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Stock Forecasting Information System using the Holt-Winters Method

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Abstract

In sales, prediction is an important element carried out by traders to help their sales efforts. Predictions involve assessing future values based on historical data. Problems that can arise from the combination of stock and transactions. The aim of this research is to create a sales prediction system, monitor sales and input transactions. This research uses the Holt-Winters method to predict sales. The main goal is to implement the findings of this research into a web administration site. In this research, transaction data is used as a basis for predictions using the Holt-Winters method. The Holt-Winters method uses a series of actual values for predictions. Parameters like Alpha, Gamma, and Beta are defined for weighting, and initial values are calculated for Trend, Level, and Seasonality attributes to achieve predicted results. Evaluation of the Holt-Winters method in this research involves searching for the Mean Absolute Percentage Error (MAPE) to determine the percentage of prediction error. The application of this research involves creating a website administration to assist sellers in combining transactions and available products. The average results of the evaluation of the administration of the website created resulted in a satisfaction percentage of 82.61%. This shows that the system can help in unifying transactions and products.

I. INTRODUCTION

In sales, prediction is an important element that traders strive to help their sales [1]. Being able to predict the future direction of sales is not only a challenge, but also a strategic opportunity. [2]. The use of predictions is the key to making more appropriate decisions in planning business aspects, such as stock inventory and marketing strategies [3]. The purpose of prediction is to get information about what is going to happen in the the future with the greatest probability of occurrence. [4] Prediction is the evaluation of future values with reference to historical data [5]. In this case, the observations range from values that have occurred to values that are expected to come [6]. This approach allows traders to plan more effective moves, based on a deep understanding of how past trends and patterns can provide insight into what may happen in the future [7]. Furthermore, the author considers this approach to be quite effective in looking at the planning needs of traders' problems.

One of the shops experienced problems because it didn't have any One of the shops that is experiencing problems regarding not having a system for evaluating sales in their shop, especially for estimating or predicting the required smartphone stock, is a SmartPhone shop called Pr1nc3 Gadget. A SmartPhone shop called Pr1nc3 Gadget sells phones and related accessories [8][9]. Due to the existence of new cellphone models and the lack of consumers for certain products, this causes the store to have problems with stock management and stock supply planning, and developing a system to monitor transactions from each branch and marketplace that the store uses, and a system to view transaction history. According to the problem description, an information system is needed to estimate the number of cellphones that must be provided to help stock availability, [10] a system to collect transaction information, and a system to input transactions from each branch and marketplace that the shop uses. [11] The ability to predict and determine how much interest customers have in each product provided is a solution for deciding stock needs in the future [12]. Therefore, based on the background presented, researchers will create a web-based product stock estimation system using the Holt-Winters Method entitled "Stock Estimation Information System using the Hot-Winters Method" [13]

II. METHODS

The data that can be obtained in this research is secondary data obtained from observations at the Pr1nc3 Gadget shop. The data used is sales data for smartphones and several other accessories at the Pr1nc3 Gadget store from January 1 2022 to January 31 2023. [14] In this research, the Holt-Winters method was used. The Holt-Winters method is indeed a form of exponential smoothing forecasting method. Advantages of the method Holt-Winters

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exponential smoothing is This method is very good at predicting data patterns which has a seasonal influence on the elements trends that arise simultaneously, methods which is simple and easy to put in in practice and competitive against more complicated forecasting models. [15] It is used for time series analysis to forecast data by considering changes based on exponential weights of historical data. This method is suitable for data that shows random trends and fluctuations but does not have a strong seasonal component [14]. In the Holt-Winters method, there are three main components, namely *Level* [14] , *Trend* [14], *and Seasonality* [14].

A. Level

The function of the *Level* attribute is to represent the midpoint or average value of data at a specific point in time. In Exponential Smoothing, the *Level* attribute is used to calculate the forecasted value for the next period, which is controlled using the parameter *Alpha* (α). *Alpha* is the parameter used to adjust the exponential weight given to the *Level*. [14]

Alpha (α) controls how much the changes in the observed data will affect the changes in the *Level* attribute in the next period. The value of *Alpha* ranges between 0 and 1, where if *Alpha* is close to 0, the Exponential Smoothing model will give more weight to historical data, and changes will respond slowly to new data. If *Alpha* is close to 1, the Exponential Smoothing model will give more weight to recent data and respond more quickly to new data changes. In other words, *Alpha* controls how quickly the *Level* attribute adapts to new fluctuations in the data. Below is an example of the formula: [14]

First *Level* and next *Level* for next periode :

First *Level*: L_t (*Level*) = X_t

Next Periode *Level* :

$$L_t\,(Level) = \alpha^* \left(\frac{X_t}{S_{t-1}}\right) + (1 - \alpha)^* \,(L_{t-1} + T_{t-1}) \qquad (1)$$

X_t is the current demand value

L_{t-1} It is the value of the *Level* in the previous period.

