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Poverty Line Forecasting Model in North Sumatera Province Using Double Exponential Smoothing Method

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Abstrak

One of the information that can be used as a consideration in preparing poverty alleviation strategies is data on the existence of poverty rates in the future. The poverty line is a variable for calculating the number of poor people. This study aims to determine the model and predict the poverty line in North Sumatra Province using the Double Exponential Smoothing method from Holt. This study uses time series data and predicts the poverty line for the coming year. In this study, data pattern analysis was carried out where the data pattern shows a trend, which means that the Double Exponential Smoothing Method from Holt is the appropriate method to use. Then the best parameter value was determined where the parameters used were the Alpha (α)and Gamma (γ)with the smallest MAPE (Mean Absolute Percentage Error) value. With the trial and error method, the Alpha parameter value (α)of 0.1 and gamma (γ)of 0.1 and the MAPE value of 2 percent) were obtained. The results of the study showed that this forecasting model has very good performance and the poverty line value continued to increase in the coming year.

1. Introduction

Poverty is a complex multidimensional problem, not only measured by income but also involves the vulnerability of people or groups of people, both men and women, to become poor (Adeyinka & Muhajarine, 2020). To measure poverty, BPS uses the concept of the ability to meet basic needs (basic needs approach)

(FARAFISHA, 2022). With this approach, poverty is seen as an inability from an economic perspective to meet basic food and non-food needs as measured by expenditure. According to BPS, a population is categorized as poor if it h (Ramadhan et al., 2023)as an average per capita expenditure per month below the poverty line (Su et al., 2018). The World Bank measures poverty from creating a good life, namely with an income of US $ 1 per day per capita (Alhindawi et al., 2020). One of the causes of poverty is the uneven distribution of income and low quality of human resources in an area.

Poverty alleviation is the focus of every country, including Indonesia. The Indonesian government has made poverty alleviation a priority in national development. The government has implemented various programs to alleviate poverty. To support these strategies and programs, accurate and precise data and information on poverty are needed. Good poverty rate measurement can be a tool to evaluate government policies in poverty alleviation efforts.

BPS stated that in general, in the period March 2009-March 2021, there was a fluctuation in the poverty rate in North Sumatra both in terms of number and percentage (Fadhilah, 2023). Based on the BPS website of North Sumatra Province, the poverty rate in North Sumatra decreased by 0.18 points to 8.15% from September 2022 to March 2023. This poverty rate is equivalent to 1.24 million people. The poverty line in March 2023 was recorded at IDR 602,999/capita/month (Deng et al., 2021). This data shows a decrease in the poverty rate in North Sumatra Province, but the government still needs to create a strategy so that poverty continues to decrease (Mirdaolivia & Amelia, 2021).

According to BPS, the Poverty Line is a depiction of the minimum amount of rupiah needed to meet minimum basic food needs equivalent to 2,100 kilocalories per capita per day and basic non-food needs (Gustriansyah et al., 2019). The lack of poverty alleviation in a region is partly caused by the lack of information about poverty. Therefore, forecasting methods can be used to determine the state of poverty in the future (Prasetyono & Anggraini, 2021). Forecasting is the knowledge and art of estimating what will happen in the future at the present time (Rabbani et al., 2021). This can be an effort to overcome poverty for a region, especially North Sumatra Province. In this study, the Double Exponential Smoothing Method will be used to predict the Poverty Line in North Sumatra Province (Yu et al., 2021).

The gap in modeling the poverty line in North Sumatra Province using the Double Exponential Smoothing method lies in the limited acquisition in capturing complex economic change patterns. This method relies on historical data patterns to predict future trends, but does not fully consider external factors such as government policies, changes in basic necessities prices, and fluctuating socio-economic conditions. As a result, the resulting predictions can have significant deviations from reality, especially in dynamic and unpredictable economic situations. The main problem in using the Double Exponential Smoothing method to predict the poverty line in North Sumatra is the failure to handle data with drastically changing trends due to external factors. This model tends to work better for data with stable growth patterns, while the poverty line is often affected by economic crises, inflation, and changes in social policies. In addition, the availability and quality of historical data are challenges in themselves, where incomplete or inconsistent data can lead to less accurate prediction results and do not reflect the real conditions of the poor in the area.

