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Prediction of Farmers' Exchange Rates in Riau Province using the Holt-Winters Approach

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ABSTRACT: The Farmer Exchange Rate (NTP) is an important indicator to measure farmers' welfare, reflecting the comparison between the prices received by farmers and the prices paid for consumption and distribution. This study aims to analyze the trends and forecast the NTP using the Holt-Winters Exponential Smoothing method in the R application with the forecast package. NTP data were obtained from the official source of the Central Statistics Agency (BPS) of Riau Province, covering the period from January 2015 to December 2024. The model evaluation was conducted using the Mean Absolute Error (MAE) as the primary metric to measure the forecasting error rate. The MAE value obtained indicates that the model can provide a fairly accurate estimate of the NTP. It is expected that the results of this study can serve as a reference for the development of the Farmer Exchange Rate in the coming years.

KEYWORDS: NTP, forecast, Holt-Winters, Mean Absolute Error (MAE)

INTRODUCTION

Agriculture is an activity carried out by humans to utilize biological natural resources with the aim of producing food, industrial raw materials, energy needs, and to preserve the environment. In the context of national development in Indonesia, the agricultural sector plays a very important role as one of the main supporting factors. Many workers from the agricultural sector should be protected and prosperous because of their role in meeting the needs of the community[1].. However, in reality, in Indonesia, farmers are often disadvantaged by low incomes. The increase in food prices, especially rice, is currently related to higher costs for farmers compared to the income they receive. Therefore, we need to deal with this issue wisely, realistically, positively, and optimistically so that future risks, especially long-term risks that could threaten the welfare of farmers and the community's economy, can be minimized. The Farmer Exchange Rate (NTP) is one of the indicators to measure the welfare of farmers. The increase in NTP indicates an improvement in farmers' welfare, while the decrease in NTP is the opposite[2].

The Farmer Exchange Rate (NTP) is one of the indicators used to measure the welfare of farmers in Indonesia. NTP describes the ratio between the price that farmers receive for their agricultural products and the prices of goods and services needed in the production process. In other words, NTP reflects farmers' purchasing power for goods and services needed, both for consumption and for production costs. If the NTP in Indonesia is high, this shows that the purchasing power of farmers is relatively strong. To determine the welfare of farmers, it can be seen from the percentage of value paid by farmers. If the percentage of NTP is more than 100, it means that the welfare of farmers is in good condition [1].

Specifically, this study aims to analyze the development of the Farmer Exchange Rate (NTP), as well as forecast how the growth of the NTP will be in the following year, whether the growth will rise, fall, or constant (stable).

RESEARCH METHODS

Data source

This study uses secondary data, namely Riau Province Farmer Exchange Rate (NTP) data from January 2015 to December 2024 obtained from the Central Statistics Agency (BPS) of Riau Province. In this study, the R application was used to help process data.

Research steps

- Farmer Exchange Rate (NTP) data processing
- Using *the Holt-Winters* method with *the Forecast package* in the R application
- Model evaluation using error metrics such as *Mean Absolute Error* (MAE)

Holt-Winters Multiplicative

Exponential smoothing method *Holt-Winters* Multiplication is used if the original data plot shows varying seasonal data fluctuations. Type *Holt-Winters* Multiplication is based on three refinement equations, namely for the level element of the data, for the trend element and for the seasonal element. The smoothing equation with this method for the

multiplication model is given by the following equation [3]:

Level refinement.

$$S_t = \alpha \frac{X_t}{I_{t-L}} + (1-\alpha)(S_{t-1} + b_{t-1}) \quad (1)$$

Trend refinement

$$b_t = \beta(S_t - S_{t-1}) + (1-\beta)b_{t-1} \quad (2)$$

Seasonal smoothing

$$I = \gamma \frac{X_t}{S_t} + (1-\gamma)I_{t-L} \quad (3)$$

X_t : data to-t
S_t : Exponential refinement of the$t$
S_{t-1} : Exponential refinement to-t
S_L : Initial Level Refinement
b_t : Smoothing *Trend* Period to-t
b_{t-1} : Smoothing *Trend* period to-(t-1)
b_L : Smoothing *Trend* beginning
α : exponential parameters ($0 < \beta < 1$)
β : Element Parameters *Trend* ($0 < \gamma < 1$)
I_t : seasonal refining
I_{t-L} : seasonal refining $t = 1, 2, \ldots, t - L$
L : seasonal length (L= 3, 4, 6, or 12).

