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A Comparison of Simple and Holt's Exponential Smoothing Method in Forecasting the Poverty Line in Riau

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ABSTRACT: *Riau is one of the provinces in Indonesia. According to the data published by the Central Statistics Agency (BPS), the poverty rate in Riau for September 2022 stands at 6.84%. There has been a 0.06%-point rise in comparison to March 2022. In order to mitigate poverty in the region of Riau, it is imperative to develop a methodology for forecasting future poverty levels. One approach involves the utilization of poverty line forecasts. This study aims to identify an improved forecasting approach that can yield precise forecasting outcomes based on available data. The employed models consist of simple exponential smoothing (SES) and Holt's exponential smoothing (HES). A comparative analysis of the two models reveals that Holt's Exponential Smoothing method yields more precise predictions of poverty-level data in Riau Province. Specifically, when the parameter value alpha is set to 1 and a beta value of 0.6508, the resulting Mean Absolute Percentage Error (MAPE) is calculated to be 2.747%. It contrasts with the Simple Exponential Smoothing method, which yields a MAPE value of 5.884%. Using Holt's Exponential Smoothing approach in the forecasting model can serve as a valuable instrument for the Government in Riau Province to facilitate effective planning and policy formulation in the context of poverty alleviation.*

Keywords: *Poverty Line, Simple Exponential Smooting method, Holt's Exponential Smooting method, Forecasting*

I. INTRODUCTION

Indonesia is a nation comprised of several islands. Indonesia, boasting a population of over 230 million individuals, ranks as the fourth most populous country globally. This substantial population size is a crucial determinant for the notable birth rate observed among the Indonesian populace. If the high population growth is not effectively managed, it might lead to adverse consequences. Indonesia experiences various issues, including crime, economic challenges, and food scarcity, which can be attributed to insufficient economic conditions, including poverty. Poverty can be attributed to the incapacity to meet fundamental human necessities, including but not limited to food, education, healthcare, and shelter. According to the World Bank, poverty is characterized by a lack of adequate human living standards, encompassing physical and social dimensions.

The Central Statistics Agency (BPS) collected the initial data collection and computation of poverty rates in Indonesia in 1984. The primary dataset employed in this study is the Consumption Module of the National Socio-Economic Survey (Susenas). Subsequently, at regular intervals of three years, the Bureau of Public Statistics (BPS) has consistently disseminated data about the quantity and proportion of impoverished

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individuals who have been assisted in both urban and rural regions. According to Kotze (Hikmat, 2004: 6), individuals with little financial means possess a comparatively favorable capacity to acquire resources using available possibilities. According to Supriatna (1997:90), poverty is a constrained circumstance that arises independent of the affected individual's desires.

Riau is one of the provinces in Indonesia. According to the data published by the Central Statistics Agency (BPS), the poverty rate in Riau during September 2022 stood at 6.84%. There has been a 0.06%-point rise compared to the data observed in March 2022.

II. MATERIAL AND METHODS

2.1. Description of the context and material

The accurate prediction values of other investigations using the Holt's Exponential Smoothing approach have piqued the author's interest in conducting such experiments. Hence, the author intends to employ the exponential smoothing method to forecast the extent of poverty in Riau Province. In addition, this study will likely assist national and regional governments in devising strategies to address the issue of poverty in the forthcoming years, drawing upon data from prior years.

One contributing factor is the insufficient initiatives to address poverty in a particular region, primarily stemming from a dearth of knowledge about poverty-related issues. Hence, it is imperative to establish a methodology for forecasting prospective poverty levels to mitigate poverty within a given region. Given the context above, it is imperative to research future projections of the Poverty Line. This study serves as a preemptive measure for the government in addressing the issue of poverty since the Poverty Line serves as a metric for quantifying the population of individuals living in poverty. The objective of this study is to forecast the poverty line by employing the Holt's Exponential Smoothing Method. The employed methodology pertains to data exhibiting a linear trend, wherein a straight line is constructed based on observed patterns within a specific temporal interval. Trend models are commonly employed to make long-term predictions.

Prediction is the discipline encompassing both the artistic and scientific aspects of forecasting forthcoming occurrences. Predictions sometimes entail utilizing historical data and extrapolating it into the future using a specific mathematical model. This prediction has the potential to be subjective or based on intuition.