T_{t-1} It is the value of the *Trend* in the previous period.

S_{t-1} It is the value of the *Seasonality* the previous period.

B. Trend

The function of the *Trend* attribute is to identify and represent the pattern of data changes. This attribute allows the Exponential Smoothing model to estimate how the data tends to change, whether it's increasing or decreasing over time. The value of *Trend* is controlled using the parameter *Beta*, which acts as a smoothing factor to adjust the exponential weight given to *Trend* changes in calculating and updating the *Trend* attribute's value in future periods. [14]

Beta (β) controls how the data changes in the *Trend* attribute for the next period. The value of *Beta* (β) ranges between 0 and 1. If *Beta* is close to 0, the model will give more weight to historical *Trend* changes, and the *Trend* will respond slowly to new changes. If *Beta* is close to 1, the model will give more weight to recent *Trend* changes, and the *Trend* will respond quickly to new changes. In other words, *Beta* determines how quickly the data changes in the *Trend* attribute. Below is an example of the initial *Trend* formula:

First *Trend*:

$$T_t(Trend) = X_t - X_{t-1} \qquad (2)$$

Next Priode *Trend* :

$$T_t\,(Trend) = \beta^* \,(L_t - L_{t-1}) + (1 - \beta)\, T_{t-1} \qquad (3)$$

Lt It is the current value of the *Level* attribute.

Lt-1 It is the value of the *Level* attribute in the previous data point.

Tt-1 It is the value of the *Trend* attribute in the previous data point.

C. *Seasonality*

The *Seasonality* attribute serves to depict periodic or *seasonal* patterns in time series data. *Seasonality* refers to fluctuations or patterns that occur in data at specific time intervals, such as *seasonal* or yearly cycles, monthly patterns, weekly patterns, and so on. *Seasonality* is controlled by the parameter *Gamma* (γ), which is responsible for controlling the influence of *Seasonality* on forecasts and helps model the *seasonal* patterns in the existing data. [14]

The *Gamma* (γ) parameter controls the impact of *seasonal* components on forecasting by assigning weights to the data that fall within the *seasonal* pattern. A larger *Gamma* value will give higher weight to *seasonal* data, while a smaller *Gamma* value will give lower weight. By adjusting the *Gamma* value, you can control how much the *seasonal* component affects the forecast. Below are examples of the initial *Seasonality* formula and *Seasonality* for subsequent periods:

Next *Seasonality*= X_t/L_t (4)

Seasonality Next Periode :

$$S_t\,(Seasonality) = \gamma^*\,(X_t - L_t) + (1-\gamma)^*\,S_{-1} \quad (5)$$

Xt is the current demand value
St-1 is the value of the *Seasonality* in the previous period.
Lt It is the current value of the *Level* attribute
Lt-1 It is the value of the *Level* attribute in the previous data point

III. RESULTS

Next, we will perform Holt-Winters calculations to predict iPhone 11 Pro Max/156GB sales next month. In determining sales predictions, it is necessary to determine level, trend and seasonality attributes from the database With the formula:
Initial level = actual value in the related period (x)
Initial trend = actual value(x) – with level
Seasonality = actual value(x)/level value

A. *Dataset*

Tabel 1 menunjukkan, Data yang digunakan dalam penelitian ini merupakan data sekunder yang diperoleh dari observasi yang dilakukan di toko Gadget Pr1nc3. Data yang digunakan terdiri dari penjualan smartphone dan beberapa aksesoris lainnya di toko Gadget Pr1nc3 dari tanggal 1 Januari 2022 sampai dengan 31 Januari 2023. Data awalnya dicatat di logbook dan kemudian dipindahkan ke format Excel.

TABLE 1
DATA SALES PR1NC3 GADGET STORE

periode	qty
Jan-22	3
Feb-22	3
Mar-22	3
Apr-22	2
May-22	2
Jun-22	2
Jul-22	3
Aug-22	3
Sep-22	2
Oct-22	2
Nov-22	2
Dec-22	2
Jan-23	1

B. Formula Implementation

TABLE 2
IMPLEMENTATION OF *LEVEL*, *TREND AND SEASONALITY* FORMULAS

periode	qty	*Level*	*Trend*	*Seasonality*
Jan-22	3			
Feb-22	3	3	0	1
Mar-22	3	3	0	1
Apr-22	2	2.8	-0.2	0.942857143
May-22	2	2.504242	-0.32	0.914014659
Jun-22	2	2.185024	-0.3568484	0.914276105
Jul-22	3	2.118797	-0.1224835	1.014600435
Aug-22	3	2.188417	0.07825377	1.085851177
Sep-22	2	2.181711	0.02491969	1.052023288

Oct-22	2	2.145524	-0.0164064	1.028053255
Nov-22	2	2.092379	-0.0422299	1.013612548
Dec-22	2	2.034747	-0.0522598	1.007474635
Jan-23	1	1.784506	-0.2487573	0.918055527

The table 2 above is the result of calculations from the *Trend Level* and Seasonality formulas.

