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Predicting Selling Product of Single Variant Using Arima, Trend Analysis, And Single Exponential Smoothing Methods (Case Study: Swalayan Xyz Store)

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ABSTRACTS

The availability of goods in a store is very important. Predicting is a tool that is used to help predict the data needed by an organization or company. The purpose of this study is to predict the sale of a product that has a high risk of damage and fast expiration time by using existing techniques in forecasting. Forecasting can also be used to make product stock safety at the XYZ Supermarket. The results of this study are in the form of forecasting the sale of a product in a store by using the existing methods of forecasting that are adjusted to the sales data of one product. The method used in forecasting is the ARIMA method, Trend Analysis, and Single Exponential Smoothing. Trend Analysis Method has the highest accuracy with MAPE 9.91%, which means that forecasting is very good, compared to ARIMA with MAPE 37.21% and Single Exponential Smoothing with MAPE 10%. So that the results of the Trend Analysis forecasting will be used for the decision-making process about forecasting stockpiles and stock safety in the future.

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1. INTRODUCTION

Sales is an activity that aims to seek, influence and give instructions to buyers to be able to adjust their needs to the products offered and make commitments regarding prices that are mutually beneficial for both parties.

There are three main stages in the decision-making process, such as data collection, data processing, and storage of processed data. To conduct an analysis of the planning of the right inventory, the company can apply a method that will be carried out to estimate the amount of inventory data in the future, activities are called forecasting methods.

In a newly developed business, there are often problems to try to forecast data that has the risk of damage or has a fast expiration period. The product used in this forecasting is chicken eggs. Time Series Forecasting is one way that allows providing forecasting solutions based on the latest data or a short time to forecast future data.

To get good forecasting, forecasting is done by following the steps or procedures so that it will determine the quality and quality of the forecasting results. In general, there are 3 important forecasting steps, namely (Al-Khowarizmi et al., 2020; Barbaglia et al., 2023):

- Analyzing past data, this stage is done to see patterns that have occurred in the past.
- Determine the data be used. The method that has the smallest error value is the best method.
- Projecting past data using the method chosen for forecasting, taking into account the existence of several factors of change.

In this study, a model or forecasting technique is designed with the data that is owned, with data for 13 months or 52 weeks to determine the results of forecasting the future stock of goods based on sales data in a certain period of time, by collaborating time series forecasting techniques to obtain an accurate high.

2. RESEARCH METHOD

2.1. Literature review

2.1.1 Sales

To get a big profit, a company, both goods, and services must have a sales strategy. One way to do this sales strategy is to do sales forecasting. Forecasting sales (sales forecasting) is a technique used to project potential customer demand, from time with various conditions (Januschowski et al., 2020).

2.1.2 Forecasting

In general, the time period for forecasting can be grouped into three categories, namely (Pal et al., 2021):

- Short term forecasting, forecasting carried out in less than three months.
- Medium-term forecasting, forecasting carried out within a period of three months to three years.
- Long-term forecasting, forecasting carried out over a period of more than three years.

To forecast demand must use a certain method (Pandey & Jain, 2023). Basically, all forecasting methods have the same purpose, namely by using data in the past to estimate or project data in the future.

2.1.3 Research design (data processing)

The flow of research design can be seen in Fig. 1.

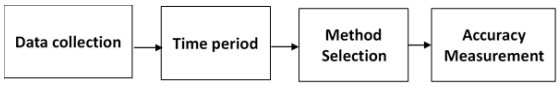

Fig. 1. The flow of Research Design

2.1.4 Time series analysis

To get an appropriate time series method, it is necessary to consider the type of data pattern, so that testing a pattern can be done with the most appropriate method.

2.1.5 Trend analysis forecasting

The trend is a long-term movement in a series of times that can be described as a straight or smooth curve (Roth & Singhal, 2022).

Matching a straight line to stationary (horizontal) data can be done by minimizing MSE using:

$$\mathbf{b}\overline{X} = \frac{\sum_{i-1}^{n} X_t}{n} \quad (1)$$

The formula for linear trend lines for periodic data:

$$Xt = a + bt \quad (2)$$

Values a and b that minimize MSE can be obtained using the following equation :

$$b = \frac{n\sum tX - \sum t \sum X}{n\sum t^2 - (\sum t)^2} \quad (3)$$

$$a = \frac{\sum X}{n} - b\frac{\sum t}{n} \ldots \quad (4)$$

Information:

a = intercept

b = slope

Trend Analysis Forecasting Flow can be seen in Fig. 2.

