

Comparison Of Exponesial Smoothing With Linear Regression Predicting Amount Of Goods Sales

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Abstract: A trading business is a business that operates in the sales sector with the aim of obtaining maximum profits through sales activities. To be able to sell efficiently, a prediction system is needed, so that there is no excess or shortage of inventory and the sales process can run smoothly. Human limitations in solving prediction problems without using tools that apply prediction methods are one of the obstacles in finding the right prediction value. Therefore, we need a prediction system that can help find accurate and fast values. So the problem formulation is how to design and build a sales prediction system using exponential smoothing and linear regression methods, then compare the two and find out which method is the best, both of which use periodic data prediction models. The data collection method used is secondary data from previous research and journals, as well as combining library study methods, namely information obtained from books, references and scientific works related to predictions. The tool used to build applications is MS-Visual Studio 2010 and WEB based system.

Keywords: *Comparison of two prediction methods, exponential smoothing, forecasting sales numbers, linear regression, prediction of sales numbers.*

INTRODUCTION

Predicting production quantities is one way to determine raw material purchases to producers. Apart from that, the aim of predicting production quantities is to avoid accumulation of raw material stocks in the PT Futami Food & Beverages warehouse. Because if there is a buildup of raw materials, it will cause the raw materials to go unused until the validity period of the raw materials expires. In this research, the prediction of production quantities at PT Futami Food & Beverages uses the double exponential smoothing forecasting method. Historical data calculated using the double exponential smoothing method is the total sales data for all Futami 17 GT product variants in 2016 from June to November. According to research, sales data at PT Futami Food & Beverages has an upward and downward trend data plot. From the results of this research, the Production Quantity Prediction Information System application will be used to determine production quantities. With the results of application feasibility testing with decent category with a score percentage of 80% for all aspects (I.- & Utomo, 2019). From the research above, it can be said that the linear regression method has good ability to predict. So in this study a simple linear regression method was used with the hope of seeing predictions of the number of new students in the next 5 years and getting the MAPE (Mean Absolute Percentage Error) value as small as possible so that the



prediction results have a high level of accuracy (Almumtazah et al., 2021). Business in the property sector can be said to be quite profitable but has high risks, especially the predictions in this research are based on its advantages in estimating simple model parameters and time series based data. Apart from that, this method can carry out analysis using several independent variables (X) so that prediction results can be more accurate (Ayuni & Fitriannah, 2019). The application of the multiple linear regression method and the use of SPSS as a data mining tool in this research aims to estimate the population growth rate of Musi Banyuasin Regency in the following year at the Central Statistics Agency of Musi Banyuasin Regency by applying data analysis methods so as to obtain good and efficient regression results and apply hypothesis testing method to find whether there is a relationship between the variables taken between each other (Candra Adi Rahmat et al., 2023). The choice of linear regression as a forecasting method in this research is based on simple model parameters and the advantages of time series-based data estimation. In addition, this method allows for analysis using several independent variables (X), which can produce more accurate predictions (Rizaldy et al., 2023). The exponential smoothing method is a development of the moving averages method. In this method, forecasting is done by repeating calculations continuously using the latest data. Each data is given a weight, newer data is given a greater weight. Two methods of exponential smoothing include single exponential smoothing and double exponential smoothing (Wiranti & Dhamayanti, 2020).

