | 185.835                 |
| July     | 170.247            | 200.125        | 177.902                 |
| August   | 143.049            | 221.226        | 150.289                 |
| September| 132.342            | 262.908        | 140.235                 |
| October  | 145.688            | 233.286        | 155.206                 |
| November | 150.635            | 227.410        | 156.234                 |
| December | 190.345            | 259.588        | 198.213                 |
| Total    | 1,692.046          | 2,697.644      | 1,935.487               |
Figure 1. Demand of the 220 ml glass bottles in 2018

From Table 1, it can be seen that the demand for the 220 ml glass bottle size packaging did not meet with the production amount. Therefore, proper production planning is needed by doing the forecasting method. For this reason, the methods used in this forecasting are Linear Regression, Moving Average, and Exponential Smoothing. These three methods are used because they use data that occurs within a certain period and is past or past. Costs incurred to order goods at SS Ltd. can be seen in Table 2. Ordering costs do not depend on the number ordered but depend on the number of times an order is placed.

Table 2. Costs of glass bottles

| Cost Components                        | (IDR/order)          |
|----------------------------------------|----------------------|
| Telephone Charges                      | IDR 200,000          |
| Administrative Costs                   | IDR 200,000          |
| Loading and unloading costs            | IDR 2,500,000        |
| Transportation costs                   | IDR 2,000,000        |
| **Total Booking Fee**                  | IDR 4,900,000        |
| Storage Fee (Price per crate IDR 15,000 x 10%) | IDR 1,500/crate    |
| Lead Time                              | 7 days               |

Forecasting can be done by looking at the demand data in the previous period. Forecasting is done in this study to provide an overview of companies on how to determine alternative policies towards demand in the coming period. There are three methods used in this forecasting research namely Moving Average, Exponential Smoothing and Linear Regression.

By comparing the forecasting results of the three methods is expected to obtain the smallest forecast error value, so that it can be used as a guideline for companies to determine to forecast in the future.
To get the correct forecasting method so that it can be applied to the company, it is important to compare the accuracy of forecasting errors in each method. The accuracy of forecasting errors consists of MAD, MSE, and MAPE.

### Table 3. Comparison of forecasting error for demand for the 220 ml glass bottles

| No. | Method                        | Forecasting | Size of Forecasting Error | MAD   | MSE     | MAPE  |
|-----|-------------------------------|-------------|---------------------------|-------|---------|-------|
| 1   | Moving Average $n = 9$        | 233,862     | 13,680                    | 283,370,239 |
| 2   | Exponential Smoothing $\alpha = 0.5$ | 254,910     | 27,179                    | 1,366,058,662 |
| 3   | Linear Regression             | 259,422     | 21,940                    | 718,339,387 |

Based on the results of the comparison, the appropriate method used to apply to forecast to the demand for the 220 ml glass bottles is the Moving Average method $n = 9$. This means forecasting can begin from the tenth month of October 2018, because in January 2018 until September 2018 is used as a basis for determining the forecast of production demand for the 220 ml glass bottle size packaging for the next 1 year. The forecasting is shown in Table 4.

### Table 4. Results of forecasting production demand with the Moving Average Method $n = 9$

| Period (2019) | Forecast (crate) |
|---------------|------------------|
| January       | 233,862          |
| February      | 236,003          |
| March         | 233,844          |
| April         | 234,250          |
| May           | 238,042          |
| June          | 239,910          |
| July          | 237,355          |
| August        | 237,807          |
| September     | 238,962          |
| October       | 236,671          |
| November      | 236,983          |
| December      | 237,092          |
| **Total**     | **2,840,789**    |

Based on the data processing above, it can be seen the forecasting of demand for the production of 220 ml glass bottles for one year later in 2019, with the number of demand forecasting of 2,840,789 crates.

