


Application of the Double Exponential Smoothing Brown Method in Forecasting the Number of Poor Population

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Article Info	ABSTRACT
<p>Article History: Received: January 30, 2026 Revised: February 26, 2026 Accepted: March 27, 2026 Available online: March 27, 2026</p> <p>Keywords: double exponential smoothing brown; forecasting; poverty; time series</p>	<p>Poverty is a socio-economic issue that requires policy planning based on accurate forecasting. This study uses the Brown Double Exponential Smoothing method to forecast the number of poor people in Metro City for the period 2026-2030, using data from 2005-2025 obtained from BPS. The analysis was conducted using a trial and error method for the alpha (α) parameter ranging from 0.1 to 0.9 based on the smallest MAD, MSE, and MAPE values. The study results indicate that the optimal alpha parameter is $\alpha = 0.5$ with a MAPE of 15.91231%, which indicates good accuracy. The forecast shows an increasing trend from 321.90 thousand people (2026) to 338.87 thousand people (2030), with an average increase of 4.24 thousand people per year. The results of this study can be used as a basis for planning poverty alleviation programs in Metro City.</p> <p> This is an open access article under the Creative Commons Attribution 4.0 International License</p>

INTRODUCTION

Poverty is one of the crucial socio-economic problems that Indonesia is still facing as a developing country. Although it has experienced a consistent decline in recent years, from 9.82% in March 2018 to 8.57% in September 2024, the absolute number of Indonesia's poor still reaches 24.06 million people (BPS, 2025). This condition requires serious attention from the government and stakeholders to design effective and data-based poverty alleviation policies. Research by Dini Purwanti & Joko Purwadi (2019), on forecasting the inflation rate in Indonesia using *the Brown's Double Exponential Smoothing* method proves that this method is effective in handling *time series* data with trend patterns, where the optimal parameter value of α is 0.9 with a MAPE value of 10.607%. At the local level, Metro City as one of the cities in Lampung Province also faces similar challenges in efforts to reduce poverty rates.

Forecasting the number of poor people is an important instrument in development planning and policy-making. Accurate predictions can assist local governments in allocating budgets, designing social intervention programs, and evaluating the effectiveness of poverty alleviation policies that have been implemented (Hidayat et al., 2024). In this context, an accurate and reliable forecasting method is indispensable to produce projections that can be used as a basis for decision-making.

Various previous studies have used *the time series* method to predict poverty levels in various regions of Indonesia. Agusdin et al. (2024), used *Holt's Exponential Smoothing method* to predict the poverty level in the Special Region of Yogyakarta with the best parameter configuration results of $\alpha.\beta = 0.9$. Langowuyo et al. (2022), compared the *Double and Triple Exponential Smoothing methods* to predict the poverty level of Yahukimo Regency for the 2025-2030 period. The latest research by Ngabidin et al. (2023), implements the *Double Exponential Smoothing Brown* method to forecast the number of poor people in Blitar Regency with a MAPE value of 3.79%.

Nevertheless, there is a significant research gap. First, there has been no specific study that uses the *Double Exponential Smoothing Brown* method to predict the number of poor people in Metro Cities. Second, most previous research focused on comparing different forecasting methods but lacked depth in optimizing parameters on one particular method. Third, the historical data periods used in previous studies are relatively limited, while the Metro City data from 2005 to 2025 (21 years) provide a stronger basis for long-term trend analysis.

This research makes a new contribution in several important aspects. First, this study is the first study that specifically applies the *Double Exponential Smoothing Brown* method to forecast the number of poor people in Metro Cities using 21-year historical data (2005-2025). The *Double Exponential Smoothing Brown* method was chosen because of its advantages in handling *time series* data that has a linear trend pattern, where this method performs double smoothing to adjust to the data trend (Aminudin & Handoko, 2019). According to Farida et al. (2023), in their research on the HDI forecasting of Bojonegoro Regency, it was shown that the *Double Exponential Smoothing Brown* method with the parameter $\alpha = 0.7$ produced a MAPE value of 0.376% which was included in the criteria of very good. A similar study by Ngabidin et al. (2023) predicted that the number of poor people in Blitar Regency using the same method obtained the best results with a MAD value of 4.95, MSE 49.47, and MAPE 3.79% at *alpha* parameter 0.7. Another study by Talia et al. (2019), on the forecasting of the poverty level of the population of East Kalimantan Province using the *Double Exponential Smoothing* method shows that this method is effective in producing accurate forecasting by considering historical data trend patterns. A comparative study by Pujiati et al. (2016), which used the *Double Exponential Smoothing method from Brown* to predict the *Consumer Price Index of Samarinda City* found that the best a parameter of 0.61 was able to produce optimal forecasting.