LITERATURE REVIEW

Literature review on "Comparison of Exponential Smoothing with Linear Regression in Predicting the Number of Sales of Goods". A prediction system is a computer program that can predict and calculate the number of sales of goods to solve a specific problem. Decisions can be made intelligently. Exponential smoothing and linear regression algorithms are two algorithms that can be used in decision support systems and artificial neural networks and are often used in solving complex problems because they have a good level of accuracy. The results of this research show that these two algorithms have a good level of accuracy in predicting the number of sales of goods, predicting production quantities is one way to determine raw material purchases to producers. From the results of this research, the Production Quantity Prediction Information System application will be used to determine production quantities. With the results of application feasibility testing in the feasible category with a score percentage of 80% for all aspects (- & Utomo, 2019). The "Joint Business" Employee Cooperative is a cooperative that has a minimarket business that sells various basic necessities needed by the community. The number of sales of goods each day is sometimes erratic, there are days where sales are very high and sales are very low the next day. The aim of this research is to predict the sales of goods sold every day. With the results of these predictions, the cooperative can create and develop sales strategies so that profits are maximized. This research was carried out using the Linear Regression method and also used the CRISP-DM process model as the data mining process flow. The results obtained from this research involving sales data from March to April 2022 obtained an error of 10.7% on MAPE and 42,091 on RMSE (Galih et al., 2023). The number of new students at a university over the last 5 years, namely from 2016 to 2020, has increased and decreased. This data will then be used to predict the number of students in the next 5 years. The purpose of making a prediction is to find out the ratio of available lecturers to the number of new students, prepare lecture rooms and other facilities. One method of using past data to make predictions is the linear regression method. In this study, the independent variable is the academic year period, while the dependent variable is the number of new students. The data that will be used is data from new students from the faculty of science and technology consisting of 6 study programs with MAPE (Mean Absolute Percentage Error) scores, namely mathematics (7.2%), marine science (8.76%), biology (5.84 %), information systems (6.46%), architecture (7.98%), and environmental engineering (7.52%). Based on the results of the data analysis, a prediction graph for the number of new students in the next 5 years was also obtained with a decreasing linear graph pattern for each study program (Almumtazah et al.,

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2021). Forecasting is an activity to predict events that will occur in the future. The data used in this study is data on the addition of positive cases of COVID-19 per day in Papua Province from March 21, 2020 to November 25, 2020. The forecasting method used for data that has an element of trend is the double exponential smoothing brown method. The number of additional positive cases of COVID-19 which tends to increase is assumed to be a trend. In this study, the used $\alpha = 0.10$ which is obtained based on the smallest SSE, MSE, and MAE values. Forecasting the addition of positive cases of COVID-19 in Papua Province for the next 7 days, namely November 26, 2020 to December 2, 2020, obtained additional positive cases of COVID-19 per day as many as 81, 82, 82, 83, 83, 84, and 84 (Ali et al., 2022). In trading companies, determining inventory is important, a case study of the successful Tirta Harum shop which sells bread and plastic raw materials. The problem that is often faced is inaccurate inventory of goods in the warehouse. Goods in the warehouse are empty or there has been a buildup of several types of goods over a long period of time. Facts that occur in the field show that purchases of goods from customers have seasonal patterns and trends. Management is obliged to determine the number of orders in the coming period, so that the most appropriate amount of inventory can be determined to reduce storage costs to a minimum. Therefore, we need a system that can forecast existing raw material supplies. For this forecasting, we use the Exponential Smoothing method by taking sales data from the previous period to determine the next demand amount. After obtaining the results, the calculation process is then carried out using the Economic Order Quantity (EOQ) formula to obtain the amount of inventory that must be in the warehouse and the reorder point (Susanti & Sahli, 2019).

METHOD

Exponential Smoothing Method

The Exponential Smoothing forecasting method is a development of the simple Moving Averages method. This method is used to reduce seasonal irregularities from past data. The exponential method is based on predictions based on more recent experience, namely by averaging (smoothing) the values from a series of previous data by reducing them exponentially by giving a certain weight to each data. The weight is symbolized by α (alpha) and moves between 0 and 1. Business Forecasting, Jakarta, Graha Indonesia). The exponential technique consists of a one-parameter linear single exponential technique (single exponential smoothing) and an adaptive approach, one parameter Brownian linear double exponential. The following is an explanation of these exponential methods according to the formula for:

a. Calculate the first exponential smoothing value given the symbol S_t' with the following equation:

$$S_t' = \alpha Y_t + (1 - \alpha) S_{t-1}' \dots\dots\dots 1)$$

b. Calculate the second exponential smoothing value given the symbol S_t'' using the following equation:

$$S_t'' = \alpha S_t' + (1 - \alpha) S_{t-1}'' \dots\dots\dots 2)$$

c. Calculate the third exponential smoothing value and adjust the seasonal component given the symbol S_t''' using the following equation:

$$S_t''' = \alpha S_t'' + (1 - \alpha) S_{t-1}''' \dots\dots\dots 3)$$

Calculate the magnitude of the constant at

$$a_t = 3S_t' - 3S_t'' + S_t'''$$

Calculate the value of the bt slope

$$b_t = [\alpha / \{2(1-\alpha)^2\}] [(6 - 5\alpha)S_t' - (10-8\alpha)S_t'' + (4-3\alpha)S_t''']$$

