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# Application of the Triple Exponential Smoothing Method in Forecasting Covid-19 Cases in Central Java

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## ABSTRAK

Saat ini kasus Covid-19 sedang menurun, namun masih dapat menjadi ancaman bagi masyarakat Indonesia, tak terkecuali bagi masyarakat di Provinsi Jawa Tengah dengan penduduk yang cukup padat dan mobilitas cukup tinggi. Di masa mendatang, tidak menutup kemungkinan kasus Covid-19 akan terjadi kenaikan kembali, sehingga diperlukan peramalan (*forecasting*) untuk memprediksi kasus Covid-19 sebagai bahan pertimbangan untuk mengambil suatu kebijakan yang lebih baik bagi pemerintah, dinas pendidikan dan dinas kesehatan Jawa Tengah di tahun 2023. Penelitian ini bertujuan untuk mengetahui perkembangan kasus Covid-19 di Jawa Tengah dengan melakukan simulasi menggunakan metode peramalan *Triple Exponential Smoothing Winter* (TESW). Metode ini digunakan karena data kasus Covid-19 di Jawa Tengah berfluktuasi secara random dan terdapat pengaruh musiman. Terdapat dua model musiman dalam metode *Triple Exponential Smoothing Winter* yaitu model aditif dan model multiplikatif. Berdasarkan hasil penelitian diperoleh metode *Triple Exponential Smoothing Winter* model multiplikatif lebih baik dibanding dengan model aditif yang ditunjukkan dengan nilai MAPE yang lebih kecil yaitu 15,69% untuk meramalkan jumlah kasus Covid-19 di Provinsi Jawa Tengah dari bulan Mei 2022 hingga bulan Desember 2022. Hasil peramalan menunjukkan kasus Covid-19 berangsur turun setiap bulannya.

**Kata Kunci:** peramalan, *triple exponential smoothing*, kasus Covid-19

## *ABSTRACT*

*Currently, Covid-19 cases are decreasing, but it can still pose a threat to the people of Indonesia, not least for the people in Central Java Province, with a reasonably dense population and high mobility. In the future, Covid-19 cases may increase again, so forecasting is needed to predict Covid-19 cases as consideration for a better policy for the government, education authorities, and the Health Office of Central Java in 2023. This research aims to determine the development of Covid-19 cases in Central Java by conducting simulations using the Triple Exponential Smoothing Winter (TESW) forecasting method. This method was used because the data of Covid-19 cases in Central Java fluctuated randomly, and there was a seasonal effect. There are two seasonal models in the Triple Exponential Smoothing Winter method: the additive model and the multiplicative model. Based on the research results, the Triple Exponential Smoothing Winter multiplicative model was better than the additive model indicated by a smaller MAPE value of 15.69% for forecasting the number of Covid-19 cases in Central Java from May 2022 to December 2022. Forecasting result shows that Covid-19 cases are gradually decreasing every month.*

**Keywords:** *forecasting*, *triple exponential smoothing*, Covid-19 *cases*

## Introduction

Covid-19 cases can still threaten Indonesia's people, not least in Central Java Province, with a reasonably dense population and high mobility. Even though the case is declining, Covid-19 cases may increase again, so forecasting is needed to predict future Covid-19 cases as consideration for a better policy for the government and the provincial health office. The policy is related to whether tourist attractions in Central Java can be reopened and implementing 100% face-to-face meetings in the schools.

Forecasting is a calculation analysis technique to predict future events, which is carried out with qualitative and quantitative approaches using historical references of data in the past. Sofjan Assauri argues that forecasting is an activity to predict future values by referring to data in the past [1]. In addition, forecasting, according to Heizer and Render, is the art and science of predicting future events using historical data and projecting them using specific mathematical models. Forecasting

results can be used as a guide in making plans[2]. Some things that must be considered in making forecasts are as follows:

1. Forecasting errors are very likely to occur in the forecasting process. Researchers can only reduce the error rate that may occur.
2. The error level in forecasting is essential to provide information about the magnitude of the error value that may occur in the forecast.
3. The fewer the period in the forecast, the less and relatively constant the factors that influence it. The longer the period, the more factors that influence it. So forecasting with short-term periods is relatively more accurate than forecasting with long-term periods.