The employed forecasting model utilizes the Holt's Exponential Smoothing method. The initial stage in employing the Holt's Exponential Smoothing method for prediction is the preliminary task of graphically representing the data to discern any discernible patterns within the dataset. The subsequent stage involves estimating or determining parameters, specifically alpha (α) and beta (β). The alpha parameter (α) regularly applies a smoothing method to the original data to smooth out tendencies. This approach employs two parameters, namely alpha and beta. The analysis yielded optimal parameter settings, with alpha = 1 and beta = 0.650802, resulting in the lowest Mean Absolute Percentage Error (MAPE) values.

The subsequent phase involves forecasting data for the upcoming year. The predicted outcomes of the Poverty Line are expected to exhibit a persistent upward trend due to alterations in consumption patterns and escalations in the costs associated with necessities. Projection models serve as a valuable instrument for governments and other stakeholders in formulating strategic plans and policies to mitigate poverty in immediate and extended timeframes. Indeed, extensive research has been conducted on poverty prediction, explicitly focusing on the comparative analysis of double and triple-exponential smoothing methods for forecasting the poverty rate of Yahukimo Regency between 2025 and 2030. However, this study will employ an alternative approach. The objective of this study is to utilize Simple Exponential Smoothing and Holt's Exponential Smoothing method to forecast the Poverty Line in Riau. This forecast will be valuable for data analysis and strategic planning in poverty alleviation initiatives. Additionally, the performance of the Poverty Line projection model, employing the Holt's Exponential Smoothing, will be evaluated.

2.2 Evaluation Methods

The present work employs a descriptive method that centers on resolving problems. The author employed a quantitative research methodology in this study. The quantitative methodology employed in this study primarily involves using numerical data, with statistical analysis serving as the primary means of data interpretation. This study employed the Holt's Exponential Smoothing method within a statistical framework. This methodology is employed in cases where the data exhibits a discernible pattern or tendency. Exponential smoothing with trend operates similarly to basic smoothing, with the distinction that two components, namely the level and trend, are updated at each period. The collected data is regularly updated after each time interval. The observed pattern is a refined approximation of the mean rate of increase during the concluding interval.

2.2.1 Simple Exponential Smoothing (SES)

This model is typically applied to data sets that lack discernible trends or seasonal patterns. The time series under consideration is represented by the sequence $X_1, X_2, X_3, \cdots, X_n$. Simple Exponential Smoothing (SES) formula can be generally expressed as follows:

$$\hat{X}_{i+1} = \alpha X_i + (1-\alpha)\hat{X}_i$$

With

$\hat{X}_{i+1}$ = The estimated value for a specific period, $i + 1$, Smoothing constant with a value between 0 and 1

α = Smooth of constants with values between 0 and 1

X_i = Actual value of the series known for a specific period i

$\hat{X}_i$ = Estimated value of variable Y during interval i

2.2.2 Holt's Exponential Smoothing (HES)

This model is typically applied to datasets exhibiting discernible trends but lacking seasonal patterns. For instance, let $X_1, X_2, X_3, \cdots, X_n$ represent a collection of observations inside a time series. As described below, the HES formula can be derived using two smoothing constants.

$$B_t = \alpha X_t + (1-\alpha)(B_{t-1} + T_{t-1}) \qquad (0 < \alpha < 1; \quad t = 1,2,\cdots,n)$$

$$T_t = \beta(B_t - B_{t-1}) + (1-\beta)T_{t-1} \qquad (0 < \beta < 1; \quad t = 1,2,\cdots,n)$$

Thus, the HES formula is as follows:

$$\hat{X}_{t+p} = B_t + pT_t\hat{X}_{i+p} = B_t + pT_t \qquad (p = 1,2,3,\cdots,k)$$

$\hat{X}_{t+p}$ = Forecasting result to p

p = The total period of the future prediction

B_t = Forecasts in the period t

T_t = Trend in the period t

2.2.3 Error Metrics

The optimal model can be determined using error metrics such as the mean absolute percentage error (MAPE) and the mean absolute deviation (MAD).

$$MAD = \frac{1}{n}\sum_{t=1}^{n}\left|X_t - \widehat{X_t}\right|$$

$$MAPE = \frac{100}{n} \sum_{t=o}^{n} \frac{|X_t - \widehat{X_t}|}{X_t}$$

III. RESULT

This study employed two exponential smoothing models to demonstrate the poverty line in Riau from 2010 to 2022. The data is presented in Table 1.

Year	Poverty Line (IDR)
2010	301,190
2011	296,379
2012	310,603
2013	350,129
2014	379,223
2015	399,211
2016	426,001
2017	456,493
2018	479,944
2019	500,612
2020	544,057
2021	565,937
2022	605,912

Source: BPS Riau Province

Table 1. Poverty Line in Riau 2010 – 2017

The employed models consist of simple exponential smoothing (SES) and Holt's exponential smoothing (HES), as depicted in Figure 1 and Figure 2, respectively.