Calculate the magnitude of the ct value

$$c_t = [\alpha^2 / (1-\alpha)^2] [S_t' - 2S_t'' + S_t''']$$

Determine the magnitude of the forecasting value, using the following formula:

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$$F_{t+m}' = a_t + b_t(m) + 0,5c_t (m^2)$$

Linear Triple Exponential Smoothing Method One Brownian parameter can be formulated as follows:

$$S_t' = \alpha Y_t + (1 - \alpha) S_{t-1}'$$

$$S_t'' = \alpha S_t' + (1 - \alpha) S_{t-1}''$$

$$S_t''' = \alpha S_t'' + (1 - \alpha) S_{t-1}'''$$

$$a_t = 3S_t' - 3S_t'' + S_t'''$$

$$b_t = [\alpha / \{2(1-\alpha)^2\}] [(6 - 5\alpha)S_t' - (10-8\alpha)S_t'' + (4-3\alpha)S_t''']$$

$$c_t = [\alpha^2 / (1-\alpha)^2] [S_t' - 2S_t'' + S_t''']$$

$$F_{t+m}' = a_t + b_t(m) + 0,5c_t (m^2) \dots \dots \dots 4)$$

Where :

- St' = First smoothing in period t
- α = Smoothing Constant (0 < α < 1)
- Yt = real value for period t or actual data
- St'' = Smoothing of both periods t
- St''' = Smoothing of the three periods t
- at = The value of the constant at
- bt = Slope value bt
- ct = CT value

Ft+m' = Basic forecast value

Linear Regression Method

The ilinear regression method is a statistical method that makes predictions by developing mathematical relationships between variables, namely the dependent variable (Y) and the independent variable (X). The dependent variable is the variable that results or is influenced, while the independent variable is the variable that causes or influences. Predicting the value of the dependent variable can be done if the independent variable is known. Generally, sales or demand for a product is expressed as a dependent variable whose magnitude or value is influenced by the independent variable. Linear regression is a method used to forecast or predict quality and quantity characteristics. This is because by estimating different product combinations, companies can maximize their profits and estimate the right amount of output. The general equation of simple linear regression is as follows:

$$Y = a + bX \dots \dots \dots (5)$$

Information :

Y : Dependent variable (predicted value)

x : Independent variable

a : Constant

b : Regression coefficient (value of increase or decrease)

The following formula is used to determine the values of a and b, namely:

$$a = \frac{\sum Yi - b \sum xi}{n} \dots \dots \dots (6)$$

$$b = \frac{n \sum xy - \sum x \cdot \sum y}{n \sum x^2 - (\sum x)^2} \dots \dots \dots (7)$$

According to (Putri et al., 2019) the steps for calculating linear regression are as follows:

1. Identify the dependent (y) and independent (x) variables
2. Prepare the data that will be used as variables x and y
3. Calculate the values of x^2, xy, and each total value
4. Calculate the values of a and b using formulas (6) and (7)
5. Form a model used for the linear regression equation using formula (5)

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RESULT

Sales Prediction Results Using Exponential Smoothing						
Date	Month	Year	Product name	Types of products	the month	predictions
03-20-2020:19:58:00	September	2022	PHILIPS	NEON	6	145.67
03-20-2022:20:51:11	September	2022	BROCO	CRM5511	6	126.88
03-20-2022:20:55:26	September	2022	PHILIPS	NEON	6	145.67
03-22-2022:17:58:21	September	2022	SNI	Bangkok	6	123.92
					Print	Exit