Second, this study uses a forecasting period for the next five years (2026-2030) which is in line with the regional development planning cycle, so that the results of the research can be directly utilized by the Metro City government in the preparation of the Regional Medium-Term Development Plan (RPJMD). According to Syarmilati & Rifai, (2024), in his research on HDI forecasting in Belitung Regency used the same method for the period 2023-2027 and concluded that the results of the forecasting can help the government in measuring the success of human development. Atussaliha et al. (2020), applied the *Double Exponential Smoothing* method to the poverty level forecasting system of Pangkep Regency and found that this method is appropriate because the data pattern shows a trend. Research by Rosa et al. (2019), on the projection of the number of poor people in West Nusa Tenggara using the *Exponential Smoothing* method proves that this method is able to provide a good projection with the best *alpha* value of 0.9 with the smallest error rate. Research by Utami et al. (2024), on exponential smoothing forecasting to determine the amount of production emphasizes the importance of looking for the smallest errors through MAPE that has been tested with an *alpha* constant value to produce accurate forecasting.

Third, this study uses *multiple error metrics* (MAPE, MSE, MAD) to measure the accuracy of the model comprehensively. According to Nurohmah et al. (2025), in his research on the prediction of the number of prospective new students using *the Double Exponential Smoothing Brown method*, emphasizing the importance of using these three accuracy measures to obtain optimal *alpha* parameters through *the trial and error* method from 0.1 to 0.9. Research by Audinasyah & Solehudin (2024), in a *production planning* forecasting system using *the Single Exponential Smoothing method*, the best results with a MAD of 73.75, MSE of 5,738, and MAPE of 2.92%, which shows the effectiveness of the *exponential smoothing method* in providing accurate forecasts. Zahrunnisa et al. (2021), conducted a comparison of *the Exponential Smoothing and ARIMA methods* in the forecasting of the poverty line in Central Java Province and concluded that the selection of the forecasting method must consider several things, including the ability of the method to revise prediction errors. A study by Riski Aspriyani & Najmah Istikaanah (2023), on *time series analysis* to predict the number of poor people in Cilacap using *the moving average, weighted moving average, and exponential smoothing methods*, showed that *the exponential smoothing method* was the best method with an error rate of 6.77% or an accuracy of 93.23%. The study of Hidayah et al. (2024), on the application of *the Double Exponential Smoothing Brown method* for the forecasting of *the Consumer Price Index* in Sorong City before and during the COVID-19 pandemic proves that this method is *robust* in dealing with changes in data patterns caused by external factors.

Fourth, the use of *time series* data for 21 years (2005-2025) provides a stronger basis for long-term trend analysis than previous studies that generally used 9-10 years of data. In their research, Prasetyono et al. (2021), on the analysis of poverty level forecasting in Indonesia using the *ARIMA* model using test data from 2011 to 2020 and emphasizing that poverty level forecasting is very important to estimate future conditions so that anticipatory measures can be taken quickly. Maricar (2019), in his research on revenue forecasting in Company XYZ compared the *Moving Average and Exponential Smoothing methods* by using MAD (*Mean Absolute Deviation*), MSE, and MAPE calculations to obtain the method with the highest accuracy value. Kurnia et al. (2024), in their research on modeling poverty level cases in Indonesia for the period 2015-2021 with a geographically weighted panel regression model, concluded that panel data analysis by considering time aspects and spatial aspects simultaneously can provide better estimation results. The research of Lisa Agustin & Hadi Sumarsono (2022), on the influence of unemployment, HDI, and social assistance on poverty in East Java Province shows the importance of understanding the factors that affect poverty as a basis for making more accurate projections.

Based on the above research background and gaps, this study aims to: Implement the *Double Exponential Smoothing Brown method* to forecast the number of poor people in Metro Cities for the 2026-2030 period. Determine the optimal *alpha* (α) parameter values that produce the best level of forecasting accuracy based on the error size of the MAPE, MSE, and MAD. Analyze the historical trend data patterns of the number of poor people in Metro Cities from 2005 to 2025. Providing forecasting the number of poor people for the next five years as the basis for planning poverty alleviation policies in Metro Cities.