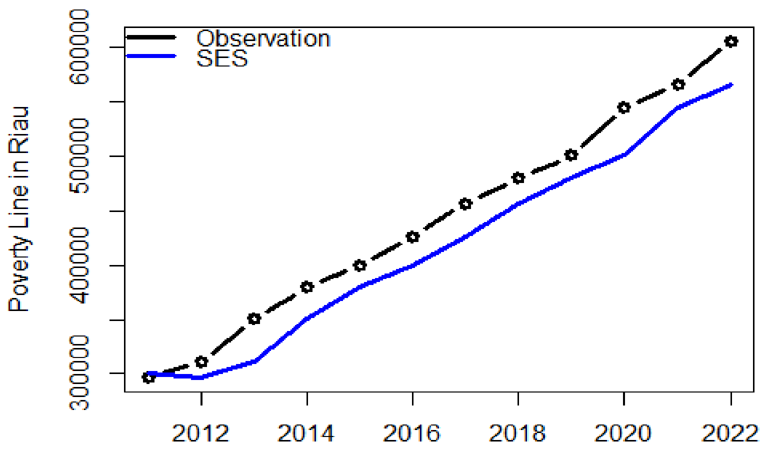

Figure 1. Graph of SES poverty line in Riau 2010-2022

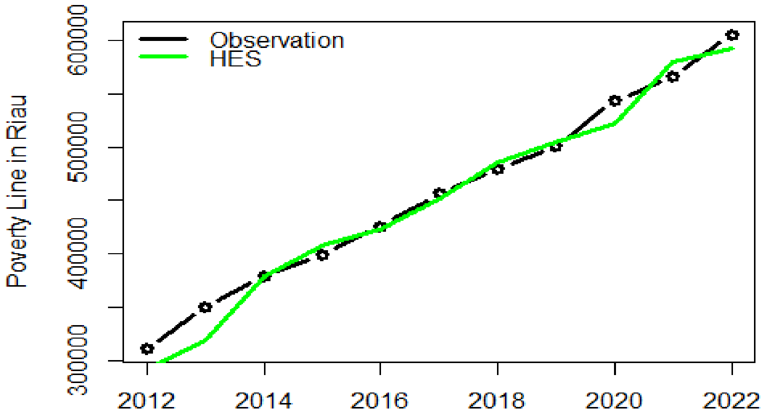

Figure 2. Graph of HES poverty line in Riau 2010-2022

The graphical representations in Figures 1 and 2 show that the curve derived from the SES model is depicted in blue, but the curve resulting from the HES model is represented in green. There is no denying the similarity between the HES model's generated curve and the observed data graph.

The optimal approach can also be assessed based on the mistake rate. The strategy employed is considered more effective when the error value is smaller. According to the data presented in Figure 4, it can be observed that the HES model exhibits comparatively reduced error rates in terms of Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE) when compared to the SES model.

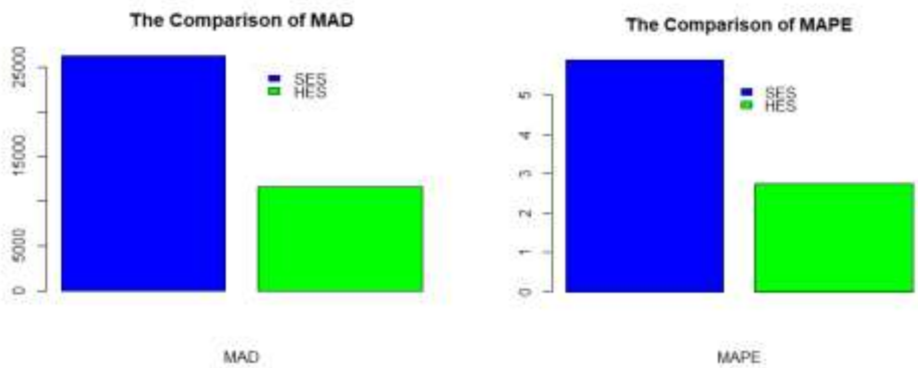

Figure 4. Comparison of MAD and MAPE from SES and HES models

Table 2 shows the values of Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE).

Model	Comparison of model errors	
	MAD	MAPE
SES	26197.02	5.883921
HES	11607.11	2.747279

Table 2. Values of MAD and MAPE from SES and HES models

The HES model is more suitable for predicting the poverty line in Riau based on a comparison of the Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE) metrics. Table 3 presents the outcomes of data processing employing the HES methodology, wherein the parameters alpha = 1 and beta = 0.65802, respectively, span from 2010 to 2022.