In accordance with the results of Sales Prediction Results Using Exponential Smoothing, based on the date of the month and year, along with the Product name, Types of products and the.... month, the prediction results obtained are as follows: 145.67, 126.88,145.67, and 123.92

Prediction Result of Amount Using Linier Regression Method					
Period(n)	Y	X	X^2	XY	Y
Jan-2022	190	1	1	190	143.910256
Feb-2022	189	2	4	378	137.668998
Mar-2022	200	3	9	600	131.427739
Apr-2022	50	4	16	200	125.186480
May-2022	45	5	25	225	118.945221
Jun-2022	78	6	36	468	112.703963

The results obtained using linear regression for the 6th consecutive month are: 143.19,137.66,131.42,125,186,118.945, and 112.70

DISCUSSIONS

Exponential Smoothing

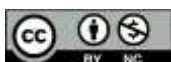
Exponential Smoothing is a time series forecasting technique that applies weighted averages to past observations, giving exponentially decreasing weights to older data points. This method is particularly effective for data with no clear trend or seasonal pattern and provides a straightforward approach to generating short-term forecasts.

Adaptability to Data Patterns: Exponential Smoothing is highly adaptable to recent changes in the data. By placing more emphasis on the most recent observations, it can quickly adjust to fluctuations in sales patterns, which is beneficial for businesses operating in dynamic markets.

Ease of Implementation: The simplicity of Exponential Smoothing makes it easy to implement and understand. This is advantageous for practitioners who may not have extensive statistical backgrounds, enabling them to apply and interpret the method effectively.

Limitations in Capturing Trends: While Exponential Smoothing is effective for short-term forecasts, it may struggle with long-term predictions, especially if there are underlying trends or seasonal variations in the sales data. This limitation necessitates caution when using the method for extended forecasting horizons.

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Linear Regression

Linear Regression is a statistical method that models the relationship between a dependent variable (in this case, sales) and one or more independent variables. By fitting a linear equation to the observed data, it can identify trends and make predictions based on the relationship between variables.

Ability to Model Trends: Linear Regression excels in identifying and modeling trends within the data. If the sales data exhibit a clear upward or downward trend, Linear Regression can provide accurate forecasts by extrapolating the observed trend into the future.

Incorporation of Multiple Variables: One of the strengths of Linear Regression is its ability to incorporate multiple independent variables. This allows for the consideration of various factors that may influence sales, such as marketing spend, economic indicators, and seasonal effects, leading to more robust predictions.

Sensitivity to Outliers: Linear Regression can be sensitive to outliers, which may skew the results and lead to inaccurate forecasts. It requires careful preprocessing of the data to ensure that outliers do not unduly influence the model.

Comparative Analysis

Accuracy: The accuracy of both methods can vary depending on the characteristics of the sales data. For short-term predictions, Exponential Smoothing may provide more accurate forecasts due to its responsiveness to recent changes. However, for long-term forecasts and data with clear trends, Linear Regression may outperform Exponential Smoothing by effectively capturing and extrapolating the underlying trend.

Complexity and Usability: Exponential Smoothing is simpler to use and interpret, making it accessible for practitioners with limited statistical knowledge. In contrast, Linear Regression, while more complex, offers greater flexibility and the potential for more accurate predictions when multiple influencing factors are considered.

Application Context: The choice between Exponential Smoothing and Linear Regression should be guided by the specific context and requirements of the sales forecasting task. For businesses with stable sales patterns and a need for short-term forecasts, Exponential Smoothing may be the preferred method. Conversely, for businesses with variable sales patterns influenced by multiple factors, Linear Regression may provide more insightful and actionable forecasts.

CONCLUSION

Both Exponential Smoothing and Linear Regression have their respective strengths and limitations in predicting the amount of goods sales. Exponential Smoothing offers simplicity and responsiveness to recent data, making it suitable for short-term forecasts. Linear Regression, with its ability to model trends and incorporate multiple variables, is better suited for long-term forecasts and data with clear influencing factors. The selection of the appropriate forecasting method should be based on the specific characteristics of the sales data and the forecasting horizon, ensuring that the chosen method aligns with the business's needs and objectives.

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