The calculation of the analysis of shard bottle inventory control can be done using the EOQ method with the assumption that 1 cate contains as many as 24 glass bottles. The EOQ method allows companies to determine the most economical quantity of glass bottle orders with a constant number of requests and lead time.

a. EOQ calculation

This economical glass bottle purchase is based on the calculation in Table 5.
Table 5. EOQ formulation data

| Data Type                      | 2019                  |
|-------------------------------|-----------------------|
| Glass Bottle Total Needs (D)  | 2,840.789 crates      |
| One-Time Booking Fee (S)      | Rp4,900,000/order     |
| Storage Fee (H)               | Rp1,500/crate         |
| EOQ                           | 136,234 crates        |

b. Frequency of purchase of glass bottle

Using the EOQ method, the number of order frequencies in one year can be calculated as follows:

\[ F = \frac{D}{EOQ} = \frac{2,840.789}{136,234} = 21 \]

Orders in 2019 are made 21 times a year precisely every 18 days.

c. Total inventory cost

To calculate the total cost of inventory, what you need to know is as follows:

\[ TIC = S \times \frac{D}{EOQ} + H \times \frac{EOQ}{2} \]

\[ = 4,900,000 \times \frac{2,840.789}{136,234} + 1.500 \times \frac{136,234}{2} \]

\[ = 102,176,154 + 102,175,500 \]

\[ = IDR 204,351,654 \]

Based on the above calculation, it is known that the total inventory cost that must be borne by the company in 2019 is IDR 204,351,652.-

d. Safety stock

The calculation of standard deviation can be seen in Table 6.

Table 6. Calculation of standard deviations

| Period  | Glass Bottle Need (Y) | X   | (Y-X) | (Y-X)^2 |
|---------|-----------------------|-----|-------|---------|
| January | 233,862               | 236,733 | -2,871 | 8,242,641 |
| February| 236,003               | 236,733 | -730  | 532,900  |
| March   | 233,844               | 236,733 | -2,889 | 8,346,321 |
| April   | 234,250               | 236,733 | -2,483 | 6,165,289 |
| May     | 238,042               | 236,733 | 1,309  | 1,713,481 |
| June    | 239,910               | 236,733 | 3,177  | 10,093,329 |
| July    | 237,355               | 236,733 | 622   | 386,884  |
| August  | 237,807               | 236,733 | 1,074  | 1,153,476 |
| September| 238,962              | 236,733 | 2,229  | 4,968,441 |
| October | 236,671               | 236,733 | -62   | 3,844    |
| November| 236,983               | 236,733 | 250   | 62,500   |
| December| 237,092               | 236,733 | 359   | 128,881  |
| Total   | 2,840,789             | 2,840,796 | -15 | 41,797,987 |
X = Glass Bottle Needs 1 year
n
= \frac{2,840,789}{12}
= 236,732,417 = 236,733

SD = \sqrt{\frac{\sum (Y-X)^2}{n}}
= \sqrt{\frac{4,179,987}{12}}
= 1,866,32 = 1,866

Assuming that the company uses a 5% significant deviation is not tolerated and uses one side of normal, the value of which can be seen in the table that is 1.65, Then the quantity of safety stock is:

SS = SD \times Z
= 1,866 \times 1.65
= 3,078.9 crates = 3,079 crates

e. Reorder Point
SS Ltd has a lead time of 7 days with an average number of working days of 300 days for a year. Then the calculation of the glass bottle ordering point is as follows:

ROP = (d \times L) + SS
= (\frac{2,840.789}{300} \times 7) + 3,079
= (9,469 \times 7) + 3,079
= 69,362 crates

Based on the reorder point calculation, the company must order a glass bottle when it reaches the amount of 69,362 crates.

4. Conclusion
Based on the calculation of the results of forecasting errors, the most appropriate method used for forecasting requests for the 220 ml glass bottle packaging is the Moving Average method n = 9 with the lowest forecast error rate compared to other methods. Where the MAD value is 13,680, MSE is 283,370,239, and MAPE is 5.49%. The most economical number of orders for purchasing glass bottles is 136,234 crates with ordering frequency 21 times a year, total inventory costs are IDR 204,351,654 safety supplies are 3,079 crates of glass bottles and re-ordering points when reaching 69,362 crates of glass bottles.

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