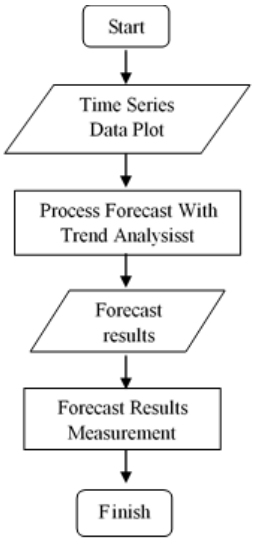

Fig. 2. Trend Analysis Forecasting Flow

2.1.6 Single exponential smoothing forecasting

Forecasting Single exponential smoothing is used in short-term forecasting, usually only for the next month. The model assumes that data fluctuates around a fixed mean value, without trends or consistent growth patterns (Saad et al., 2021). The formula for Single exponential smoothing is as follows:

Ft+1 = α * Xt + (1 – α) * Ft

Ft = forecasting for period t.

Xt + (1-α) = Actual time series value

Ft+1 = forecasting at the time t + 1

α = leveling constant between 0 and 1

The single exponential smoothing forecasting flow can be seen in Fig. 3.

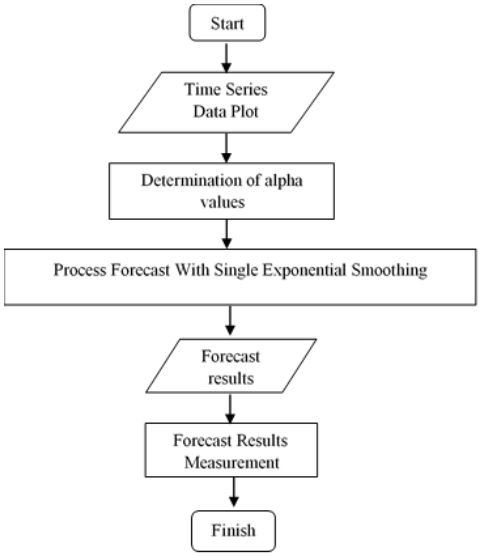

Fig. 3. Single Exponential Smoothing Forecasting Flow

2.1.7 ARIMA forecasting

ARIMA also has limitations on predictive accuracy but is used more broadly to estimate successive values in the future in the time series (Tian & Hao, 2020; Verano et al., 2020). ARIMA is also often referred to as Box-Jenkins models. ARIMA represents three models, namely from Autoregressive models (AR), Moving Average (MA), and Autoregressive and Moving Average models (ARMA) (Wijaya et al., 2023). The stages of implementation carried out in the search model, namely:

- Identify temporary models using past data to get the right model from ARIMA. The identification phase is carried out by observing the estimation pattern of ACF (Autocorrelation Function) and the Partial Autocorrelation Function (PACF) obtained from the data and then used to obtain projected models that correspond to the data pattern.
- Perform parameter estimates from the ARIMA model using past data.
- Perform diagnostic testing to test the feasibility of the model. If the model is not feasible, identification, estimation, diagnostic testing, and obtaining an appropriate ARIMA model are carried out.
- Implementing, that is forecasting the value of future periodic data using the tested method.

The Box-Jenkins Model (ARIMA) is divided into 3 groups, namely: the Autoregressive (AR) model, Moving Average (MA), and ARIMA (Autoregressive Moving Average) mixed models that have the characteristics of the first two models.

1) Auto-Regressive Model (AR)

The general form of the Auto-Regressive model with order p (AR (p)) or the ARIMA model (p, 0,0) is stated as follows:

$$XI = \mu^1 + \phi_1 X_{t-1} + \phi_2 X_{t-2} + \cdots + \phi_p X_{t-p} + e_t[0] \quad (5)$$

Information :

μ_1 = a constant

ϕ_p = p. Autoregressive parameter

e_t = value of error at t

2) Moving Average Model (MA). The general form of the order Moving Average q (MA (q)) or ARIMA (0,0, q) is stated as follows:

$$XI = \mu^I + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-k} \quad (6)$$

Dimana :

μ_1 = a constant

θ_1 to θ_k is the Moving Average parameter

e_{t-k} = error value at the time t – k

3) Mixed models

a) Process ARMA

The general model for a mixture of pure AR (1) and MA (1) processes, for example, ARIMA (1,0,1) is stated as follows:

$$XI = \mu^1 + \phi_1 X_{t-1} + e_t - \theta_1 e_{t-1} \quad (7)$$

or :

$$(I - \phi_1 B)X_t = \mu^1 + (I - \theta_1 B)e_t$$

AR(1) MA(1) (8)

b) Process ARIMA

If non-stationarity is added to the ARMA process mixture, then the general ARIMA model (p, d, q) is fulfilled. The equation for the simple case of ARIMA (1,1,1) is as follows:

$$(I - B)(I - \phi_1 B)X_t = \mu^1 + (I - \theta_1 B)e_t$$

AR(1) MA(1) (9)