The solution of the Double Exponential Smoothing method can be combined with other more adaptive approaches, such as Machine Learning-based models or Bayesian Forecasting, which are better able to capture the influence of external factors in poverty line forecasting. In addition, improving the quality of historical data through more structured data collection and the use of additional variables such as inflation rates, consumer price indexes, and unemployment rates can help improve model accuracy. With this more comprehensive approach, the results of poverty line predictions can be more accurate and used as a better basis for designing poverty alleviation policies in North Sumatra.

Based on the description above, the formulation of the problem in this study is how to determine the model and forecast of the Poverty Line specifically in the province of North Sumatra for the period 2024 to 2026 using the Double Exponential Smoothing Method from Holt (Konita & Rijanto, 2024). The method used in this study is a descriptive method with a quantitative approach where the presentation of data is dominated by numbers and analyzed using a statistical approach method, namely the Double Exponential Smoothing method from Holt. Research related to poverty forecasting with samples of several regions in Indonesia has been conducted using various forecasting methods (Rao et al., 2023). Specifically, this study aims to analyze the Poverty Line forecasting model in North Sumatra Province using the Double Exponential Smoothing forecasting method from Holt.

2. Methods

The method used in this study is a descriptive method, which focuses on solving problems by describing data systematically, factually, and accurately. In addition, this study also applies a quantitative approach, where the data obtained is dominated by numbers and analyzed using statistical methods (Li & Zhang, 2019). One of the statistical methods used in this study is Holt's Double Exponential Smoothing Method, which is a time series forecasting technique that is able to handle data with trends. This method works by giving greater weight to the latest data to increase forecasting accuracy, especially in conditions where data patterns experience gradual changes in trends. One application of the Double Exponential Smoothing Method is in the Poverty Line Forecasting Model in North Sumatra Province. By using this method, the trend of changes in the poverty line can be analyzed more accurately based on historical data, so that the government and policy makers can formulate more effective strategies in overcoming poverty. Forecasting with this method allows the identification of patterns of increases or decreases in the poverty line, which can then be used to design more targeted intervention policies. Therefore, this approach is very relevant in research that aims to understand the socio-economic dynamics in a region quantitatively and based on statistical data.

This study was conducted in North Sumatra Province using secondary data in the form of Poverty Line data for the period 2013-2023. The types of data used in this study consist of time series data and cross-section data, all of which were obtained from the Central Statistics Agency (BPS) of North Sumatra Province. This data reflects the development of poverty levels in the region over the past ten years, so that it can provide a comprehensive picture of trends and patterns of changes in the poverty line from year to year. To analyze and predict the development of the poverty line in North Sumatra Province, this study applies the

Double Exponential Smoothing method. This method was chosen because it is able to capture trend patterns in time series data more accurately, especially when there is a tendency to increase or decrease over a certain period of time. By using this approach, the study aims to produce a forecasting model that can assist in making more targeted policies in an effort to reduce poverty levels in North Sumatra Province.

The research work procedure begins with data collection which is then analyzed using Holt's Double Exponential Smoothing Method. This method is used to predict data trends by considering first and second level smoothing factors, which allows for more accurate detection of change patterns. To measure the accuracy of the forecast results, the Mean Absolute Percentage Error (MAPE) is used, which shows the percentage error of the prediction results. The expected MAPE value is below 10%, which indicates that the model has a high level of accuracy in forecasting. In the context of forecasting the poverty line in North Sumatra Province, the Double Exponential Smoothing method can be the right approach to capture economic and social trend patterns that develop over time. By considering economic change factors, such as inflation and economic growth, this method can help predict the poverty line more precisely. A low MAPE value in this forecast will indicate that the model is able to provide an accurate picture of future poverty trends, so that it can be the basis for making more effective policies in overcoming poverty in the province.