According to Rosadi (2012), the value of forecasting at the time of$t$ for the multiplicative model given by the equation

$$F_t = (S_t + b_t)\, I_{t-L} \quad (4)$$

Meanwhile, the forecast value m of the future period with the initial value at *time* t for the multiplicative model is given an equation

$$F_{t+m} = (S_t + b_t)I_{t-L+m} \quad (5)$$

Where : Forecasting Value in the Fourth Period$t$
F_t
F_{t+m} : Forecasting Value m Ahead Period
m :Forecasting m Ahead Period

Holt-Winter Additive

Holt-Winter Additive used if the data shown is seasonal and tends to be constant (stable).

Used equations

Level Smoothing

$$Lt = \alpha\,(Yt - St{-}c + (1-\alpha)\,(Lt{-}1 + Tt{-}1)) \quad (7)$$

Trend Smoothing

$$Tt = \beta\,(Lt - Lt{-}1 + (1-\beta)\,Tt{-}1) \quad (8)$$

(8)

Seasonal Smoothing

$$St = \delta\,(Yt - Lt) + (1-\delta)\,St{-}c) \quad (9)$$

(9)

with $0 < \alpha, \beta, \delta, \leq 1$ Information:

α = Parameters for data smoothing

β = Trend smoothing parameters

δ = Seasonal smoothing parameters[4].

***Mean Absolute Error* (MAE)**

Mean Absolute Error (MAE) is one of the methods used to measure the accuracy of forecasting models. The MAE value shows the absolute average error between the forecast/prediction results and the real value[5].

The equation is obtained:

$$\text{MAE: } \frac{1}{n}\sum^{n} |fi - yi| \quad (10)$$

fi= value of the forecast result

yi = actual value

n= A lot of data

RESULTS AND DISCUSSION

Processing and Exploration of Farmer's Exchange Rate data

The following is the data on the Farmer Exchange Rate (NTP) from January 2015- December 2024 which was officially obtained from the Data of the Central Statistics Agency (BPS) of Riau Province.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
2015	96.34	96.63	97.55	96.44	95.24	96.24	94.74	92.85	93.06	94.11
2016	95.65	96.82	97.36	99.41	99.78	98.11	97.41	97.98	99.11	99.65
2017	102.94	103.79	103.50	103.10	101.98	102.59	101.25	101.90	101.70	103.00
2018	103.15	104.35	102.87	101.55	99.60	97.73	95.78	94.58	96.13	94.73
2019	95.10	96.61	96.41	95.70	95.76	92.77	92.40	93.48	95.39	95.45
2020	123.93	117.90	113.70	115.64	111.74	109.66	113.57	116.88	120.94	123.61
2021	132.92	133.04	137.64	134.54	135.13	135.26	132.16	136.74	141.32	144.90
2022	149.90	153.64	156.11	159.22	136.03	133.68	118.40	133.35	139.27	143.86
2023	151.91	154.52	161.24	157.34	151.69	145.32	148.31	150.46	151.26	152.50
2024	156.59	157.79	164.08	168.62	167.50	168.55	172.96	175.65	176.91	182.53

	Nov	Dec
2015	94.70	95.03
2016	100.62	102.23
2017	105.00	104.90
2018	92.90	92.70
2019	97.69	100.27
2020	127.32	130.34
2021	148.38	152.18
2022	151.97	152.94
2023	154.33	156.29
2024	190.79	196.72

