Forecasting Methods Comparison Based on Seasonal Patterns for Predicting Medicine Needs with ARIMA Method, Single Exponential Smoothing

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Abstract. The purpose of this study is to predict the needs of medicines by using forecasting techniques and calculating the value of Economic Order Quantities. Fluctuations in the use of drugs that occur every year is an obstacle for the drug warehouse in planning procurement in hospitals. The method used in this study is ARIMA time series forecasting for the process of prediction and calculation of EOQ. The results of this study in the form of an estimated value of drug needs for one coming period is shown by the smallest forecasting error value, namely ARIMA (1.0.0) with an error value of 13%, and the results of calculations of the Quantity of Economic Order for future drug needs. Forecasting results between ARIMA and the Exponential Smoothing method show that forecasting has the smallest error value, using ARIMA (1.0.0).

1. Introduction

Hospital is a health service institution that organizes individual health services in a comprehensive manner that provides inpatient, outpatient, and emergency services [1]. Indramayu Regional General Hospital (RSUD Indramayu) is a type B government hospital, which carries responsibility as a referral hospital in the Indramayu Regency area. One that becomes a concentration is improving services by continually increasing the availability of medicines and medical devices in accordance with the patient's needs optimally in an appropriate amount and time and quality. Facilities and infrastructure are important things that must be considered and developed by the hospital. The actual conditions relating to facilities and infrastructure still have many shortcomings, such as supporting facilities namely inadequate parking, lack of free access from the entry of ambulances to the emergency installation, the condition of elevator facilities intended for patients far from feasibility standardization, etc. There are still shortcomings of the basic facilities or services of the hospital, such as the lack of patient bed facilities, facilities for the needs of health tools that are not maximized, until the medicine needs for inpatients and outpatients are not fully available, and there are still many shortages of medicine stock.

Medication is a vital component of hospital services. Minister of Health Decree no. 1333 / Menkes / SK / XII / 1999 concerning "Hospital Service Standards" [1] states that management of hospital services must maintain that the medicines needed are available at all times in sufficient quantities to support services and provide benefits to patients and hospitals. The quality of hospital services is of particular concern with regard to the availability of medical equipment and medicines, which are influenced by several factors, including the high maintenance of medical devices, expired medicines, and running out of supplies of medicines and medical devices. It is important for hospitals to plan medicine supplies to overcome problems related to the availability of medical devices and medicines. Fluctuations in the use of medicines that occur every year are an obstacle to the medicine warehouse in procurement planning in hospitals. The research that will be done is to predict the need for paracetamol medicines by using techniques in forecasting.
procure inventory needs, especially medicines found in Indramayu District Hospital. Based on previous year's use which led to a change in the proposal for medicine procurement every year. The lack of medicine stock causing sudden orders with a purchase price that will become more expensive, it is a problem for hospitals. A forecasting or strict forecasting is needed to predict medicine needs in the future. Forecasting is the art and science of predicting future events by taking historical data and projecting it into the future using several forms of mathematical models [2]. Based on opinion, forecasting is the activity of implementing a model that has been developed in the future. In the opinion of, forecasting is an objective calculation using past data to determine something in the future. From some forecasting done by experts, it can be concluded that forecasting is a science to predict the needs of a data in the future, by analyzing previous data to be applied mathematically and in the form of a model [3-4]. Based on opinion, forecasting is the activity of implementing a model that has been developed in the future. In the opinion of, forecasting is an objective calculation and by using past data to determine something in the future. From some forecasting according to experts, it can be concluded that forecasting is a science to predict the needs of a data in the future by analyzing previous data to be applied mathematically and in the form of a model [5-7].

The research conducted by which uses the Double Exponential Smoothing technique stated that the amount of data continuously shows an increase every year. So, when the data analysis is carried out a trend pattern will be found [8]. While the research conducted by with 45 months test data shows that the ARIMA method is the best method used compared to the Winter method because the calculation results show the ARIMA method has the smallest error value. In this study, a model or forecasting technique was designed, to find out which pattern is suitable for the case of data that will be the object of research and determine the results of forecasting the availability of medicines in the future within a certain time period by comparing the forecasting technique between ARIMA and Exponential Smoothing. Forecasting according to is the process of estimating some future needs which include the needs in terms of quantity, quality, time, and location needed to fulfill the demand for goods or services. According to Gaspersz, forecasting activity is a business function that seeks to estimate demand and use of products so that the products can be made in the right quantity [9-11].