3. Findings and Discussions

3.1 Findings

The forecasting method used in this study is the Double Exponential Smoothing Method from Holt. This method does not use a direct smoothing formula, but smooths the trend value with different parameters from the two parameters in the original series (Mgale et al., 2021). The data in this study uses secondary data obtained from the official website of the Central Statistics Agency (BPS) of North Sumatra Province (https://sumut.bps.go.id). The data used is the Poverty Line data of North Sumatra Province for 2013–2023. The data is shown in Table 1.

Table 1. Poverty Line in North Sumatra 2013-2023

Year	Poverty line (in Rupiah)
2013	311,063
2014	318,398
2015	347,953
2016	388,156
2017	411,345
2018	435,970
2019	466,122
2020	502,904
2021	525,756
2022	561,004
2023	602,999

The data in Table 1 is a recapitulation and average value of the poverty line from 25 districts and 8 cities in North Sumatra from 2013 to 2023. From the data

used, it can be seen that the data shows a trend pattern so that the Double Exponential Smoothing Method is expected to be suitable for the analysis of this research (El Hikmah, 2023).

Holt 's Double Exponential Smoothing forecasting method begins with a data plot to identify data patterns. The goal of this stage is to determine whether it is cyclical, trend, seasonal, random, or stationary. To draw a time series data pattern from the data obtained, the Poverty Line data in North Sumatra for 2013–2023 is made in the form of a plot and the results are presented in Figure 1.

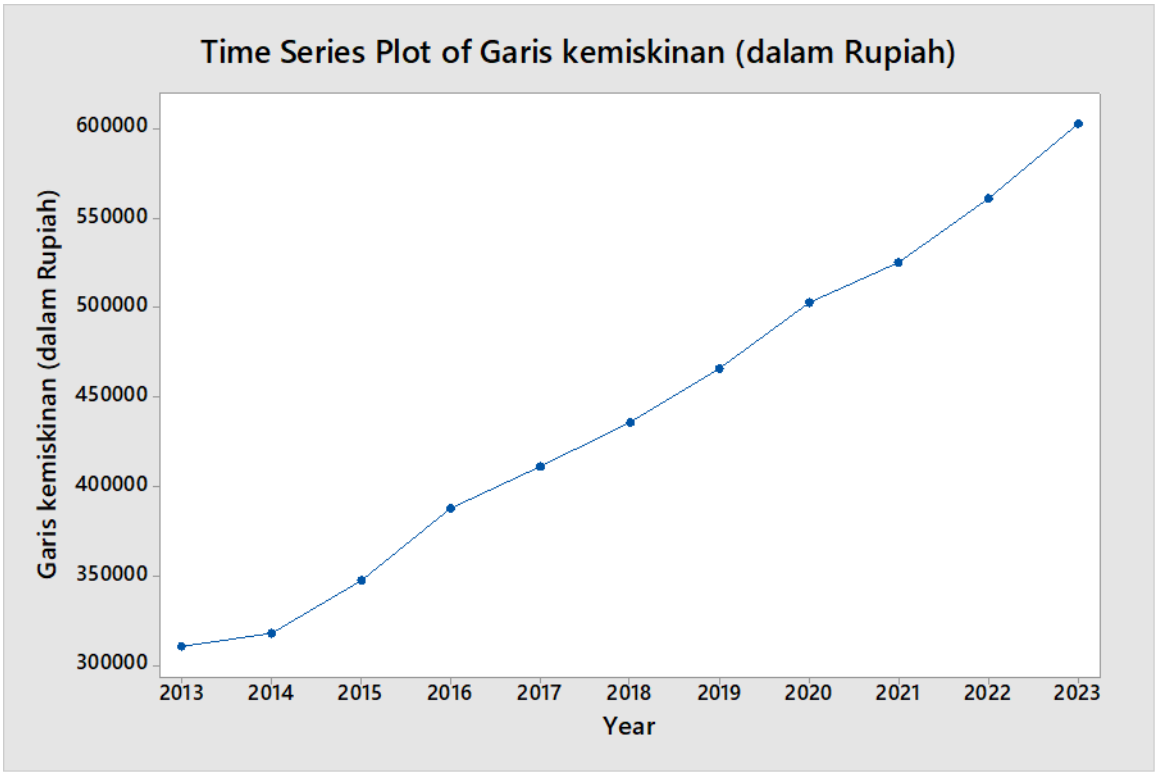

Figure 1. Time Series of Poverty Line Plot

Figure 1 shows that the Poverty Line pattern shows that the data pattern is a linear trend. Therefore, Brown 's Double Exponential Smoothing method and Holt 's Double Exponential Smoothing method are the best and most appropriate to use. The researcher chose to use Holt 's Double Exponential Smoothing method, which uses two smoothing parameters alpha (α) and gamma (γ) to smooth the trend data.