Forecasting models of Covid-19 cases have been carried out by several researchers, including forecasting the spread of Covid-19 cases in Central Java using the Arima Model [3], then Forecasting the Number of Daily Covid-19 Cases in West Java using the Vector Autoregressive (VAR) Model. In addition, Forecasting Covid-19 cases in DKI Jakarta with the ARIMA Model [3]. The research on the application of the triple exponential smoothing method that has been done includes forecasting the number of tourists in Banyuwangi Regency and forecasting the number of tourists at the Ijen Crater Tourism Park [4] and forecasting the monthly inflation rate of Aceh Province in 2019-2020[5].

This research aims to determine the development of Covid-19 cases in Central Java by conducting simulations using the Triple Exponential Smoothing (TES) Winter forecasting method. This method was used in this research because historical data on Covid-19 cases in Central Java showed a pattern of random fluctuations and a seasonal effect. Forecasting using the Triple Exponential Smoothing method also prioritizes the lowest forecasting error rate with a standard statistical measure, namely MSE (Mean Square Error) and relative statistical measures such as MAPE (Mean Absolute Percentage Error). This research is expected to help local governments, education offices, and health offices of Central Java in determining policy in 2023.

## Research methods

The method used in this research is a quantitative method with a Covid-19 case study approach. The data used is secondary data on the number of daily positive cases of Covid-19 in Central Java from April 2020 to April 2022 sourced from. This research applies the Triple Exponential Smoothing (TES) forecasting method based on past historical data to predict some data that may occur in the future. This research is limited to only assessing the number of new daily positive Covid-19 cases in Central Java without paying attention to the factors that affect the increase or decrease in Covid-19 cases.

The flowchart description of the research process is as follows:

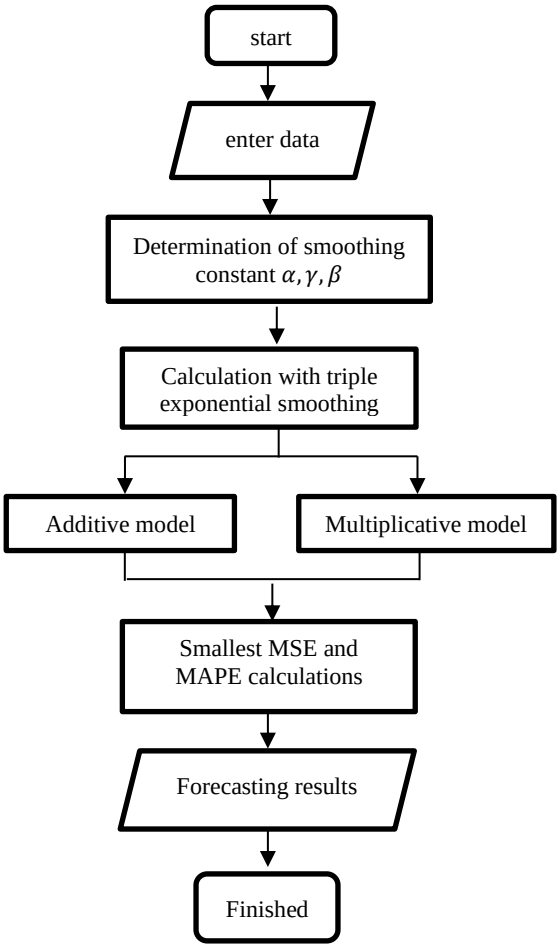


**Figure 1.** Flowchart For Forecasting The Triple Exponential Smoothing Method

The initial step of the research is to study supporting literature consisting of several journals, books, and articles. Furthermore, daily data on COVID-19 cases in Central Java was taken from April 2020 to April 2022. Then the data were identified and averaged monthly. After that, the Triple Exponential Smoothing (TES) Winter method of multiplicative and additive models was applied with the help of R software and the Zaitun Time Series [6]–[10]. The program's output is a forecasting model along with graphs of actual data and forecasting data along with values such as Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) to evaluate forecasting methods. The final step is the conclusion that results from predicting the number of Covid-19 cases from May 2022 to December 2022 in Central Java.[11]–[13]

### Exponential Smoothing (ES) Method

The exponential smoothing method is a moving average forecasting method that

exponentially decreases the weighting of the observation value of the previous period [14]. Generally, the problem faced in this method is how to choose the right value of the smoothing constant to minimize the error rate in forecasting. Since $0 < \alpha < 1$ applies, the following guidelines are used :

1. If the historical pattern of the actual data fluctuates unstable from time to time, then the smoothing constant value α is chosen close to one.
2. If the historical pattern of the actual data is relatively stable, then the value close to zero is chosen. The value chosen in the forecast is the one that produces the lowest error rate.