Forecasting is classified based on the future time horizon covered. According to Makridakis forecasting is clarified based on the future time horizon covered. This study aims to predict the needs of medicines by using forecasting techniques and calculating the value of Economic Order Quantities. The method used in this study is ARIMA time series forecasting for the process of prediction and calculation of EOQ.

2. Method

At this stage a series of designs are carried out from the processes or stages of the research being carried out.

2.1 Flow of Research Work

The steps taken in this study are recap data per period and make a pattern with a line chart to make it look like the pattern of the data. Conduct analysis of forecasting methods that have a season or seasoning pattern. Conducting the forecasting process using the ARIMA method, beginning with calculating the stationary value of medicine use data, determining the value of ACF and PACF, looking for the ARIMA model that is suitable for subsequent data forecasting processes for the future period. Conducting a forecasting process with other methods to find the smallest error value, namely with the Exponential Smoothing method. Beginning with forecasting using the single exponential smoothing method and continued with the double exponential smoothing method. Then determine the smallest error value from each of the previous calculation results. Finally, forecast for the next period using forecasting method that has the smallest error value after going through the data testing stage with that method.
2.2 Data Collections

At this stage, several series of data collection are carried out to support research needs, namely primary and secondary data. Primary data is obtained by conducting an observation process of medicine use and purchase data obtained from informants, namely the head of the pharmacy installation at Indramayu Hospital. Secondary data is obtained through intermediary media in the form of books, records, existing evidence, or files that are either publicly published or not publicized.

The data is obtained directly from the Indramayu General Hospital pharmacy installation for a period of three years or 36 months, and conducts question and answer sessions about which medicine needs have a fast and significant turnaround. Medicinal data that was the target of the study were the paracetamol medicine which became the basic medicine for reducing heat and fever, as well as a basic medicine in performing treatments.

The next data, obtained in the library study process. In this literature study the author collects and studies various basic theories and concepts of forecasting or forecasting, as well as calculation and analysis techniques related to the case to be studied.

3. Results and Discussion

3.1 Data Identification

At this stage the identification of data obtained, namely the use of medicines within three years or 36 months. This stage is explained about the number of the medicine units used (see Table 1).

| Medicine for | Paracetamol generic 500mg |
|--------------|---------------------------|
| Brand        | Sanbe farma               |
| Unit         | 1 box contains 10 strips  |
|              | 1 strip contains 10 tablets |
|              | 1 box = 100 tablet        |
| Price        | Price/sheet Rp. 5.500     |
|              | Price/box Rp. 50.000 (valid for purchases >100 boxes) |
|              | Price/box Rp. 60.000 (valid for purchases <100 boxes) |
| Time of order| Conducted once a year during the procurement of medicines when the new fiscal year |
| Delivery time| Performed every 3 months  |

Then explained the data pattern that became the object of research, here is the pattern of ordering and shipping data per period in Table 2:

| Time       | Amount | Time       | Amount |
|------------|--------|------------|--------|
| December 2014 | 200 boxes | January 2015 | 50 boxes |
| December 2015 | 210 boxes | April 2015   | 50 boxes |
|             |        | July 2015   | 50 boxes |
|             |        | October 2015| 50 boxes |
|             |        | January 2016| 50 boxes |
| December 2016 | 210 boxes | April 2016   | 50 boxes |
|             |        | July 2016   | 50 boxes |
|             |        | October 2016| 60 boxes |
|             |        | January 2017| 60 boxes |
Identification of data to be processed, namely medicine data issued based on prescriptions given by doctors to patients, and based on needs in each inpatient room. The unit of medicine use is per item/tablet. Following is the pattern of medicine expenditure data for 36 months, as shown in Figure 1:

- The number of medicines used in the first year (months 1-12) for one-year period amounted to 22,827 tablets. That is the same as 228 Box 2 strips of 7 items.
- The number of medicines used in the second year (13-24 months) of one-year period amounts to 20988 tablets. That is the same as 209 boxes of 8 grain strips.
- The number of medicines used in the third year (25-36 months) in one-year period is 21344 tablets. That is the same as 213 boxes of 4 strips of 4 grains.