The second step is the estimation or determination of the alpha (α) and gamma (γ) parameters. The values of these parameters range between 0 and 1. The alpha (α) parameter is used to smooth the original data periodically while smoothing the trend. The value of this parameter determines the difference between the estimated value and the actual data. An alpha value close to 1 indicates more weight is given to the most recent data, resulting in a smaller smoothing effect. Conversely, an alpha value close to 0 indicates less response to the most recent data, resulting in a larger smoothing effect (Cheng et al., 2019).

Due to the presence of a narrowed set of alpha (α) and gamma (γ) choices, the Double Exponential Smoothing method is usually considered an easier method to use. However, in practice, the determination of alpha (α) and gamma (γ)

parameters only takes a limited range of values. The gamma (γ) parameter is used to reduce the slight uncertainty in the data generated during the estimation (Banat & Wirananda, 2024). The ideal values of alpha (α) and gamma (γ) parameters were found using the trial-and-error method, which produced the smallest MAPE value, which was 2%. The results of data processing using the computer program, Minitab, showed that the value of alpha = 0.1 and gamma 0.1, each of which produced the smallest MAPE value, which was 2 percent. For more details, see Table 2.

Table 2. Measurement Parameters

A	γ	MAP	MAD	MSD
0.1	0.1	2	6707	64500663
0.2	0.1	2	7131	70758472
0.3	0.1	2	7410	75798984
0.4	0.1	2	7615	80195303
0.5	0.1	2	7801	84740837
0.6	0.1	2	7992	89964575
0.7	0.1	2	8182	96075932
0.8	0.1	2	8369	103080798
0.9	0.1	2	8604	110898101

The MAPE value is a measure of relative accuracy to calculate the percentage deviation of the forecast results, which shows that the MAPE value produces a percentage error of the forecast results in this study. Next, table 1 is used to proceed to the third step, namely the processing of Poverty Line data. The results of data processing that produce forecast numbers can be seen in table 3 below.

Table 3. Results of Poverty Line Data Processing Using the Holt's Double Exponential Smoothing Method (in Rupiah) 2013-2023

Year	Poverty line (in Rupiah)	Smooth	Predict	Difference
2013	311063	296833.5	295252.5	15810.5455
2014	318398	325705	326516.9	-8118.9418
2015	347953	354571.9	355307.3	-7354.2909
2016	388156	384506.1	384100.6	4055.43775
2017	411345	413802.3	414075.4	-2730.3608
2018	435970	442606.8	443344.3	-7374.2759
2019	466122	471479.8	472075.1	-5953.0567
2020	502904	501090	500888.4	2015.57112
2021	525756	530042.5	530518.8	-4762.8196
2022	561004	559581.8	559423.7	1580.25705
2023	602999	590380.8	588978.8	14020.2234

Table 3 shows the results of the Poverty Line forecasting processing from 2013 to 2023. The forecast approach value shows an increasing *trend* in each period, and the accuracy of the forecast value can be seen from the forecast value that is close to the actual value. The forecast value closest to the actual value,

which is IDR 1580, is in 2022, while the forecast value that is the furthest from the actual value is in 2013, where the *error value* or wrong calculation is IDR 15810 (Latumahina et al., 2021). Furthermore, the forecast values for the future, namely the estimates for 2024 – 2026, are shown in Table 4 below.

