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Forecasting Analysis of Palm Oil FFB Price with Holt-Winters Approach: Case Study in Riau Province

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ABSTRACT

The price of oil palm Fresh Fruit Bunches (FFB) fluctuates and is influenced by various factors such as the price of crude palm oil (CPO), market demand, and weather conditions, forecasting FFB prices is important for industry players and farmers in making decisions. The data used is FFB price data in Riau Province in a certain period. The forecasting process was carried out using R software with the forecast package. The results showed that the *Holt- Winters* model was able to capture trend and seasonal patterns in FFB price data with a high level of accuracy. model evaluation was carried out using *Mean Absolute Error* (MAE) as the main metric for measuring the level of forecasting error. The MAE value obtained shows that this model can provide a fairly accurate estimation of FFB prices. It is expected that the results of this study can be a reference for farmers and stakeholders in planning business strategies and palm oil industry policies.

KEYWORDS: FFB, forecast, *Holt-Winters*, *Mean Absolute Error* (MAE).

INTRODUCTION

Oil palm plants are one of the largest foreign exchange contributing commodities in the plantation sector. Riau Province is one of the centers of oil palm plantations in Indonesia, so it plays a major role in the community's economy because oil palm planters are spread almost throughout the region [1] . The oil palm plantation sector is one of the sectors that currently occupies an important position and is the leading plantation sector in Indonesia [2].

Riau is the main and largest center in Indonesia for oil palm development [3]. The price of Fresh Fruit Bunches (FFB) is an important indicator in determining profits for farmers and plantation companies. However, FFB prices often experience fluctuations that are influenced by various factors, accurate forecasting methods are needed to help farmers and industry players make better decisions.

The method used in this research is the *Holt Winters Exponential Smoothing* Method which is a forecasting method that not only looks at trend factors but also looks at seasonal factors [4]. This method has considerations such as the level or trend of a *time series* data then also considers seasonal data and data [5]. There are two models in this method, namely *multiplicative* and *additive*.

In this study, the *Holt-Winters* method is applied using R software, which is one of the statistical analysis and forecasting tools that are widely used in academic and industrial world. R has various packages and functions that allow time series data analysis to be done efficiently and accurately. By utilizing the forecast package, this research aims to analyze the pattern of FFB prices in Riau Province and provide predictions that can be used by stakeholders in production planning and marketing strategies. In addition, this research aims to analyze and forecast FFB prices using the *Holt-Winters* method with additive and multiplicative approaches.

RESEARCH METHODS

This research uses secondary data. The data used in this method is FFB price data from January 2010 to December 2024 obtained from the Riau Province Statistics Agency.

1. Research steps

   Research steps include:
   - Processing and exploration of FFB price data.
   - Implementation of the *Holt-Winters* method in R using the forecast package.
   - Model evaluation using error metrics such as *Mean Absolute Error* (MAE)

2. *Holt-Winter*

The *Holt-Winter* method is an extension of the Holt PEL to account for seasonality denoted as St. There are two versions, multiplication and addition [6]. There are two models in this method, multiplicative and additive. The multiplicative model is used when the magnitude of the seasonal pattern in the data depends on the magnitude of the data. On the other hand, in additive models, the magnitude of seasonality does not change with respect to time [7].

The parameters used in this method are α, β and γ with values between 0 and 1. The following is the initial equation in using the holt winter method:

$$L_s = \frac{1}{s}(Y_1 + Y_2 + \cdots + Y_s) \quad (1)$$

$$b_s = \frac{1}{k}\left(\frac{Y_{s+1}-Y_1}{s} + \frac{Y_{s+2}-Y_2}{s} + \cdots + \frac{Y_{s+k}-Y_k}{s}\right) \quad (2)$$

(i) Multiplicative Seasonnality

This Holt-Winters method is used if the actual data plot shows seasonal data fluctuations that vary. Here is the equation:

$$S_k = \frac{Y_k}{L_s}, k = 1,2, \dots, s \quad (3)$$

$$L_t = \alpha \frac{Y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + b_{t-1}) \quad (4)$$