**Triple Exponential Smoothing Method**

The Triple Exponential Smoothing method is used if the data pattern shows significant fluctuations or changes. The Triple Exponential Smoothing (TES) method used in this research is Triple Exponential Smoothing Winter (TESW), using three smoothing equations, namely the overall smoothing equation, the trend component smoothing equation, and the seasonal component smoothing equation. Based on the seasonal model, the Triple Exponential Smoothing Winter (TESW) method has two models: the multiplicative seasonal model and the seasonal additive model. If data shows an increasing seasonal fluctuation, the multiplicative seasonal model TESW method is used. If data shows a long-term increase and relatively constant seasonal fluctuations with an increasing observation period, then the additive seasonal model TESW method is used [15]. The TESW method uses three different parameters for smoothing values, namely the base smoothing parameter, trend smoothing parameter, and seasonal smoothing parameter. The equation for the TESW method in this research is as follows [12] :

Totality smoothing :

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

Then look for trend smoothing $b_t$ and seasonal smoothing $I_t$ With equation :

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

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

As for the forecasting value $F_{t+m}$ Determined by the equation:

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

where :

$X_t$ : actual data period *t*
$S_t$ : the new smoothing value
$F_{t+m}$ : forecast value period *m*
$\alpha$ : the smoothing constant value ($0 < \alpha < 1$)
$\gamma$ : smoothing constant for trend parameter $0 \leq \gamma \leq 1$
$b_t$ : trend estimation
$\beta$ : smoothing constant for seasonal parameters $0 \leq \beta \leq 1$
$I_t$ : seasonal estimate
$m$ : forecasted period
$L$ : seasonal length

***Mean Square Error* (MSE)**

The statistical measure Mean Square Error is used to measure the accuracy of forecasting data. Errors in each period are squared, then averaged by dividing the number of observations. Mathematically, calculating the size of the MSE statistic is defined as follows:

$$MSE = \sum_{t=1}^{N} \frac{e_t^2}{N} \quad (5)$$

where :

$e_t$ : error in period-*t*
$N$ : number of periods

***Mean Absolute Percentage Error* (MAPE)**

One way to measure the accuracy of the estimated model value expressed as an average absolute percentage error is to calculate the Mean Absolute Percentage Error (MAPE). MAPE is widely used to determine the magnitude of deviations from forecasting results. If the MAPE value is getting smaller, then the forecasting results are said to be more accurate [13]. The formula for calculating MAPE is as follows:

$$MAPE = \left(\frac{1}{n}\sum_{t=1}^{n}\left|\frac{y(t)-y'(t)}{y(t)}\right|\right) \times 100\ \% \quad (6)$$

where :

$y_t$ : observation value at time *t*
$y'_t$ : forecast value at time *t*
$n$ : number of observations

## Results and Discussion

This research uses data on the number of daily Covid-19 cases in Central Java for 1 April 2020 - 1 April 2022, and then the monthly average is taken. The graph of the pattern of data on Covid-19 cases in Central Java is as follows:

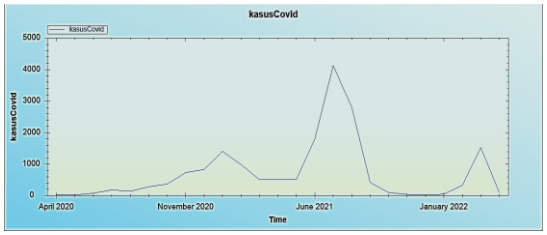


**Figure 2.** Graph Of The Data Plot Of The Covid-19 Case In Central Java

From figure **2**, it can be seen that data from the monthly average number of new cases of Covid-19 in Central Java contains an element of trend due to an increase in graphic data patterns over a certain period, and there is a seasonal effect with a sharp

increase in July-August 2021[16]–[18]. Figure **2** shows the historical pattern of the actual unstable data, which is indicated by an increase from April 2020 to January 2021, then a decrease in cases from February to April 2021, there will be a significant increase from May 2021 to August 2021; this is a consideration in determining the value of $\alpha$. The data obtained is then used in the forecasting process. Furthermore, forecasting is carried out according to the data pattern identified in the trend analysis process. The Zaitun Time Series and R software assist the forecasting data analysis process. [19], [20]

