Analysis of Drug Forecasting with Single Moving Average and Single Exponential Smoothing Approach (Case Study in Jombang Regency 2017-2019)

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Abstracts. Drug forecasting is done by all health facilities including government’s health facilities. It aims to consider the type of medication, the amount needed to realize a good drug management system. However, a of methods requires large selection using evaluation multiple measures of error in drug forecasting. The study aims to find out the method with the size of the least forecasting error between Single Moving Average and Single Exponential Smoothing. The data used is the annual primary data of the period 2017-2019. Samples amounted to 35 Public health centers. Forecasting calculation has been done using Single Moving Averages and Single Exponential Smoothing methods and testing errors using Mean Absolute Deviation and Mean Square Error methods. The study used 5 major medications with the most forecasting for 3 years. The drug with the most consecutive planning period 2017-2019 is paracetamol tablets 500 mg of 694,911 tablets, 126,713,379 tablets and 11,705,308 tablets. The conclusion of results showed a Single Moving Averages = 12,681 milions tablet with MAD = 0,594 milions and MSE = 666,841 millions. While, Single Exponential Smoothing = 7,949 milions with MAD = 4,557 milions and MSE = 372,884 millions. So, both of methods have small error measurement.

Keywords: Single Moving Average; Single Exponential Smoothing; Forecasting; Mean Absolute Deviation; Mean Square Error.

1. Introduction

The Government which has the main task to carry out the recording, planning, reporting drugs and pharmaceutical products which are necessary to health services in all public health centers. In the planning, recording and reporting sections often face inventory problems such as certain drug items experiencing overstock and understock. This problem is likely due to the lack of attention and proper planning in the inventory. This can happen if there is a demand for drugs that cannot be controlled[1][2].

The Planning method used by the health office of Jombang regency is a consumption method. This method is applied based on real data consumption of last period pharmaceutical products, with various adjustments and corrections. Making methodologically and scientifically thorough predictions allow them to anticipate the future and plan the activities which will contribute to attaining their objectives[3][4]. The forecasting method that can be used depends on the retrospective data patterns they have. According to J.E Hanke and Wichern, data patterns consist of 4 types. Appropriate methods used for stationary data patterns include the Single Exponential Smoothing and Single Moving Average methods, while the trend data pattern is the Double Exponential Smoothing method, and for the seasonal data pattern the Triple Exponential Smoothing method[5][2][6].

Research conducted by with 45 months test data shows that the Autoregressive Moving Average (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[4][7]. However, there has been no
forecasting research using the single moving average method in the pharmaceutical field. And it’s limited. While, Exponential smoothing is a method of forecasting which is very popular in supply chain management because it is simple, transparent and accurate[8][6]. Related research to predict sales of multiple products (6,877 products) using the Single Exponential Smoothing (SES) approach, which is expected to improve the efficiency of the inventory system[9][10].

It is necessary analyze of drugs needs forecasting methods by using another method. This research used Single Moving Average (SMA) and Single Exponential Smoothing (SES) method. These two methods are considered appropriate to use for the type of forecasting which has a stationary pattern without any seasonal and Trend data. This research aims to know the comparison between SMA and SES forecasting. In this study, 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 period time by comparing the forecasting technique between Single Moving Average and Single Exponential Smoothing in pharmaceutical filed. It is adjusted with planning data pattern in all public health centers in jombang regency from 2017 until 2019. The measuring result of these two methods will be compared for their level of accuracy due to the measurement result of the error level. Two Related research measurement accuracy of prediction study using a standard measurement Mean Absolute Percentage Error (MAPE)[9][1]. There are two measurements others which often used to measure the error level of a forecasting method; the Mean Absolute Deviation (MAD) and the Mean Squared Error (MSE). The forecasting with the smallest error level method will be the reference to give a recommend as an alternative method that has been used before[11].

2. Literature Review

2.1 Forecasting
In planning, the method generally used as an effort to estimate future drug needs is forecasting. Many factors have uncertainty, so it is impossible to make perfect forecasting which is why it is necessary to find the best forecasting method to use.