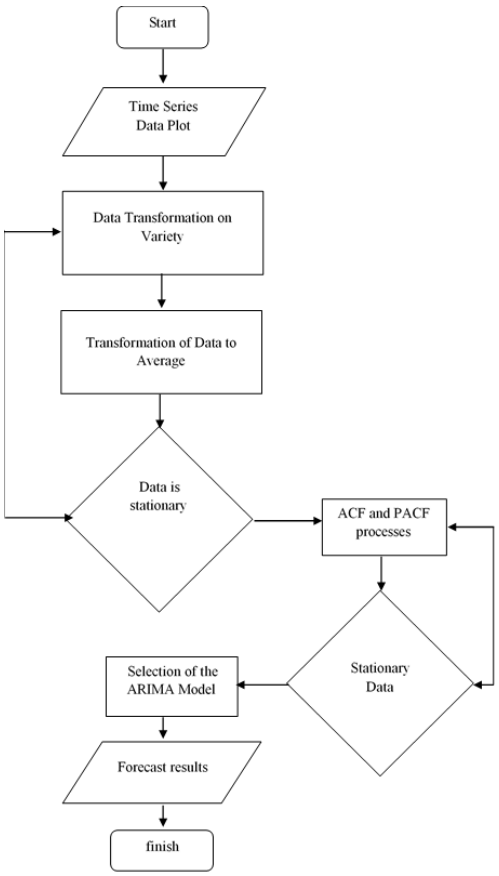

Fig. 4. The flow of Forecast ARIMA

2.1.8 Safety stock

The stages in determining safety stock are (Pandey & Jain, 2023):

1. Determine the value of the level of service desired by a company.

2. After knowing the level of service then proceed with calculating the safety stock with the following formula:

$$SS = Z\, x\, \sigma\sqrt{t} \quad (10)$$

Information:

SS = Safety stock

Z = Normal distribution standard deviation

3. RESULTS AND DISCUSSION

3.1. Data identification

At this stage identification of the data obtained, namely the sale of chicken eggs

in the period of 13 months or 52 weeks. This stage is explained about the number of chicken egg transactions that occur within 13 months or 52 weeks starting from April 2017 to April 2018. The forecasting process is carried out using sales data of one of the data in the XYZ Supermarket, namely: data on chicken egg sales from April 2017 to April 2018 or 52 weeks. The results of Sales data plot can be seen in Fig. 5.

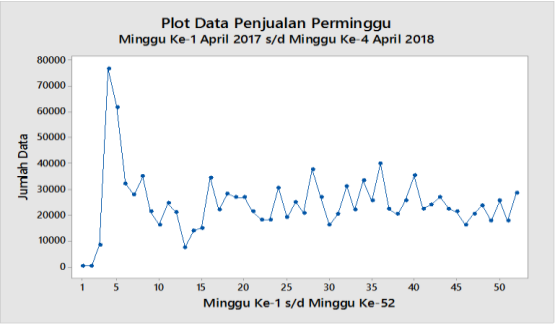

Fig. 5. Sales Data Plot

3.2. Forecasting Using the ARIMA Method

At this stage, the ARIMA model is tested

3.3. Steps in doing ARIMA forecasting

Stationarity is applied to the variety until it has a Rounded Value of 1 as shown below in Fig. 6.

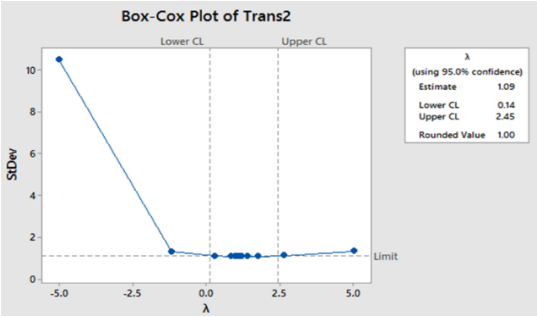

Fig. 6. Box-Cox Plot With Value 1.00 Rounded

Next, do stationarity to the average by doing ACF and PACF As shown below in Figs. 7-8.