3.2 Stationarity

Data pattern in figure 1, the data contains seasonal or seasonal patterns. Then stationary calculations are made in order to determine the method to be used in the forecasting process. Data stationary can be tested by plotting data and calculating the autocorrelation function (ACF). Through the data plot, it is seen visually whether the data has a tendency to increase, decrease, or there are seasonal fluctuations. Whereas from the ACF value, if the ACF value approaches zero in the second or third lag, then the data is stationary. If the observed data has a seasonal pattern, the ACF plot will show a significant ACF value in multiples of the season.

3.3 Calculation of ACF dan PACF

At this stage, the next step is by calculating the ACF or Autocorrelation Function, which indicates the value of autoregressive and viewing stationarity by analyzing the plot chart Autocorrelation Function (ACF), if the data drops to near zero quickly, it can be said that the data is stationary. The modeling results from ACF were like Figure 2:
PACF modeling results such as Figure 3:

![PACF Chart]

**Figure 3. PACF Modeling Results**

The ACF chart looks dying down in the second lag, while the PACF graph is cut off in the second lag. The conclusion from the results of the above calculation is that the Autocorrelation Function (ACF) has a dying down pattern and the Partial Autocorrelation Function (PACF) has a cut-off pattern. Then the model is ARIMA with pure AR (Auto Regresive).

3.4 Forecasting Using ARIMA

At this stage, the ARIMA model [16] test is carried out with the provisions of the results of ACF and PACF calculations which show pure AR models, then the ARIMA model to be used is the ARIMA Model (p, d, q). Calculation of the forecasting process using ARIMA (1.0.0), where the value of p is autoregressive = 1, the value of d = 0 (stationary data), and the value of q = 0. This pattern shows pure Auto Regresive. ARIMA (1,0,0). The processed results of ARIMA data (1,0,0). This calculation uses SPSS software. The following is the result of ARIMA (1.0.0) calculation in Table 3.

| Model Statistics | Number of Predictors | Model Fit Statistics | Ljung-Box Q (18) |
|------------------|----------------------|----------------------|------------------|
|                  |                      | Stationary R-squared | R-squared        |
| VAR0000 1-       | 0                    | .338                 | .338             |
| Model_1          |                      | 283.715              | 13.828           |
|                  |                      | RMSE                 | MAPE             |
|                  |                      | s                    | 14.801           |
|                  |                      | DF                   | .610             |
|                  |                      | Sig.                 | 0                |

3.5 Forecasting Using Exponential Smoothing

At this stage the best alpha value is searched to produce the smallest error value for the single exponential smoothing method. to find out MAPE and MAD to find out the smallest error value of each model. Search for the best alpha values as shown in Figure 4:
The explanation of Figure 4 is to do a random test to get the best alpha value by comparing the smallest MAD (Mean Absolute Deviation) value of each alpha model that was tested. The results show that alpha 1 has the smallest MSD value, as in Table 4:

Table 4. Best alpha values based on MAD values

| Alpha | MAD  | MAPE |
|-------|------|------|
| $\alpha=0$ | 291  | 18   |
| $\alpha=0.1$ | 293  | 18   |
| $\alpha=0.2$ | 292  | 17   |
| $\alpha=0.3$ | 285  | 17   |
| $\alpha=0.4$ | 271  | 16   |
| $\alpha=0.5$ | 261  | 15   |
| $\alpha=0.6$ | 258  | 15   |
| $\alpha=0.7$ | 258.7 | 14.8 |
| $\alpha=0.8$ | 257.7 | 14.7 |
| $\alpha=0.9$ | 255.8 | 14.5 |
| $\alpha=1$ | 253.2 | 14.2 |

The next step is to do forecasting provided that alpha value = 1. As shown in Figure 5:

In the picture above, it is explained that the Single Exponential Smoothing method has MAPE 14.2, MAD 253.2 and MSD 94874.5. Calculation of the value of MSE for etode exponential smoothing using SPSS, as in Table 5:
Table 5. Results of calculation of Exponential smoothing error values

| Model Statistics | Number of Model Fit statistics | Ljung-Box Q (18) | Number of Outliers |
|------------------|--------------------------------|------------------|-------------------|
| Model            | Number of Predictors | Stationary R-squared | R-squared | RMSE | E | MAP | Statistics | DF | Sig. |
| VAR0000          | 1                | Model_1            | 0     | 6.662E-5 | .189 | 309.52 | 14.08 | 5   | 6    | 11.524 | 17 | .828 | 0 |