Data analysis was performed using the Triple Exponential Smoothing Winter (TESW) method to obtain the best forecasting model. The best forecasting model is the one that can minimize the forecast error value that can be seen based on the MSE (Mean Square Error) and MAPE (Mean Absolute Percentage Error) values. The forecasting process includes calculating smoothing constants ($\alpha$, $\beta$, dan $\gamma$) by trial and error with a value range of 0 to 1 [14], which minimizes forecasting errors in calculating the smoothing value [21], [22]. Forecasting the number of Covid-19 cases in Central Java using 2 models in the TESW method, namely the multiplicative model and the additive model, as follows.[23]–[25]

**Multiplicative Model Smoothing Constant**

Determination of smoothing constants $\alpha$, $\gamma$, and $\beta$ and using 100x trial on Zaitun Time Series software and selected three with the smallest MSE and MAPE values shown in the following table:

**Table 1**. Smoothing Constants For The Multiplicative Model TES Method

| Smoothing constant | | | MSE | MAPE |
|---|---|---|---|---|
| $\alpha$ | $\gamma$ | $\beta$ | | |
| 0,9 | 0,1 | 0,2 | 874781,64 | 15,81% |
| 0,9 | 0,1 | 0,3 | 873768,76 | 15,89% |
| 0,9 | 0,1 | 0,1 | 873214,35 | 15,69% |

Table **1** shows 3 out of 100 possible constant values $\alpha$, $\gamma$, and $\beta$, which minimizes MSE and MAPE. Based on table 1, the smallest MSE and MAPE values are obtained at the value of $\alpha = 0{,}9$ , $\gamma = 0{,}1$ and $\beta = 0{,}1$ with value of MSE = 873214,35 and MAPE = 15,69%.

**Additive Model Smoothing Constant**

Determination of smoothing constant $\alpha$, $\gamma$, and $\beta$ using 100x trial on Zaitun Time Series software and selected three with the smallest MSE and MAPE values shown in the following table:

**Table 2**. Smoothing Constants Of Additive Model TES Method

| Smoothing constant | | | MSE | MAPE |
|---|---|---|---|---|
| $\alpha$ | $\gamma$ | $\beta$ | | |
| 0,9 | 0,1 | 0,2 | 892192,73 | 25,17% |
| 0,9 | 0,1 | 0,3 | 887480,98 | 24,43% |
| 0,9 | 0,1 | 0,1 | 888625,41 | 25,96% |

Table **2** shows 3 of 100 possible smoothing constant values $\alpha$, $\gamma$, dan $\beta$. Based on the table, the smallest MSE and MAPE values are obtained at the value of $\alpha = 0{,}9$ , $\gamma = 0{,}1$ dan $\beta = 0{,}3$ with the value of MSE = 887480,98 and MAPE = 24,43%.

**Best Forecasting Model**

To determine whether the forecasting model has been efficient, it is possible to use a statistical measure of the error rate of the forecasting results. The forecasting error rate can be calculated through the size of the forecasting error using MSE and MAPE. MAPE score criteria are given in the following table [26]:

**Table 3.** Criteria of MAPE

| MAPE Value (%) | Criteria |
|---|---|
| <10 | Very good forecasting ability |
| 10-20 | Good forecasting ability |
| 21-50 | Sufficient forecasting ability |
| >50 | Poor forecasting ability |

After calculating the smoothing constant with multiplicative and additive models, compare the smallest MSE and MAPE values.