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \quad (5)$$

$$S_t = \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-s} \quad (6)$$

$$F_{t+m} = (L_t + b_t m)S_{t-s+m} \quad (7)$$

(ii) Addictive Seasonnality

Addictive season is the *Holt-Winters* method if the original data plot shows constant seasonal data fluctuations. The equation of the addictive season is as follows:

$$S_k = Y_k - L_s, k = 1,2, \dots, s \quad (8)$$

$$L_t = \alpha(Y_t - S_{t-s}) + (1-\alpha)(L_{t-1} + b_{t-1}) \quad (9)$$

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \quad (10)$$

$$S_t = \gamma(Y_t - L_t) + (1-\gamma)S_{t-s} \quad (11)$$

$$F_{t+m} = (L_t + b_t m) + S_{t-s+m} \quad (12)$$

Description:

L_s	: Level estimate of the data set at time s
S	: Number of periods in one season cycle
Y_s	: Actual value at time s
b_s	: Trend estimate of the data set at time s
Y_{s+k}	: Actual value at time $s + k$
Y_k	: Actual value at time k
S_k	: Seasonal estimate of the data set at time k
L_t	: Level estimate of the data set at time t
α	: Smoothing constant for level $(0 < \alpha < 1)$
S_{t-s}	: Seasonal estimate of the data series at time $t - s$
b_t	: Estimated trend of the data set at time t
β	: Smoothing constant for trend $(0 < \beta < 1)$
L_{t-1}	: Level estimate of the data set at time $t - 1$.
b_{t-1}	: Estimated trend of the data set at time $t - 1$.
S_t	: Seasonal estimate of the data series at time t
γ	: Smoothing constant for seasonality $(0 < \gamma < 1)$
F_{t+m}	: Forecast value at time $t + m$
m	: Number of future periods to be forecasted
S_{t-s+m}	: Seasonal estimate of the data series at time $t - s + m$

3. Average Forecasting Error Measurement

Mean Absolute Error (MAE) is the average error value that is positive absolute value of the amount of data, according to the following equation [8].

$$MAE = \frac{1}{n}\sum|X_t - Y_t| \quad (13)$$

Description:

X_t : Actual data in period t

Y_t : Forecasting value in period t

n : Amount of data.

This aims to anticipate errors or errors that are negative, so as to determine the average error value appropriately.

RESULTS AND DISCUSSION

1. Processing and exploration of FFB price data.

Data on the price of fresh fruit bunches (FFB) from 2010 to 2024 were obtained from the Central Bureau of Statistics (BPS) of Riau Province. This data is displayed in R software as shown in Figure 1.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1410.21	1706.55	1624.69	1713.20	1708.49	1975.05	1767.26	1501.17	2144.37	2349.10	1727.04	2399.34
2011	1388.16	1805.93	1586.41	1829.10	1714.57	1959.89	1787.20	1341.02	1883.93	2577.31	2293.32	2445.10
2012	1461.70	1779.73	1586.06	1937.53	1800.89	1877.07	1968.61	1302.97	1643.55	2347.14	2503.45	2481.32
2013	1422.95	1531.63	1295.60	1948.45	1617.94	1761.35	2012.47	1490.01	1805.81	2370.82	2500.53	2488.85
2014	1465.12	1615.17	1282.86	1993.26	1610.79	1893.85	2058.89	1576.28	1466.77	2750.10	2793.01	2641.77
2015	1423.51	1630.33	1235.91	2103.50	1692.33	2082.12	1900.58	1511.82	1520.46	2798.24	2711.58	2753.44
2016	1397.90	1430.43	1346.04	1951.12	1570.01	1873.04	1850.52	1502.60	1649.40	3004.49	2617.54	2883.02
2017	1567.71	1487.69	1421.23	1922.58	1376.44	1959.23	1883.42	1413.64	1952.94	3414.14	2633.88	2814.96
2018	1591.14	1578.87	1424.35	1846.92	1210.38	2159.06	1886.17	1380.81	2033.11	3336.90	2888.35	2881.41
2019	1665.24	1655.57	1411.87	1891.07	1442.27	2238.46	1873.10	1329.54	2044.02	3362.10	2725.61	2949.00
2020	1835.61	1653.50	1444.61	1721.91	1299.87	2265.19	1826.84	1434.61	2128.69	3613.34	2421.90	2989.16
2021	1933.15	1795.87	1508.03	1543.30	1350.33	1947.26	1747.57	1482.97	2160.63	3995.86	2265.96	3075.75
2022	2002.63	1882.33	1464.68	1675.24	1410.81	1835.06	1641.11	1441.34	2223.08	3866.19	2388.62	3266.03
2023	1983.04	1757.99	1489.73	1697.50	1575.37	1809.40	1585.41	1668.24	2166.72	3242.38	2440.34	3541.38
2024	1795.32	1536.93	1687.53	1648.20	1714.86	1837.69	1589.33	1900.95	2338.86	2549.01	2418.26	3665.05