Table 4. *Forecast Results* Using *Holt's Double Exponential Smoothing Method* (in Rupiah) 2024-2026

Year	Forecast (Rupiah)	Upper	Lower
2024	619918	636350	603486
2025	649455	665971	632940
2026	678992	695596	662389

Figure 2 shows the next step to create a Poverty Line forecast plot, which shows the annual increase in the Poverty Line due to consumption patterns and increases in the prices of basic necessities (Nuraisyah, 2022). The forecast values for the coming years are shown in Table 4.

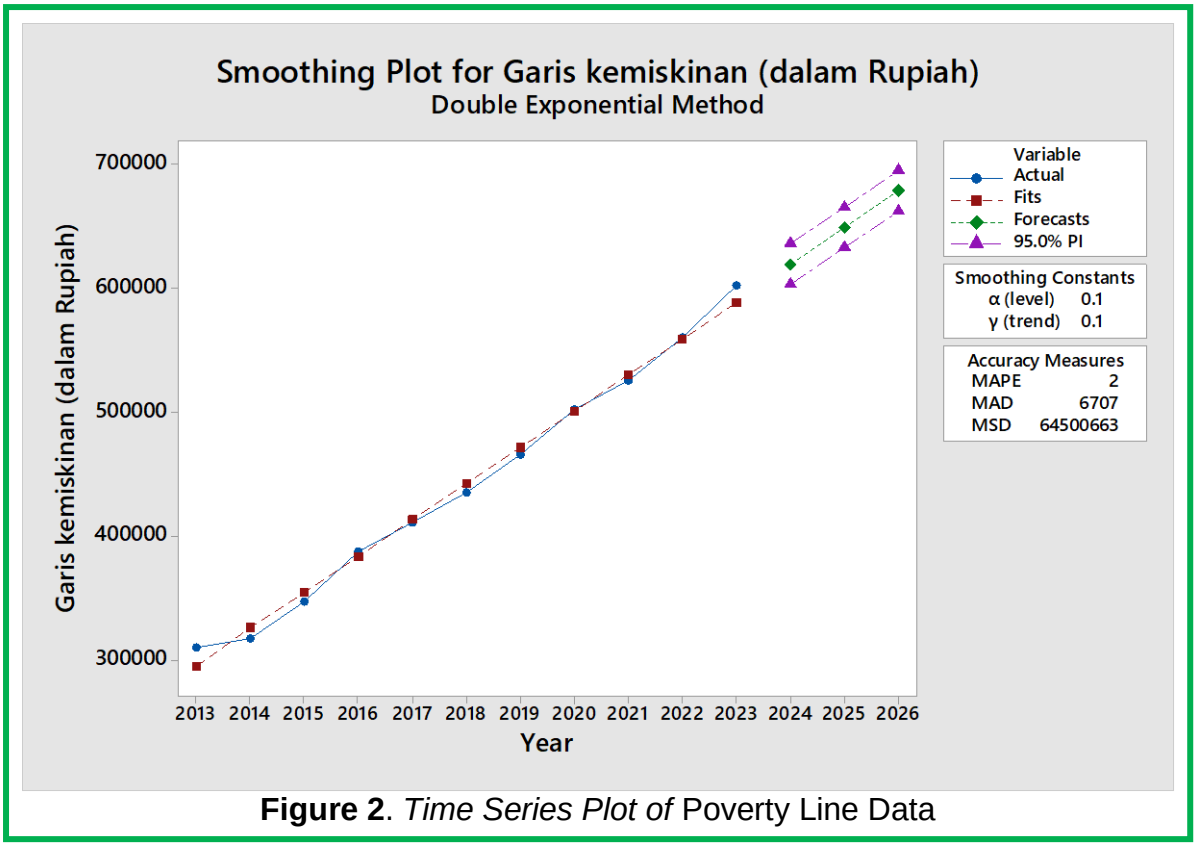

Figure 2. *Time Series Plot of* Poverty Line Data

Figure 2 shows the *actual, fits, forecasts,* and 95% PI variables. Alpha (α) 0.1 and Gamma (γ) 0.1 reflect smoothing constants. In addition, *the accuracy measures* MAPE, MAD, and MSD are presented. MAPE is 2 percent accurate, MAD is 6707, and MSD is 64500663. A model performs well if the MAPE value is less than 10% and between 10% and 20% (Zhu et al., 2018).