METHODS

This study uses a quantitative approach with a time series forecasting design. The data used is secondary data in the form of the number of poor people in Metro City from 2005 to 2025 which is sourced from the Central Statistics Agency (BPS) of Metro City. The research stage follows procedures commonly used in similar studies, namely: (1) data plot creation to

identify patterns; (2) calculation of the value of single exponential smoothing; (3) calculation of double exponential smoothing value; (4) Calculation of Constant Values (AT) and Slope (BT); (5) calculation of forecast value; (6) determination of α parameters through trial and error methods with a range of 0.1 to 0.9 and comparing MAPE, MSE, and MAD values; and (7) forecasting the number of poor people for the next five years.

The Double Exponential Smoothing Brown method works by performing two exponential smoothing to capture the level and trend components in the data, then using one α parameter for both smoothing processes. The optimal α value is determined by selecting the value that produces the smallest error rate based on three accuracy measures, namely MAPE, MSE, and MAD. The model with the smallest error value was chosen as the best model to make a projection in the period 2026–2030. With a systematic methodological approach and the use of comprehensive historical data, this research is expected to be able to produce an accurate and useful forecasting model for the development planning of Metro City, especially in efforts to alleviate poverty towards the achievement of sustainable development goals (Sustainable Development Goals).

RESULT AND DISCUSSIONS

The data used in this research is data on the number of poor residents of Meitro City from 2005 to 2025 which was collected from the Central Statistics Agency (BPS) of Meitro City. The data include 21 annual observations presented in Table 1.

Table 1. Data on the Number of Poor Residents in Meitro City in 2005-2025

No	Years	Number of Poor Residents (thousands)
1	2005	8,6
2	2006	15,5
3	2007	15,5
4	2008	15,5
5	2009	21,22
6	2010	20,1
7	2011	19
8	2012	18,34
9	2013	17,08
10	2014	16,95
11	2015	16,2
12	2016	16,26
13	2017	16,06
14	2018	15,06
15	2019	14,49
16	2020	14,31
17	2021	15,32
18	2022	13,68
19	2023	12,8
20	2024	12,07
21	2025	11,58

To find out the data patterns of the peirlu, a data plot is carried out using graphs. The data plot of the number of poor residents in Metro City from 2005 to 2025 is presented in Figure 1.

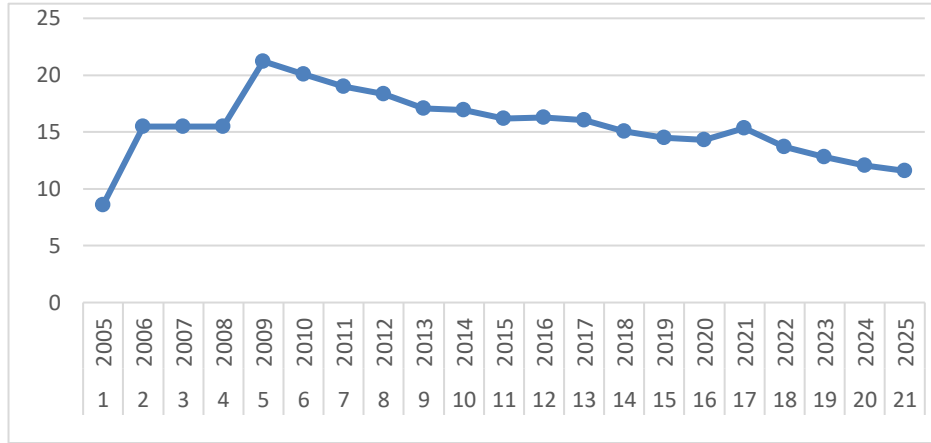


Figure 1. Data Plot on the Number of Poor Residents in Metro City in 2005-2025

Based on the results of the data plot in Figure 1, it can be seen that the number of poor residents in Meitro City from 2005 to 2025 has fluctuated. The data shows a sharp increase from 2005 to a peak in 2009, with a steady decline in consumption until 2025. Therefore, the data on the number of poor residents in Meitro City shows a pattern of **data on the number of poor people in the first place**, although there is a significant increase in the number of people who live in the area at the beginning of the survey.