3.6 Analysis Results

Based on the two models, ARIMA and Single Exponential Smoothing by comparing the average error values of each model, in Table 6 shows that:

| Model                          | MAPE Value | MSE Value |
|--------------------------------|------------|-----------|
| ARIMA (1.0.0)                  | 13%        | 283.715   |
| Single Exponential Smoothing   | 14%        | 309.525   |

Then the smallest error value based on the value of MAPE and MSE is the ARIMA (1.0.0) model with the value of MAPE 13%, the value of MSE 283,715

3.7 Analysis of Forecast Results

The forecasting process is carried out after knowing the analysis of several models that have the smallest error values. At this stage, forecasting over a period of one year using previously available data for 36 months using the arima (1.0.0) method is as follows (see Figure 6):

Based on the results of the forecasting above, the calculation of the amount of medicine needed for the next year is shown in Table 7:
3.8 Calculation of the Economic Order Quantity (EOQ)

The following is a breakdown of medicine needs for the next one year or one subsequent period and costs needed to determine the value of the Economic Order Quantity, such as Table 8:

| No. | Type of Needs                                                                 | Amount                          | Note                                                                 |
|-----|-------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------|
| 1   | Medicine needs in the future period according to what has been predicted (D) | 22243 items = 223 boxes = 230 boxes | Purchases can be made with a number of multiples of 10               |
| 2   | Purchase Fee (S)                                                              | Rp. 50,000, - / boxes.          | Rp. 11,500,000, - / 230 boxes                                       |
| 3   | Storage fee (H)                                                                | Rp. 1000 / boxes / year         | Including the cost of shipping and unloading goods                   |

\[
\text{EOQ} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(230 \text{ boxes}) \times (Rp. 11,500,000)}{Rp. 1,000}} = \sqrt{5,290,000} = 2300 = 23 \text{ box}
\]

1.9 Value of Safety Stock

To calculate the safety value of the stock to minimize the occurrence of stock outs and reduce the addition of storage costs and total stock out costs, namely by the following formula (see Figure 7):

Safety stock formula = safety factor x standard deviation.
Safety stock = \(Z \times \sqrt{(PC / T)} \times \sigma D\)
with:
- \(Z\) = safety factor (see table)
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- PC = performance cycle = forecast cycle and order cycle
- \( \sigma_D \) = standard deviation of demand
- \( T \) = demand period cycle

| Month | Forecast | mean | demand | 1853.583 |
|-------|----------|------|--------|----------|
| 37    | 1813     |      |        |          |
| 38    | 1978     |      |        |          |
| 39    | 1762     | std Dev | 156.246 |
| 40    | 1841     |      |        |          |
| 41    | 1831     | service level | 95%    |
| 42    | 1996     |      |        |          |
| 43    | 1640     | service factor | 1.644854 |
| 44    | 1575     |      |        |          |
| 45    | 1789     | safety stock | 257.0018 |
| 46    | 1938     |      |        |          |
| 47    | 2135     |      |        |          |
| 48    | 1945     |      |        |          |

Figure 7. Safety stock Result

The data is actually used every week. Search for a standard deviation with the excel formula: std deviation = STDEV (actual column highlight usage) obtained 156. Then determine a service level in percent, 95%. Service factors are calculated using the excel formula: = NORMSINV (highlight the service level column) get the number 1.64. For that, the service level of 95% is required for the safety stock = (service factor x std dev). that is equal to 257 (units of grains per month), which with an average demand of 1853.

4. Conclusion

The forecasting results between the ARIMA and Exponential Smoothing methods indicate that the forecasting has the smallest error value, namely by using the ARIMA (1,0,0) method with the value of MAPE 13% and MSE 283.715. Forecasting results of medicine needs in the next period, namely as many as 222 boxes of 4 strips with 4 grains, carried out by making 223 Boxes. For that, the service level of 95% is required for the safety equal to 257 (units of grains per month), which with an average demand of 1853.

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