**Table 4.** Comparison Of Smoothing Constant Values

| Smoothing constant | Multiplicative Model | Additive Model |
|---|---|---|
| $\alpha$ | 0,9 | 0,9 |
| $\gamma$ | 0,1 | 0,1 |
| $\beta$ | 0,1 | 0,1 |
| MSE | 874781,6399 | 888625,41 |
| MAPE | 15,69% | 25,96% |

Table **4** shows the comparison of the values of $\alpha$, $\gamma$, and $\beta$ TESW multiplicative model and additive model. Based on the results of MSE and MAPE in table 4, it is found that the multiplicative model TESW method denotes MSE and MAPE values that are smaller than the MSE and MAPE values in the additive model TESW method. So this research uses the TESW method with a

multiplicative model. In addition, the range of MAPE values is from 10% - 20%, which means the forecasting criteria have good forecasting ability. The smoothing constant values are used to find $S_t$, $b_t$ and $I_t$ so that the equation:

$$S_t = 0{,}9X_t + (1 - 0{,}9)(S_{t-1} + b_{t-1}) \quad (7)$$

$$b_t = 0{,}1(S_t - S_{t-1}) + (1 - 0{,}1)b_{t-1} \quad (8)$$

$$I_t = 0{,}1\frac{X_t}{S_t} + (1 - 0{,}1)I_{t-L} \quad (9)$$

So that it is obtained:

$$F_{t+m} = (0{,}9X_t + (1 - 0{,}9)(S_{t-1} + b_{t-1}) + (0{,}1(S_t - S_{t-1}) + (1 - 0{,}1)b_{t-1})m)I_{t-L+m} \quad (10)$$

The following plots the results of the actual data calculations and the prediction results of the Triple Exponential Smoothing Winter multiplicative model method:

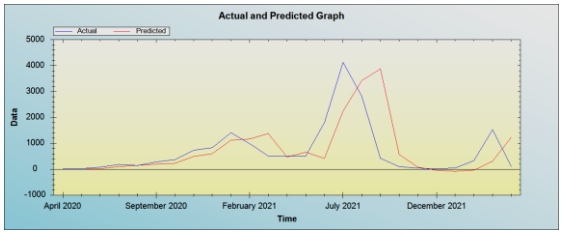


**Figure 3**. Graph Of Actual Data And Predicted Data

Forecasting results using the Triple Exponential Smoothing Winter multiplicative model show the number of Covid-19 cases is decreasing, and the cases are negative starting in September, which means there are no new Covid-19 cases. The forecasting results can be used as consideration for the government, health, and education offices of Central Java in determining policies in 2023. Forecasting results are tabulated in the following table:

**Table 5.** Multiplicative Model Forecasting Results

| Month-Year | Forecasting Results |
|---|---|
| May 2022 | 208 |
| June 2022 | 120 |
| July 2022 | 96 |
| August 2022 | 32 |
| September 2022 | -16 |
| October 2022 | -57 |
| November 2022 | -128 |
| December 2022 | -145 |

The following is a graph of the actual data plot and the results of the multiplicative model TESW forecasting method:

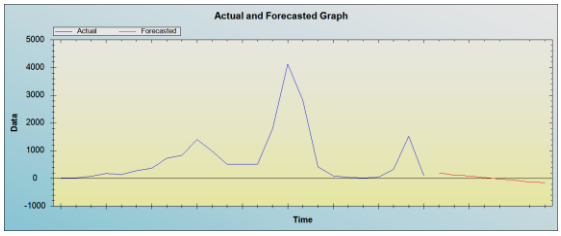


**Figure 4.** Graph Of Actual Data And Forecasting Results

The plot graph depicts the data indicated by the blue line and the forecasting results indicated by the red line. The plot graph in figure **4** shows that the forecasting results are decreasing every month. This illustrates that Covid-19 cases are decreasing every month in 2022[27]–[31].

## Conclusion

Based on the results of the research, it can be concluded that the Triple Exponential Smoothing Winter (TESW) multiplicative model is better than the additive model for predicting the number of Covid-19 cases in Central Java. From the modeling results, the following multiplicative model equations are obtained:

$$F_{t+m} = (0{,}9X_t + (1 - 0{,}9)(S_{t-1} + b_{t-1}) + (0{,}1(S_t - S_{t-1}) + (1 - 0{,}1)b_{t-1})m)I_{t-L+m}$$

This model reveals that the results of forecasting the number of Covid-19 cases in Central Java were obtained from May to December 2022. During this period, Covid-19 cases were decreasing.

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## Bibliography

[1] S. Assauri, "Manajemen operasi produksi," *Jakarta PT Raja Graf. Persada*, 2016.