In the analysis and analysis of data on the number of poor residents in Metro City, *forecasting* was used with a pattern of *data that was trained down* using the *Double Exponential Smoothing Brown* (DEIS) and parameter method *Alpha error* (α) = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 dan 0.9. Following is the calculation for *Alpha error* (α) = 0.1, at the time $t = 1 - 3$.

1) Value determination *Single Exponential Smoothing*

$$S'_t = 0.1 \times x_t + (1 - 0.1)S'_{t-1}$$

$$S'_1 = 8.6$$

$$S'_2 = (0.1 \times 15.5) + (0.9 \times 8.6) = 1.55 + 7.74 = 9.29$$

$$S'_3 = (0.1 \times 15.5) + (0.9 \times 9.29) = 1.55 + 8.361 = 9.911$$

and so on until S'_{21}

2) Value determination *Double Exponential Smoothing*

$$S''_t = 0.1S'_t + (1 - 0.1)S''_{t-1}$$

$$S''_1 = 8.6$$

$$S''_2 = (0.1 \times 9.29) + (0.9 \times 8.6) = 0.929 + 7.74 = 8.669$$

$$S''_3 = (0.1 \times 9.911) + (0.9 \times 8.669) = 0.9911 + 7.8021 = 8.7932$$

and so on until S''_{21}

3) Determination of constant values

$$a_t = 2S'_t - S''_t$$

$$a_1 = 2 \times 8.6 - 8.6 = 8.6$$

$$a_2 = 2 \times 9.29 - 8.669 = 9.911$$

$$a_3 = 2 \times 9.911 - 8.7932 = 11.0288$$

and so on until a_{21}

4) Determination of trend coefficient values

$$b_t = (0.1)/(1 - 0.1) (S'_t - S''_t)$$

$$b_1 = (0.1)/(0.9) (8.6 - 8.6) = 0$$

$$b_2 = (0.1)/(0.9) (9.29 - 8.669) = 0.069$$

$$b_3 = (0.1)/(0.9) (9.911 - 8.7932) = 0.1242$$

and so on until b_{21}

5) Determination of the magnitude of the forecasting value

$$F_{t+m} = a_t + b_t m$$

for $m = 1$

$$F_{1+1} = 8.6 + 0(1) = 8.6$$

$$F_{2+1} = 9.911 + (0.069)(1) = 9.98$$

$$F_{3+1} = 11.0288 + (0.1242)(1) = 11.153$$

and so on until F_{21+1}

The calculation using the *Double Exponential Smoothing Brown* method is carried out repeatedly and so on until *Alpha error* (α) = 0.9 and $t = 21$, so that the results of the calculation are obtained in Table 2.

Table 2. DES Calculation Results

<i>Alpha error</i> (α)	S'_t	S''_t	a_t	b_t	F_{t+m}
0.1	277,2604006	234,0175574	311,9032438	4,804760351	302,103017
0.2	305,5441124	280,8470162	321,6412087	6,174274061	315,6406385
0.3	315,4416691	302,5540526	319,7292856	5,523264215	313,9491542
0.4	319,7572962	312,5676555	318,3469368	4,793093796	312,1059357
0.5	322,0194661	317,7782871	317,6606451	4,241178989	310,9825804
0.6	323,3645475	320,8163307	317,3127643	3,822325239	310,2497771
0.7	324,2367358	322,7356377	317,137834	3,50256233	309,7292663
0.8	324,8408594	324,0244105	317,0573083	3,265795668	309,3527086
0.9	325,2825184	324,9383522	317,0266847	3,097496502	309,0884706

Table 2 shows the results of the calculation of the values of Single Exponential Smoothing, Double Exponential Smoothing, constant values, trend coefficient values, and forecasting values based on alpha parameters and error rates. Based on the data in Table 2, the next step is to determine the optimal alpha parameter based on the smallest error value. The selected alpha parameters are then used to forecast for the next five periods, from 2026 to 2030.