Year	Poverty Line	Forecasting (α=1, β=0.6508)
2010	301,190	
2011	296,379	
2012	310,603	296,379
2013	350,129	310,603
2014	379,223	350,129
2015	399,211	379,223
2016	426,001	399,211
2017	456,493	426,001
2018	479,944	456,493
2019	500,612	479,944
2020	544,057	500,612
2021	565,937	544,057
2022	605,912	565,937

Table 3. Data processing results using HES, 2010-2022

The predicted results for the subsequent five-year period are presented in Table 4.

Year	Forecasting
2023	641,297
2024	676,682
2025	712,067
2026	747,452
2027	782,837

Table 4. Poverty line forecasting results using HES, 2023-2027

Figure 5 shows the forecast graph derived from the HES model.

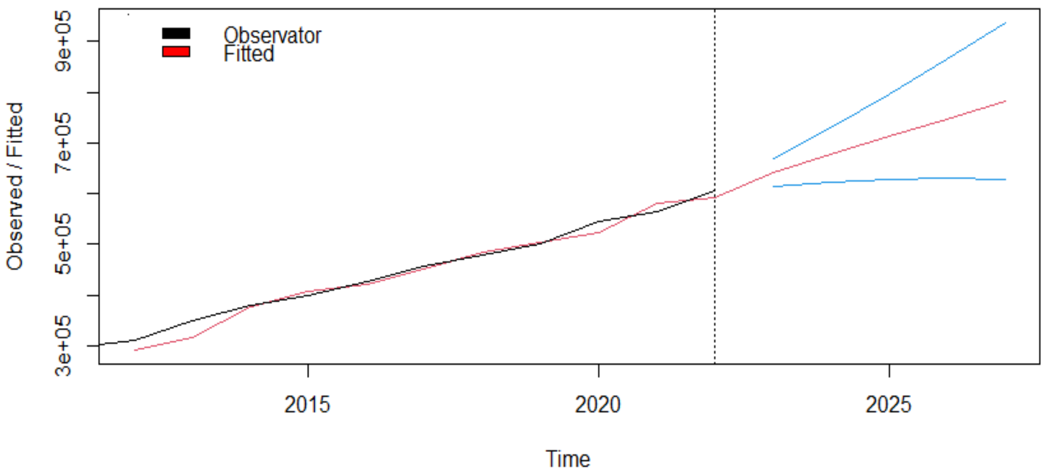

Figure 5. Graph of poverty line forecasting using HES, 2010-2027

According to the data presented in Table 4 and Figure 5, it is evident that the projected estimates for the poverty line throughout the subsequent five years exhibit a consistent annual increase.

IV. DISCUSSION

The present study examines the poverty line forecasting model and concludes that the dataset exhibits a linear trend. Consequently, Holt's Exponential Smoothing approach is deemed very appropriate for implementation. The trial-and-error method yielded optimal settings: an alpha value of 1 and a beta value of 0.6508. These values produced a mean absolute percentage error (MAPE) of 2.747%. The Mean Absolute Percentage Error (MAPE) result indicates a predicted error percentage of 2,747%.

This forecasting model exhibits strong performance since the MAPE number is below 10%. Consequently, the forecasting model applied to this dataset is deemed suitable for long-term utilization. The projected value of the Poverty Line in the upcoming year demonstrates a consistent annual increase, with a discernible linear trend in the data pattern. Several factors contribute to the extent of the rise in the poverty threshold, including individuals' spending patterns, the significant inflation rate resulting from price escalations, particularly for essential commodities, and the influence of governmental economic policies. The potential utilization of this forecasting model as a tool for the Government in Riau Province is anticipated to aid in formulating effective strategies and policies for poverty reduction.

V. CONCLUSION

Holt's Exponential Smoothing method with the parameter value alpha = 1 and beta = 0.6508 yields a MAPE value of 2.747%, whereas the Simple Exponential Smoothing method yields a MAPE value of 5.887% when predicting poverty level data in Riau Province. Holt's Exponential Smoothing method is more accurate with a MAPE value of 2,747%, where the MAPE value indicates a forecasting error percentage of less than 10%; therefore, this forecasting model has excellent performance and can be used over the long term. According to projections, the poverty rate in Riau Province will increase between 2023 and 2027. The Riau Province government can utilize this forecasting model employing Holt's Exponential Smoothing for poverty alleviation planning and policy.

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