[2] J. Heizer and B. Render, "Manajemen operasi buku 1 edisi 9," *Jakarta: Salemba Empat*, 2009.

[3] N. Qomariasih, "Peramalan Kasus Covid-19 di DKI Jakarta dengan Model Arima," *J. Syntax Transform.*, vol. 2, no. 6, pp. 849–855, 2021.

[4] F. R. Kustiawan And H. Hudori, "Forecasting Jumlah Wisatawan Di Taman Wisata Alam Kawah Ijen Dengan Metode Exponential Smoothing Berbantu Zaitun Time Series," *Transform. J. Pendidik. Mat. Dan Mat.*, Vol. 1, No. 1, 2017.

[5] V. Fitria and S. Anwar, "Penerapan Triple Exponential Smoothing dalam Meramalkan Laju Inflasi Bulanan Provinsi Aceh Tahun 2019-2020," *E-Jurnal Ekon. dan Bisnis*

*Univ. Udayana*, vol. 9, no. 2020, pp. 23–38, 2020.

[6] M. Rizki, M. I. H. Umam, and M. L. Hamzah, "Aplikasi Data Mining Dengan Metode CHAID Dalam Menentukan Status Kredit," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 18, no. 1, pp. 29–33, 2020.

[7] F. S. Lubis, A. P. Rahima, M. I. H. Umam, and M. Rizki, "Analisis Kepuasan Pelanggan dengan Metode Servqual dan Pendekatan Structural Equation Modelling (SEM) pada Perusahaan Jasa Pengiriman Barang di Wilayah Kota Pekanbaru," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 17, no. 1, pp. 25–31, 2019.

[8] H. Hertina *et al.*, "Data mining applied about polygamy using sentiment analysis on Twitters in Indonesian perception," *Bull. Electr. Eng. Informatics*, vol. 10, no. 4, pp. 2231–2236, 2021.

[9] A. Rinaldi, N. Rahmadani, P. Papilo, S. Silvia, and M. Rizki, "Analisa Pengambilan Keputusan Pemilihan Bahan Dalam Pembuatan Kemeja Menggunakan Metode TOPSIS," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 18, no. 2, pp. 163–172, 2021.

[10] J. Oscardo, A. A. Purwati, and M. L. Hamzah, "Inovasi Produk, Persepsi Harga, Pengalaman Konsumen dan Strategi Positioning dalam Meningkatkan Keputusan Pembelian Pada PT. Cahaya Sejahtera Riau Pekanbaru," *INVEST J. Inov. Bisnis Dan Akunt.*, vol. 2, no. 1, pp. 64–75, 2021.

[11] N. Nazaruddin and W. Septiani, "Risk Mitigation Production Process on Wood Working Line Using Fuzzy Logic Approach," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 19, no. 1, pp. 100–108, 2021.

[12] M. Rizki, K. Khulidatiana, I. Kusmanto, F. S. Lubis, and S. Silvia, "Aplikasi End User Computing Satifaction pada Penggunaan E-Learning FST UIN SUSKA," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 19, no. 2, pp. 154–159, 2022.

[13] F. S. Lubis, B. G. Farahitari, and M. Yola, "Efesiensi Biaya Persediaan Bahan Baku Pembuatan Paving Block Menggunakan Metode Heuristic Silver Meal," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. II, pp. 104–113, 2022.

[14] S. Makridakis, S. C. Wheelwright, and V. E. McGee, "Metode dan Aplikasi Peramalan (terjemahan)," *Jakarta Bin. Ksara*, 1998.

[15] S. N. Hamidah, N. Salam, and D. S. Susanti, "Teknik Peramalan Menggunakan Metode Pemulusan Eksponensial Holt-Winters," *Epsil. J. Mat. MURNI DAN Terap.*, vol. 7, no. 2, pp. 26–33, 2017.

[16] M. L. Hamzah, E. Rusilawati, and A. A. Purwati, "Sistem Aplikasi Sarana Prasarana Perguruan Tinggi Menggunakan Teknologi Near Field Communication Berbasis Android," *INTECOMS J. Inf. Technol. Comput. Sci.*, vol. 1, no. 2, pp. 251–261, 2018.