After obtaining the results of the analysis, the next step is to determine the best alpha parameter of the value of 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; and 0.9 by comparing the values of Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). This comparison is done to obtain the smallest error value from each time period. The following is presented a comparison of error values in the form of MAD, MSE, and MAPE in the method of forecasting the number of poor people in Blitar Regency. For $\alpha = 0.1$, the calculation is done as follows:

$$\begin{aligned} \text{MAD} &= \frac{1}{n} \sum |X_t - F_t| \\ &= \frac{|8,6 - 8,6| + |15,5 - 9,98| + |15,5 - 11,153| + \dots + |11,58 - 302,103017|}{21} \\ &= 2,893146 \end{aligned}$$

$$\begin{aligned} \text{MSE} &= \frac{1}{n} \sum (X_t - F_t)^2 \\ &= \frac{(8,6 - 8,6)^2 + (15,5 - 9,98)^2 + \dots + (11,58 - 302,103017)^2}{21} \\ &= 14,2568042 \end{aligned}$$

$$\begin{aligned} \text{MAPE} &= \frac{\sum_{t=1}^n \left| \frac{X_t - F_t}{X_t} \right|}{n} \times 100\% \\ &= \frac{1}{21} \left(\left| \frac{8,6 - 8,6}{8,6} \right| + \left| \frac{15,5 - 9,98}{15,5} \right| + \dots + \left| \frac{11,58 - 302,103017}{11,58} \right| \right) \times 100\% \\ &= 19,93461782 \end{aligned}$$

The same calculation as in the previous step is done until the parameter alpha (α) = 0.9. Furthermore, the results of the calculation of error values in the form of Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE) are presented for each parameter $\alpha = 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; \text{ and } 0.9$, as shown in Table 3.

Tabel 3. Hasil Perhitungan Nilai Kesalahan (Error)

Parameter	MAD	MSE	MAPE
0.1	2,893146	14,2568042	19,93461782
0.2	2,126049	7,326171304	52,91759
0.3	1,486795	4,302442272	27,96616
0.4	1,190941	3,099114744	18,52039
0.5	1,080331	2,733158358	15,91231
0.6	1,127522	2,884625142	17,379
0.7	1,18544	3,436446365	22,022573
0.8	1,243793	4,352926915	29,6762
0.9	1,342466	5,647443051	40,51845

Table 3 shows the results of the calculation of the error value of each alpha (α) parameter using MAD, MSE, and MAPE measures. The error values obtained are then compared to determine the parameter with the smallest error value as the best parameter. Based on Table 3, it was obtained that the alpha parameter (α) = 0.5 was chosen as the optimal parameter because it had a MAD value of 1.080331, MSE of 2.733158358, and MAPE of 15.91231 which is the smallest value compared to other parameters. The MAPE value of 15.91231 indicates that the model has a good level of accuracy based on the MAPE interpretation criteria presented in Table 4.

Table 4. Range value MAPE

Range MAPE	Remarks
<10 %	Forecasting Model Performance: Very Good
10 - 20 %	Forecasting Model Performance: Good
20 - 50 %	Forecasting Model Performance: Fair
>50 %	Forecasting Model Performance: Poor

The next stage is to forecast the number of poor residents in Metro City based on the selected alpha (α) parameter. Based on the previous results, the MAPE value at $\alpha = 0.5$ is

the smallest compared to other alpha values; therefore, this parameter is chosen as the basis for forecasting. The forecasting of the number of poor residents for the period 2026 to 2030 is conducted using the model

Tahap selanjutnya yaitu meramalkan jumlah penduduk miskin di Kota Metro berdasarkan nilai parameter *Alpha error* terpilih. Dari hasil di atas terlihat bahwa hasil perhitungan MAPE dengan nilai $\alpha = 0.5$ lebih kecil dibandingkan dengan nilai yang $F_{t+m} = a_t + b_t m$, where $a_t = 317,6606451$ and $b_t = 4,241178989$. Berikut ini adalah peramalan periode tahun 2026 sampai dengan tahun 2030.

The following presents the forecasting results for the period 2026 to 2030:

$$F_{t+m} = a_t + b_t (m)$$

1) Forecast for $m = 1$ (year 2026)

$$F_{t+m} = a_t + b_t (m)$$

$$F_{21+1} = 317,6606451 + 4,241178989 (1)$$

$$F_{22} = 317,6606451 + 4,241178989$$

$$F_{22} = 321,9018241$$

2) Forecast for $m = 2$ (year 2027)

$$F_{t+m} = a_t + b_t (m)$$

$$F_{21+2} = 317,6606451 + 4,241178989 (2)$$

$$F_{23} = 317,6606451 + 8,482357978$$

$$F_{23} = 326,1430031$$

3) Forecast for $m = 3$ (year 2028)

$$F_{t+m} = a_t + b_t (m)$$

$$F_{21+3} = 317,6606451 + 4,241178989 (3)$$

$$F_{24} = 317,6606451 + 12,723536967$$

$$F_{24} = 330,3841821$$

4) Forecast for $m = 4$ (year 2029)