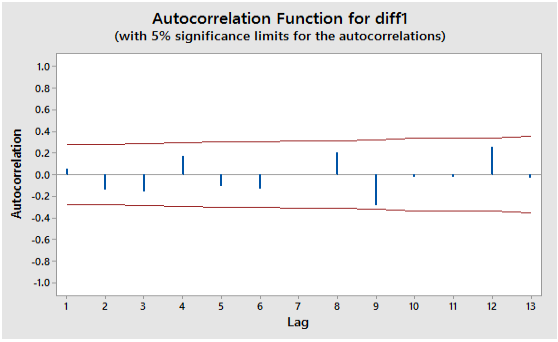

Fig. 7. ACF Process

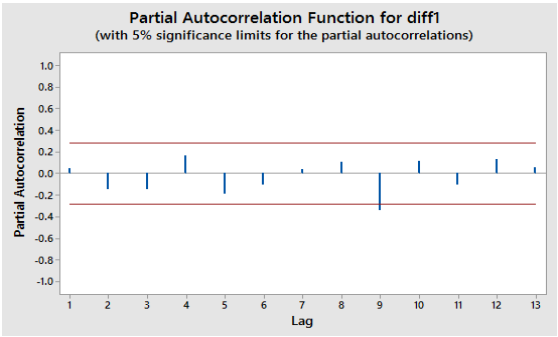

Fig. 8. PACF Process

By looking at the ACF and PACF patterns above, it can be said that the data has been stationary to the average because there is no pattern that exceeds the line and shows the ACF dying down and PACF dying down patterns which mean AR (autoregressive) and MA (moving average).

3.4 Test of ARIMA model

To determine the ARIMA tentative value, the ARIMA model (p, d, q) is used, and to get the model that will be used, namely the model that has a significance level close to zero. The results of the ARIMA model (1,1,0), (0,1,1,), (1,1,1) can be seen in tables. 1-3.

Table 1. ARIMA model (1,1,0)

Final Estimates of Parameters				
Type	Coef	SE Coef	T-Value	P-Value
AR 1	-0.177	0.140	-1.27	0.212

Table 2. ARIMA Model (0,1,1)

Final Estimates of Parameters				
Type	Coef	SE Coef	T-Value	P-Value
MA 1	0.480	0.124	3.87	0.000

Table 3. ARIMA Model (1,1,1)

Final Estimates of Parameters				
Type	Coef	SE Coef	T-Value	P-Value
MA 1	0.480	0.124	3.87	0.000
Final Estimates of Parameters				

From the table above it can be seen that the corresponding ARIMA model is the ARIMA Model (0,1,1) because it has a significance value of 0,000.

3.4.1 Forecasting with ARMA (0,1,1)

The Results of Actual Data Comparison and ARIMA can be seen in Fig. 9.

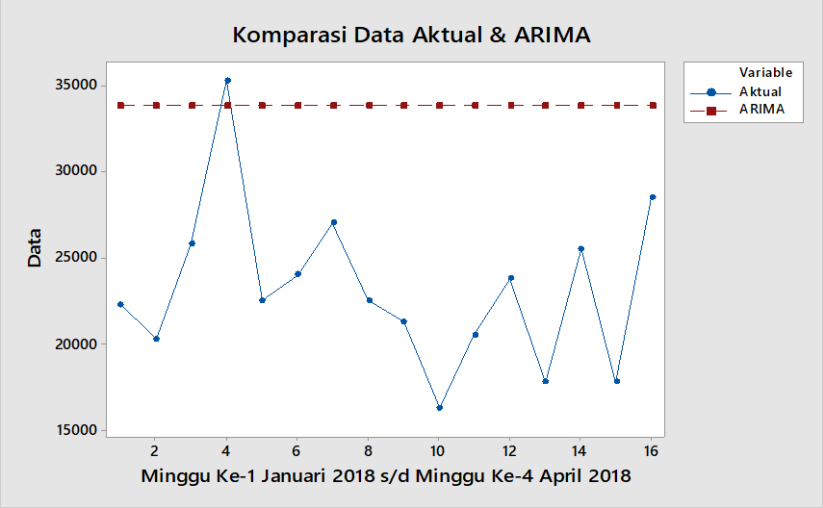

Fig. 9. Results of Actual Data Comparison and ARIMA

The results of the ARIMA forecast method (0,1,1). Then do the calculation to get the MAPE value. And the MAPE value obtained is 37.21%, which is included in the adequate/decent category.

3.4.2 Forecasting using the single exponential method

The comporative results of SES can be seen in Fig. 11.