[17] M. I. H. Umam, N. Nofirza, M. Rizki, and F. S. Lubis, "Optimalisasi Jumlah Kebutuhan Tenaga Kerja pada Stasiun Kerja Hoisting Crane Menggunakan Metode Work Sampling (Studi Kasus: PT. X)," *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 5, no. 2, pp. 125–129, 2020.

[18] D. Kurnianingtyas, M. I. H. Umam, and B. Santosa, "A hybrid symbiotic organisms and variable neighborhood searches to minimize response time," in *AIP Conference Proceedings*, 2019, vol. 2097, no. 1, p. 30095.

[19] N. Nazaruddin and S. Sarbaini, "Evaluasi Perubahan Minat Pemilihan Mobil dan Market Share Konsumen di Showroom Pabrikan Honda," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. II, pp. 97–103, 2022.

[20] S. Sarbaini, M. Imran, and A. Karma, "Metode Bertipe Steffensen dengan Orde Konvergensi Optimal untuk Menyelesaikan Persamaan Nonlinear." Riau University, 2014.

[21] S. Sarbaini, W. Saputri, and F. Muttakin, "Cluster Analysis Menggunakan Algoritma Fuzzy K-Means Untuk Tingkat Pengangguran Di Provinsi Riau," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. II, pp. 78–84, 2022.

[22] S. Sarbaini, E. P. Cynthia, and M. I. Arifandy, "Pengelompokan Diabetic Macular Edema Berbasis Citra Retina Mata Menggunakan Fuzzy Learning Vector Quantization (FLVQ)," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 19, no. 1, pp. 75–80, 2021.

[23] M. I. Arifandy, E. P. Cynthia, and F. Muttakin, "Potensi Limbah Padat Kelapa Sawit Sebagai Sumber Energi Terbarukan Dalam Implementasi Indonesian Sustainability Palm Oil," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 19, no. 1, pp. 116–122, 2021.

[24] F. Muttakin, K. N. Fatwa, and S. Sarbaini, "Implementasi Additive Ratio Assessment Model untuk Rekomendasi Penerima Manfaat Program Keluarga Harapan," *SITEKIN J. Sains, Teknol. dan Ind.*, vol. 19, no. 1, pp. 40–48.

[25] S. Sarbaini, Z. Zukrianto, and N. Nazaruddin, "Pengaruh Tingkat Kemiskinan

Terhadap Pembangunan Rumah Layak Huni Di Provinsi Riau Menggunakan Metode Analisis Regresi Sederhana," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. III, pp. 131–136, 2022.

[26] D. I. Purnama and O. P. Hendarsin, "Peramalan Jumlah Penumpang Berangkat Melalui Transportasi Udara di Sulawesi Tengah Menggunakan Support Vector Regression (SVR)," *Jambura J. Math.*, vol. 2, no. 2, pp. 49–59, 2020.

[27] A. K. Rachmawati, "Peramalan Penyebaran Jumlah Kasus Covid19 Provinsi Jawa Tengah dengan Metode ARIMA," *Zeta-Math J.*, vol. 6, no. 1, pp. 11–16, 2021.

[28] R. Yuriska, A. A. Rohmawati, and A. Aditsania, "Forecasting Jumlah Kasus Harian Covid-19 Di Provinsi Jawa Barat Menggunakan Model Vector Autoregressive (var)," *eProceedings Eng.*, vol. 8, no. 5, 2021.

[29] D. Rosadi, "Ekonometrika dan analisis runtun waktu terapan dengan eviews," 2016.

[30] C. V. Hudiyanti, F. A. Bachtiar, and B. D. Setiawan, "Perbandingan Double Moving Average dan Double Exponential Smoothing untuk Peramalan Jumlah Kedatangan Wisatawan Mancanegara di Bandara Ngurah Rai," *J. Pengemb. Teknol. Inf. Dan Ilmu Komput. E-ISSN*, vol. 2548, p. 964X, 2019.

[31] I. Sungkawa and R. T. Megasari, "Penerapan ukuran ketepatan nilai ramalan data deret waktu dalam seleksi model peramalan volume penjualan pt satriamandiri citramulia," *ComTech Comput. Math. Eng. Appl.*, vol. 2, no. 2, pp. 636–645, 2011.