$$F_{t+m} = a_t + b_t (m)$$

$$F_{21+4} = 317,6606451 + 4,241178989 (4)$$

$$F_{25} = 317,6606451 + 16,964715956$$

$$F_{25} = 334,6253611$$

5) Forecast for $m = 5$ (year 2030)

$$F_{t+m} = a_t + b_t (m)$$

$$F_{21+5} = 317,6606451 + 4,241178989 (5)$$

$$F_{26} = 317,6606451 + 21,205894945$$

$$F_{26} = 338,8665401$$

Based on the results of the above calculations, the value of the projection results of the number of poor residents in Metro City from 2026 to 2030 is presented in Table 5.

Table 5. Forecasting Results of the DES *Brown Method*

Years	Predictive Results (in thousands)
2026	321,9018241
2027	326,1430031
2028	330,3841821
2029	334,6253611
2030	338,8665401

Based on the data obtained in Table 2, the analysis was carried out using the Double Exponential Smoothing Brown (DES). Data analysis was carried out in a repetitive manner starting from Alpha error (α) = 0.1 with $t = 1, 2, 3, \dots, 21$ to the calculation of Alpha error (α) = 0.9 with $t = 1, 2, 3, \dots, 21$ to determine the value of the constant (at) and the trend coefficient (bt) of each Alpha error (α). After performing data analysis, Table 2 was obtained, after that determined the best Alpha error (α) parameters. The calculation of the most efficient Alpha error (α) is calculated starting from Alpha error (α) = 0.1 to Alpha error (α) = 0.9 and is selected based on the value of the calculation calculated by Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE). The results of the Alpha error (α) parameter analysis can be seen in Table 3, based on the table Alpha error (α) = 0.5 is selected as the best parameter chosen for the calculation of the forecast of the number of poor people in Metro Cities in 2026 to 2030.

The results of this study indicate that the best forecasting performance is achieved using the Double Exponential Smoothing Brown (DES) method. The forecasting results provide an overview of the projected number of poor residents in Metro City for the period 2026–2030. Based on Table 5, the forecast shows an upward trend over the next five periods. This indicates that the number of poor residents in Metro City is projected to increase from 321.90 thousand people in 2026 to 338.87 thousand people in 2030, with an average annual increase of approximately 4.24 thousand people. This trend differs from the historical pattern observed during 2009–2025, which generally showed a declining trend.

The projected increase suggests that, although the number of poor residents in Metro City decreased significantly between 2009 and 2025, future projections indicate a potential rise that needs to be anticipated by the local government. The relatively stable number of poor residents in recent years, ranging between 11–15 thousand people, combined with the long-term trend in historical data, influences the forecasting results. In this study, although historical data exhibit a downward trend, the Double Exponential Smoothing Brown method captures the underlying trend component that indicates a potential increase in future periods. Therefore, these forecasting results serve as an early warning for the Metro City Government to anticipate a possible rise in poverty levels and to prepare more comprehensive poverty alleviation strategies for the 2026–2030 period.

CONCLUSIONS AND SUGGESTIONS

This study applies the Double Exponential Smoothing Brown method to estimate the number of poor residents in Metro City for the 2026–2030 period. The optimal smoothing parameter obtained is $\alpha = 0.5$, with a Mean Absolute Percentage Error (MAPE) of 15.91%, indicating a good level of forecasting accuracy. The results show an increasing trend in the number of poor residents, rising from 321.90 thousand people in 2026 to 338.87 thousand people in 2030, with an average annual increase of approximately 4.24 thousand people. This upward trend serves as an early warning for the Metro City Government to anticipate a potential increase in poverty levels in the coming years. Therefore, it is recommended that the local government utilize these projections as a basis for planning poverty reduction programs and budget allocation for the 2026–2030 period, as well as conducting regular monitoring of contributing factors to poverty. For future research, it is suggested to compare the forecasting results with other methods and to extend the application of this methodology to other development indicators.

Author Contributions

Intan Utami: Conceptualization, methodology, writing-original draft, software, validation. Ana Istiqomah: Data curation, resources, draft preparation. Sangidatus Sholiha: Formal analysis, validation. All authors discussed the results and contributed to the final manuscript.

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Declarations

The authors declare no competing interest.

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