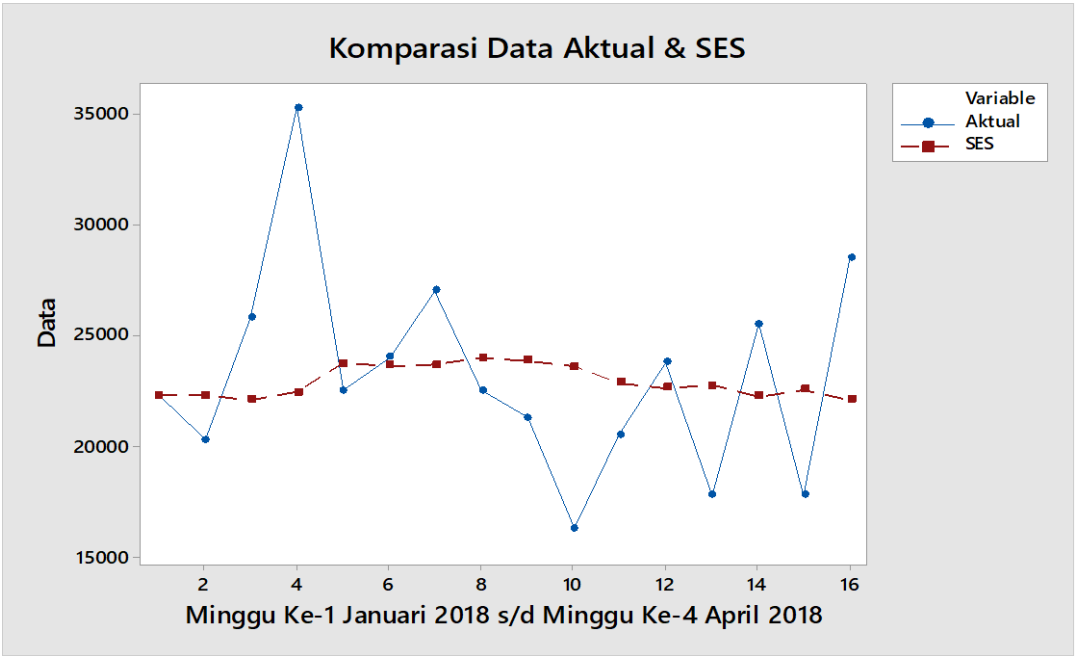

Fig. 11. Comparative Results of SES

3.5 Model analysis

Based on the three models namely ARIMA, Trend Analysis, and Single Exponential Smoothing, by comparing the value of the average error of each model, show in Table. 4.

Table 4. Results of calculation of error value

Model	MAPE value	Information
ARIMA	37.21 %	Fair / Worthy
Trend Analysis	9.91 %	Very good
Single Exponential Smoothing	10 %	Good

So, that has the smallest error value is Trend Analysis with MAPE 9.91%. Which means that forecasting skills are very good.

3.6 Analysis of forecasting results

The forecasting process is carried out after knowing the analysis of several models that have the smallest error value. At this stage, forecasting for the next 12 weeks can be seen in Figs. 12.

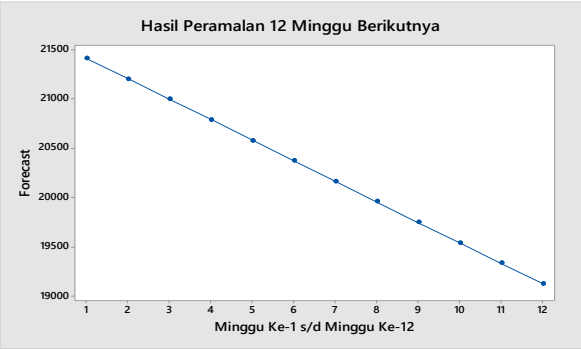

Fig. 12. Forecast results for the next 12 weeks

3.7 Calculation of safety stock value

To calculate the safety value of the stock to reduce the risk of stock out and reduce the addition of storage costs, total stockout costs, and the risk of damage or expiration, namely by the following formula:

SS = Sales for 12 weeks = 243,165.4 grams

Sales for 1 day (on average) = 243.165,4 gram /91 day = 2672 gram/day

Sales during lead time = 1 week = $\sqrt{}$ 7 hair x 2672 gram/day

Safety stock = 7.069 gram x 1 week

Using the data above, it can be seen that XYZ Supermarkets can make a decision-making process, especially in terms of stock items, namely chicken eggs with a minimum limit of 7.069 grams, to be considered in the provision of chicken eggs in the following week.

4. CONCLUSION

Conclusions can be drawn based on the description of the above research as follows: Forecasting results between the ARIMA method, Trend Analysis and Single Exponential Smoothing show that forecasting has the smallest error value, namely by using the Trend Analysis method that has a MAPE value of 9.91% which means that forecasting is very good. The results of forecasting single variant goods for the next 12 weeks amounted to 243,165.4 grams. To be used later in making decisions in providing stock for the next 12 weeks. The results of forecasting single variant goods at each week are 7069 grams. To do the process of providing stock in a weekly period.

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