2.2 Determination of the Analysis Model
In determining the most appropriate forecasting method, it is necessary to consider the types of patterns from existing historical data. Data patterns can be divided into four types, namely as follows:
1. Horizontal Pattern (H) occurs when data values fluctuate around a constant average value. Such a sequence is "Stationer" for its average value.
2. Seasonal Pattern (S) occurs when a series is influenced by seasonal factors (for example a quarter of a particular year, month, or days of a particular week).
3. Cyclical Pattern (C) occurs if the data is affected by long-term economic fluctuations such as those related to the business cycle.
4. Trend Pattern (T) Occurs when there is a long-term secular increase or decrease in the data.

2.3 Single Moving Average
Used in predicting demand by calculating the average value of the actual demand value from several specific periods before. According to Wisner and his friends moving average uses historical data to make predictions and can work well when the value is not stable. It has two special properties; to make a forecast require historical data within a certain period time, the longer the moving average will produce the smoother moving averages[12].

2.4 Single Exponential Smoothing
Also known as simple exponential smoothing which is used in short-term forecasting, usually only 1 month ahead. The model assumes that the data fluctuates around a fixed mean value, without consistent trends or growth patterns.
2.5 Testing the Measure error of forecasting method
In this study, Mean Absolute Deviation and MSE were used.

1. MAD (Mean Absolute Deviation), which measures the average magnitude of forecast error. With the formula [13]:

\[
\text{MAD} = \frac{\sum At - Ft}{n}
\]

MAD provisions, the smaller the MAD value indicates the fewer errors produced.

2. MSE (Mean Square Error), which can be calculated by summing the square of all forecasting errors in each period and dividing by the number of forecasting periods. With the formula [13]:

\[
\text{MSE} = \frac{\sum (At - Ft)^2}{n}
\]

3. Research Method
3.1. Research Design
Observational research method with a quantitative descriptive approach. Researchers evaluated through time-series data and drug management documents in 35 Public health center in Jombang Regency. The first stage is preparation (planning), the second stage is implementation included data collection and management, the third stage is data analysis and evaluation.

Forecasting is based on the classification of the drug types. Because the number of product variations reached 403 types, in this study five drugs, were selected, especially those classified as the most planned from 2017 to 2019. Table 1 is the result of the five types of drugs with the most planning.

3.2. An Object of the research
In this study, researchers used several institutions as research objects. The selected government institution is an agency engaged in the field of health, especially in carrying out routine drug planning.

3.3. Population and Sample
Data for drug management in 34 public health centers in Jombang Regency. While the sampling technique used in this study is a total sampling.

3.4. Research variable
Drug Needs Plan (RKO) is a plan for the number of drugs provided for health services which must be under the number of drugs need or use. RKO for the period of 2017-2019. Single Moving Average which is calculated by the formula [13][4]:

\[
\text{MA} = \frac{\text{At} + \text{At}-1 + \ldots + \text{At}-(N-1)}{N}
\]

Single Exponential Smoothing is calculated using the formula:

\[
F_t = Ft-1 + \alpha (At - Ft-1)
\]

Note:
- \(F_t\) = Demand forecasting in period t
- \(\alpha\) = weighting / exponential constant
- \(F_t-1\) = Demand forecasting in period t-1
- \(At\) = actual demand in the last period

3.5. Research Instruments
Microsoft Excel for data processing, estimation and error calculation.

3.6. Research Flow
Data is obtained from primary data in the form of data recapitulation from the Health Office of Jombang regency. Secondary data used are report documents and drug request sheets (LPLPO), annual reports on drug management, drug stock cards, drug need plans, list of drug prices, daily records of drug use from 25 public health centers in Jombang Regency for the 2017-2019 period. Then the 5 most planned drugs are taken during the 2017-2019 period. Carrying out Single Moving Average and Single Exponential
4. Results And Discussion

The source of the data used is secondary data which is data on drug demand in the previous period (years). The data collection method was carried out using the survey and interview methods in the 2017-2019 Drug Needs Plan data for 34 public health centers in Jombang Regency. Then data recapitulation was carried out. 5 drugs with the biggest plan in the 2017-2019 period were obtained. This is shown in table 1.