C. Sales Prediction

After finding the *Level*, *Trend* and Seasonality values, we look for the predicted values for the month of February/1023, with the formula:

$$Y_{t+1} = (L_{t-1} + 1^{*} T_{t-1}) * S_{t-1} \quad (6)$$

TABLE 3
RESULT PREDICTION

periode	qty	*Level*	*Trend*	*Seasonality*	forcast
Jan-22	3				
Feb-22	3	3	0	1	
Mar-22	3	3	0	1	3
Apr-22	2	2.8	-0.2	0.942857143	3
May-22	2	2.504242	-0.32	0.914014659	2.451429
Jun-22	2	2.185024	-0.3568484	0.914276105	1.99643
Jul-22	3	2.118797	-0.1224835	1.014600435	1.671457
Aug-22	3	2.188417	0.07825377	1.085851177	2.025461
Sep-22	2	2.181711	0.02491969	1.052023288	2.461267
Oct-22	2	2.145524	-0.0164064	1.028053255	2.321427
Nov-22	2	2.092379	-0.0422299	1.013612548	2.188846
Dec-22	2	2.034747	-0.0522598	1.007474635	2.078057
Jan-23	1	1.784506	-0.2487573	0.918055527	1.997306
				Prediction	1.409903

The table 3 abouve show, The prediction values for January and February 2022 are left empty because the Holt-Winters algorithm cannot make predictions due to the unavailability of Level, Trend, and Seasonality components for these months. Based on the prediction results, the sales forecast for the iPhone 11 Pro Max/156GB for the next month for all products is 1.409903.

D. *MAPE* Value

To calculate the Mean Absolute Percentage Error (MAPE), you can use the following formula:

$$MAPE = \left(\frac{1}{n}\right) * \sum(|(\text{Actual} - \text{Forecast/Actual}|) * 100\% \quad (7)$$

TABLE 4
MAPE VALUE

periode	qty	forcast	*MAPE*
Jan-22	3		
Feb-22	3		
Mar-22	3	3	0
Apr-22	2	3	50
May-22	2	2.451429	22.57143
Jun-22	2	1.99643	0.17852
Jul-22	3	1.671457	44.28477

Aug-22	3	2.025461	32.48465
Sep-22	2	2.461267	23.06334
Oct-22	2	2.321427	16.07134
Nov-22	2	2.188846	9.442323
Dec-22	2	2.078057	3.902844
Jan-23	1	1.997306	99.7306

Based on table 4 above, calculation results are obtained using the MAPE formula. After you calculate the MAPE value for each period, then you can calculate the average MAPE value for all periods, which is 17.42998.

A lower MAPE value indicates a better ability of the forecasting model to operate. According to [2], the MAPE value calculation has a range that can be used as a benchmark to measure the accuracy of the forecasting model. Based on table 5, the following is the range of MAPE values:

TABLE 5
RANGE MAPE VALUE

Range *MAPE*	Meaning
< 10%	Modeling skills are very good
10 –/10 %	Good Modeling Skills
20 – 50 %	Decent Modeling Skills
>50 %	Poor Modeling Skills

E. *Tweaking* Value Parameter

a. *Tweaking* Value Parameter 0.2

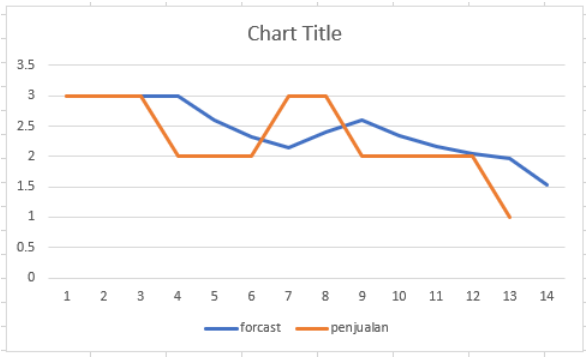

Fig. 1 Chart *Tweaking* 0.2

In graph 1 above, with the Alpha, Beta and Gamma values set at 0.2, it can be seen that the use of these parameters makes predictions more responsive to changes in historical data. The resulting Trend tends to be smoother, and changes in the Trend occur more slowly. The model is due to seasonal influences in its predictions, although the reflections are not too extreme..