3.2 Discussions

This study uses Holt's Double Exponential Smoothing forecasting method to analyze the Poverty Line data in North Sumatra Province during the period 2013-

2023. Based on data obtained from the Central Statistics Agency (BPS), there is a linear trend pattern in the development of the poverty line each year. Therefore, the Holt method was chosen because of its ability to handle data with clear trends. The alpha (α) and gamma (γ) parameters in this method are determined through a trial and error process, with the best values α = 0.1 and γ = 0.1, which produces a Mean Absolute Percentage Error (MAPE) value of 2%. This low MAPE value indicates that the forecasting method used has a high level of accuracy in predicting the development of the poverty line.

The results of the analysis show that the poverty line in North Sumatra has increased every year, caused by factors such as community consumption patterns, government economic policies, and increases in the price of basic necessities. Historical data shows that the poverty line increased from IDR 311,063 in 2013 to IDR 602,999 in 2023. The forecasting process produced predictions for 2024-2026, which showed a continuous upward trend. The estimated poverty line in 2024 is estimated to reach IDR 619,918, while in 2026 it is predicted to reach IDR 678,992. This shows that the level of community welfare is unlikely to experience significant improvement if the factors causing poverty are not addressed effectively. In the model validation process, it was found that the smallest forecast error occurred in 2022, with a difference of only IDR 1,580 between the predicted value and the actual value. Conversely, the largest error occurred in 2013 with a difference of IDR 15,810. The MAPE value of 2% indicates that this method can provide fairly accurate prediction results. Thus, the Holt's Double Exponential Smoothing model can be used as a tool in planning social and economic policies to address poverty issues. The accuracy of this model is also strengthened by the Mean Absolute Deviation (MAD) value of 6,707 and the Mean Squared Deviation (MSD) of 64,500,663, which indicates a relatively small error rate.

The results of this study, it can be concluded that the poverty line in North Sumatra has experienced a consistent increasing trend, and the Holt's Double Exponential Smoothing method has proven effective in predicting its development. This finding has important implications for the formulation of government policies in overcoming poverty, such as controlling inflation, subsidizing basic necessities, and community economic empowerment programs. By utilizing the results of this forecast, it is hoped that the government can take more appropriate steps in formulating poverty alleviation strategies, both in the short and long term.

Analysis of the Poverty Line forecasting model, which has a data pattern with a linear *trend.* This shows that *Holt* 's *Double Exponential Smoothing method* is the right method to use. The ideal parameters produced through the *trial and error method* are alpha = 0.1 and gamma = 0.1, with a MAPE value of 2%. The MAPE value shows a forecast error percentage of 2%, which shows that this forecasting model has very good performance if the MAPE value is below 10%. The data pattern shows a linear trend, and the poverty line value for the coming year continues to increase every year (Dharavath & Khosla, 2019). Community consumption patterns, government economic policies, and increases in the prices of basic necessities are some of the factors that affect the increase in the Poverty Line (Toan & Truong, 2021). Because it produces a forecast error of 2% according to the MAPE value, the forecasting model is expected to be used as a tool to assist the government and other stakeholders in planning and policies to reduce poverty in both the short and long term (de Arruda Silva et al., 2020).

4. Conclusion

Poverty line forecasting plays an important role in analyzing economic and social trends that affect people's welfare. With accurate predictions, the government and stakeholders can formulate more effective policies to overcome poverty and anticipate various factors that can increase the poverty line. In addition, this forecast can also help in budget allocation, determining social assistance programs, and evaluating the effectiveness of policies that have been implemented. Thus, poverty alleviation strategies can be more focused and in accordance with projected conditions. The results of the study showed that the model used in poverty line forecasting performed very well with a very small deviation of less than 10 percent. This indicates that the model has a high level of accuracy in predicting the poverty line in the future. The reliability of this model allows policy makers to be more confident in taking strategic steps based on existing data. With an accurate model, preventive measures against increasing poverty can be taken earlier, so that vulnerable communities can immediately get the necessary assistance.

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