Table 1 Drugs with the biggest planning 2017-2019

| No | drugs names         | 2017 (million) | 2018 (million) | 2019 (million) |
|----|---------------------|----------------|----------------|----------------|
| 1  | Paracetamol 500 mg  | 0.694          | 126.213        | 11,705         |
| 2  | Vitamin B6 10 mg    | 0.127          | 21.284         | 2,060          |
| 3  | Vitamin B Complex   | 0.179          | 5.127          | 2,848          |
| 4  | Chlorpheniramine 40 mg | 0.274        | 4,209          | 4,377          |
| 5  | Amoxicillin tab 500 mg | 0.344        | 0.453          | 5,748          |

4.1. Request Data Plots

Drug demand data that had been obtained then processed and tested for its data patterns to determine the appropriate method in solving existing problems. Figure 1 shows a chart of 2017-2019 drug planning. The graph shows 3 out of 5 drug names showing a stationary pattern. The pattern is shown in the planning of vitamin B Complex tablets, Chlorpheniramine 40 mg, and Amoxicillin tablets 500 mg in the 2017-2019 period.

4.2. Model Selection

The single exponential smoothing method is used because the data is stationary. The forecasting result using the SMA method is shown in table 2. It was obtained an SMA of 12,681. Then the calculation of forecast error accuracy was calculated to see the error percentage[16]. This calculation can be used to compare different forecasting models, also to oversee forecasting[4][17], to ensure forecasting runs well. The forecast error results are shown in table 2.

Table 2 Calculation of Single Moving Average for 2017-2019

| No. | Drugs names         | SMA (million) | (MAD)(million) | (MSE) (million) |
|-----|---------------------|---------------|----------------|-----------------|
| 1   | Paracetamol 500 mg  | 46,371        | 1,301          | 3234,206        |
| 2   | Vitamin B6 10 mg    | 7,823         | 0,229          | 90,791          |
| 3   | Vitamin B complex   | 2,718         | 0,316          | 3,301           |
| 4   | Chlorpheniramine 40 mg | 2,953        | 0,486          | 1,732           |
| 5   | Amoxicillin tab 500 mg | 3,540        | 0,638          | 2,124           |
|     | Average             | 12,681        | 0,594          | 666,431         |
Research conducted by Kolade (2019) where the study was carried out on pharmaceutical retail companies with the SMA method resulted in the value of MAD = 66.31 and MSE = 23.56. The SES method is used because the data is stationary with data values fluctuating around a constant average value[14][18]. The forecasting result using the SES method is shown in table 3. An average value of 7.940 was obtained. The forecast error results are shown in table 3.

| No  | Drugs names               | SES (million) | Average (million) | MAD (million) | MSE (million) |
|-----|---------------------------|---------------|-------------------|---------------|---------------|
|     |                           | 2017 | 2018 | 2019   |          |          |
| 1   | Paracetamol 500 mg        | 0.347| 63,704|11,705 |25,252| 21,118|1764,55 |
| 2   | Vitamin B6 10 mg          | 0.063| 10,705|11,671|7,480 |0.228|92,708 |
| 3   | Vitamin B complex         | 0.089| 2,563 |3,987 |2,243 |0.316|3,301 |
| 4   | Chlorpheniramine 40       | 0.136| 2,241 |4,292 |2,223 |0.486|1,732 |
| 5   | Amoxicillin tab 500       | 0.017| 2,436 |5,138 |2,582 |0.638|2,123 |
|     | Average                   | 0.130|16,330|7,359 |7,956 |4,557|372,884|
|     |                           | 7,940|     |     |     |     |     |

A study conducted by Kolade (2019) where the study was carried out on pharmaceutical retail companies with the SES method resulted in MAD value = 40.34 and MSE = 18.74. Kolade said SES was the most suitable method. This is because the error measurement value is smaller than the SMA method[19].

5. Conclusion
The results showed the value of Single Moving Averages = 12.681 million with MAD = 0.594 million and MSE = 666.841 million. While Single Exponential Smoothing = 7,940 million with MAD = 4,557 million and MSE = 372,884 million. So, both of these methods have small error measurements. Further research can apply various other prediction methods, such other time series model or machine learning models and so on to obtain the most accurate method for predicting the sales multiple products with data patterns such as this study or developing a toolkit to facilitate predicting the number of sales, even by involving network security[9][6][20].

6. Acknowledgement
The researcher wants to acknowledge Kadiri University, especially the Health Science Faculty, for giving a chance for doing the research and composing the report.

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