b. *Tweaking* Value Parameter 0.5

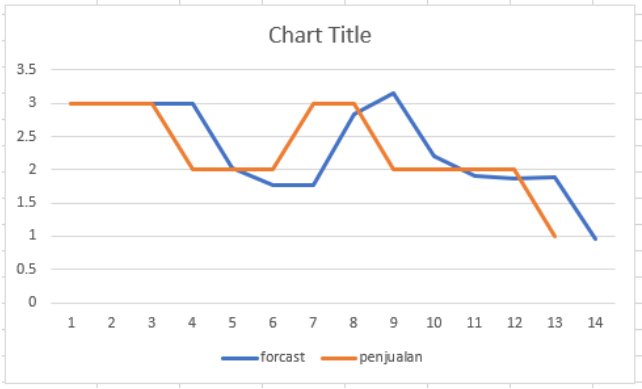

Fig. 2 Chart *Tweaking* 0.5

In graph 2 above, with the values of *Alpha*, *Beta*, and *Gamma* set to 0.5, it can be observed that using these parameters makes the predictions closely follow the historical data *Trend*. The resulting *Trend* is stronger, and the predictions respond more slowly to recent data changes. *Seasonal* effects tend to have less significant impact on the predictions.

In conclusion, when α=0.2, the model responds more quickly to changes in historical data, making it suitable for situations where data fluctuations are relatively more significant and a rapid response is required. When α=0.5, the model responds more slowly and focuses more on long-term *Trend*s, making it suitable for data with more stable *Trend*s. The α=0.2 setting results in smoother *Trend*s, while α=0.5 produces stronger and more consistent *Trend*s with historical data. The α=0.2 setting considers *seasonal* effects in predictions, but these effects are not dominant. The α=0.5 setting produces more stable predictions that are less responsive to *seasonal* effects.

IV. DISCUSSION

A. Evaluation *Holt-Winters*

Based on the calculations for the product iPhone 11 Pro Max/156GB using 11 sales periods from January 2022 to January 2023 with Alpha value of 0.2, Beta value of 0.2, and Gamma value of 0.2, the prediction result for February 2023 is obtained as 1.409903. According to Table 4, the MAPE value in this modeling falls within an acceptable range, with a value of 17.42998%.

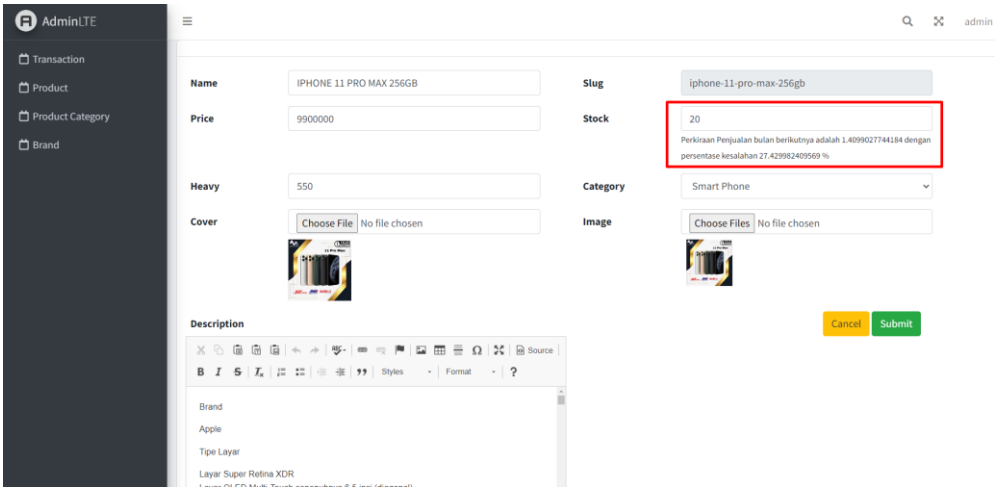

Fig. 3 Implementation of *Holt-Winters* into the system

In Figure 3, it shows an image of the product edit page where at the bottom of the stock input field, there is text containing stock recommendations for the sales of iPhone 11 Pro Max/156GB for the next month along with the percentage error of the prediction.

Suggestions for further research could be to use a larger dataset, both in terms of the number of products available or a longer time period to increase modeling accuracy. Next, add another method with the aim of comparing the method used with other methods which may have more accurate modeling accuracy values.

V. CONCLUSIONS

Based on the calculations for the iPhone 11 Pro Max/156GB product using 11 sales periods from January 2022 to January 2023 with Alpha value of 0.2, Beta value of 0.2, and Gamma value of 0.2, the prediction result for February 2023 is obtained as 1.409903. According to Table 6, the MAPE value in this modeling falls within an acceptable range, with a value of 17.42998%.. Evaluation of the Holt-Winters method in this research involves searching for the Mean Absolute Percentage Error (MAPE) to determine the percentage of prediction error. The application of this research involves creating a website administration to assist sellers in combining transactions and available products. The average results of the evaluation of the administration of the website created resulted in a satisfaction percentage of 82.61%. This shows that the system can help in unifying transactions and products.

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