Figure 1. Farmer's Exchange Rate (NTP) Data

The Holt-Winters method uses the R application with the forecast package

The following table is the result of the calculation between the results of the Holt- Winters forecast in the additive model and the results of the Holt-Winters forecast in the multiplicative model

Table 1 comparison of the Holt-Winters method of additive and multiplicative models

Moon	Forecast HW Additive	Forecast HW Multiplicative
January	198,3054	198,9875

After comparing the additive and multiplicative Holt-Winters models shown in Table 1, the visualization of the forecasting results was then carried out in the form of a graph. The graph in figure 1 shows the forecasting patterns of the two models, where different colored lines present the predicted results of each model

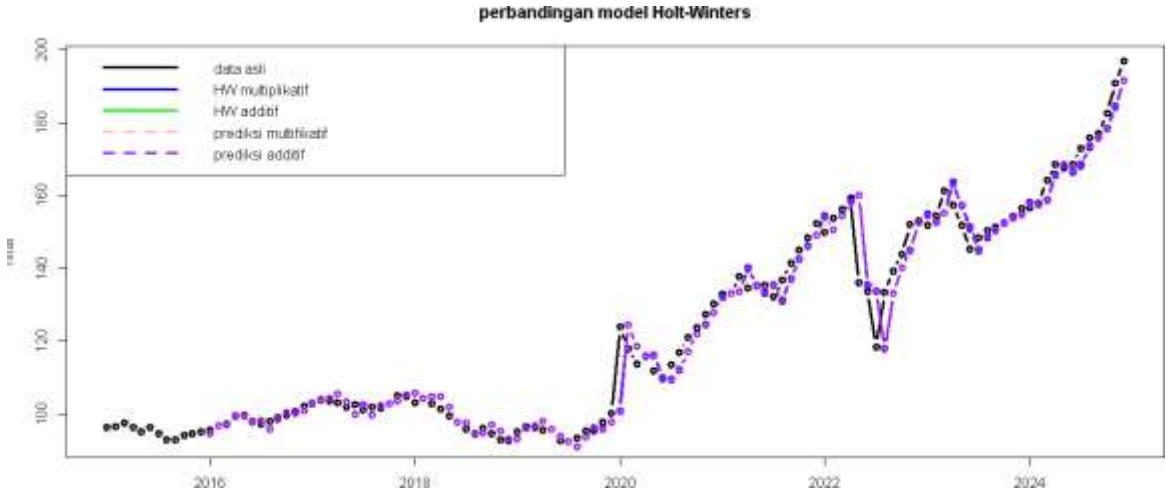

Figure 1 graph comparing the Forecast results with the original data

Model evaluation using *the Mean Absolute Error* (MAE) error metric

After displaying the forecasting results in the graph in Figure 1, the model's accuracy was evaluated using *the Mean Absolute Error* (MAE) metric.

Table 2 Comparison of MAE values in the Forecast Additive and Multiplicative methods

Forecasting Methods	MAE Score
Holt-Winter Additive	2,793921
Holt-Winter Multiplicative	2,81429

The MAE values listed in Table 2 show that the *Holt-Winter Additive* model has a smaller error rate than other models, making it more accurate in forecasting the Farmer Exchange Rate (NTP).

CONCLUSION

Based on the above research, it can be concluded that the *Holt-Winters Exponential Smoothing method* has been successfully applied in calculating the Farmer Exchange Rate (NTP) in Riau Province. This model is able to capture trend and seasonal patterns in the data with a good level of accuracy. The results of the comparison between *the Additive* Model and *the Multiplicative* Model show that the *Additive* Model provides more accurate forecasting results, as shown by the smaller *Mean Absolute Error* (MAE) *value of the Additive* compared to the *Multiplicative Model.* This shows that the lower MAE values in the *Additive* Model for Farmer Exchange Rates (NTPs) are trendy and seasonal with relatively constant fluctuations (not changing over time).

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