Figure 1: Fresh Fruit Bunch (FFB) Price Data

2. Implementation of the *Holt-Winters* method in R using the forecast package.

The following table summarizes the comparison results between the forecasting results with the *Holt-winters* method on the *Additive* model and *Holt-winters* on the *Multiplicative* model.

Table 1 Comparison of *Holt-Winters* method of *Additive* model and *Multiplicative* model

Month	HW Forecast Additive	HW Forecast Multiplicative
January	1815.096	1812.288
February	1556.706	1551.444
March	1707.306	1703.454
April	1667.976	1663.741
May	1734.636	1731.016
June	1857.466	1854.990
July	1609.106	1604.280
August	1920.726	1918.818
September	2358.636	2360.826
October	2568.786	2572.931
November	2438.036	2440.937
December	3684.826	3699.391

After comparing the additive and multiplicative *Holt-Winters* models as shown in Table 1, we then visualize the forecasting results in graphical form. The graph in Figure 1 shows the forecasting patterns of the two models, where different colored lines represent the prediction results of each model.

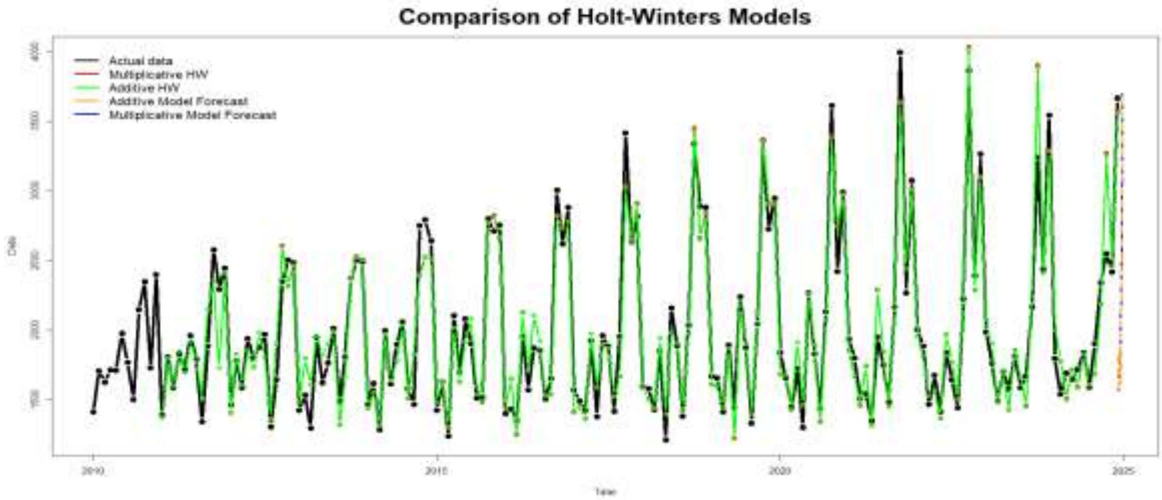

Figure 2 Comparison chart of forecast results with actual data

3. Model evaluation using error metrics such as *Mean Absolute Error* (MAE)

After displaying the forecasting results in the graph in Figure 2, the accuracy of the model is evaluated using the *Mean Absolute Error* (MAE) metric.

Table 2 Comparison of MAE Values on *Additive* model and *Multiplicative* model methods

Forecasting Methods	MAE Value
Holt-Winters Additive	0.3359614
Holt-Winters Multiplicative	0.3356553

The MAE values listed in Table 2 show that the *Holt-Winters Multiplicative* model has a smaller error rate than the other models, making it more accurate in forecasting FFB prices.

CONCLUSION

Based on the research results, the *Holt-Winters Exponential Smoothing* method was successfully applied in forecasting the price of oil palm Fresh Fruit Bunches (FFB) in Riau Province. This model is able to capture trend and seasonal patterns in the data with a good level of accuracy. The comparison between the *additive* and *multiplicative* models shows that the *multiplicative* model provides more accurate forecasting results, as indicated by a smaller *Mean Absolute Error* (MAE) value than the *additive* model. The lower MAE value in the multiplicative model indicates that this model is better able to minimize forecasting errors and is more suitable for FFB price data that has seasonal variations with changes that scale relative to the price level.

REFERENCES

1. D. Friska Putri Zal, S. Hadi, atri Yusri, M. Jurusan Agribisnis Fakultas Pertanian Universitas Riau, and D. Jurusan Agribisnis Fakultas Pertanian Universitas Riau, "Analisis Pemasaran Tandan Buah Segar (TBS) Kelapa Sawit Pola Swadaya di Desa Buluh Rampai Kecamatan Seberida Kabupaten Indragiri Hulu," 2023.
2. M. Sapfera, E. Afrianto, and P. Studi Agribisnis Fakultas Pertanian Univiversitas Muara Bungo, "Kontribusi Perkebunan Kelapa Sawit Terhadap Pembangunan Perekonomian Kabupaten Bungo."
3. Tety. Ermi and Situmorang. Helentina, "Analisis Penawaran Tandan Buah Segar di Provinsi Riau," *Pekbis Jurnal*, vol. Vol.3, No.2, pp. 482–489, 2011.
4. N. P. Dewi and I. Listiowarni, "Implementasi Holt-Winters Exponential Smoothing untuk Peramalan Harga Bahan Pangan di Kabupaten Pamekasan", doi: 10.31849/digitalzone.v11i2.4797ICCS.
5. A. Faisal, S. Syah, P. Studi Manajemen, and F. Ekonomi, "Analisis Peramalan Harga Emas Bulanan dengan Holt Winter Exponential Smoothing 1)," vol. 29, no. 2, pp. 102–113, 2023, doi: 10.55122/mediastima.v29i2.857.
6. R. Efendi, "Pengantar Analisis Runtun Waktu."
   A. B. Ariwibowo, D. Sugiarto, I. A. Marie, J. Fadhilah, and A. Siahaan, "Peramalan harga beras IR64 kualitas III menggunakan metode Multi Layer Perceptron, Holt-Winters dan Auto Regressive Integrated Moving Average," *60 ULTIMATICS*, vol. XI, no. 2, 2019, [Online]. Available: www.foodstation.co.id.
7. U. Azmi, Z. N. Hadi, and S. Soraya, "ARDL METHOD: Forecasting Data Curah Hujan Harian NTB," *Jurnal Varian*, vol. 3, no. 2, pp. 73–82, May 2020, doi: 10.30812/varian.v3i2.627.