

Poverty Estimation in Padang Pariaman Regency Using Holt Winters Exponential Smoothing

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Abstract— Poverty is a multidimensional problem faced by central and local governments, the impact of poverty covers various aspects. Padang Pariaman Regency through the Social Service for Women Empowerment and Child Protection (DINSOS P3A), one of which is the fifth mission to improve the welfare of the community by poverty alleviation. In this research, researchers used the time series method with the Holt Winters Exponential Smoothing model to predict the level of poverty in Padang Pariaman Regency start from 2021 to 2030. The dataset comes from the Central Bureau of Statistics (BPS), West Sumatra. The research process consists of four main stages, called training data input, model identification, model selection and error checking. The analysis showed that the Holt Winters Multiplicative Seasonal model got the best score with $\alpha = 0.63$ RSME = 1.55 and MSE = 2.4025. Holt Winters Multiplicative Seasonal has the smallest error rate compared to Holt-Winters-No Seasonal or Holt-Winters Additive Seasonal. The results of this research indicated that the poverty rate in Padang Pariaman Regency for the next 10 (ten) years will show a downward trend. This research can help the P3A Social department Padang Pariaman Regency in determining the right policies in the future and become an evaluation material for existing policies.

Keywords— Holt Winters, Exponential Smoothing, Estimation Multiplicative Seasonal.

I. INTRODUCTION

Poverty is a multidimensional problem faced by central and local governments, the impact of poverty, such as social, economic, legal, cultural etc. The government has made several strategic policies to alleviate poverty from year to year in a systematic and sustainable manner, it is hoped that it can reduce the level of poverty, so that all citizens can live a decent and sufficient life.

The Government of Padang Pariaman Regency, especially the Social Service for Women Empowerment and Child Protection (the P3A Social department), in accordance with one of its fifth missions is to improve community welfare by poverty alleviation. So, one important aspect to support these efforts requires the availability of accurate poverty data for further processing.

According to BPS data from West Sumatra Province, the number of poverty people in Padang Pariaman Regency for 21 years from 2000 to 2020 there was a significant decrease, it was recorded that in 2000 the number of poverty people was 43,800 people, in 2001 there was an increase of 71,400 (33.38%), then in 2004 there was a decrease in the number of poverty people by 47,000 people, then there was an increase again in 2006, in 2007-2009 the number of poverty people decreased beyond the psychological limit, so that the number

of poverty people in 2009 was 45,200, the data showed that In the span of 21 (twenty one) years there has been an improvement in people's lives, therefore estimation is important enough to determine future conditions with historical data trends of the past so that appropriate planning strategies can be formulated.

Research on estimation poverty lines using the same method has been carried out in West Java Province using Double Exponential Smoothing but the error results are still high above 3%, so the researchers tried to use several Holt Winters methods to produce better estimation results, thus helping Dinsos P3A Padang Pariaman Regency to estimate the poverty in 2021 to 2030.

II. LITERATURE REVIEW

Literature review is used as a theoretical basis for research that maximizes the process in this research

A. Poverty

Poverty is an economic inability to meet basic food and non-food needs as measured in terms of expenditure. The poverty is people who have an average monthly expenditure below the poverty line, while the poverty is people with an average monthly expenditure below the poverty line. Poverty is also a complex problem regarding welfare which is influenced by various factors such as unemployment, health, education, access to goods and services, geography and the environment.

Padang Pariaman Regency is one of the districts in the province of West Sumatra, with an area of 1,332.51 (square kilometers) and a total population of 430,626 (people), the poverty in the region are 28,980 (6.95%) in 2020. One of them is the mission of Padang Pariaman regency is "Improving people's welfare through poverty alleviation". The P3A Office is an agency under the Padang Pariaman Regency that is tasked with carrying out the main tasks of regional government in the social, women's empowerment and child protection sectors.

B. Estimation

Estimation is a calculation analysis technique carried out with both qualitative and quantitative approaches that predict future events based on past reference data.

Time Series is a estimation method based on a certain time sequence to predict future events based on previous data. The time series method is used for data that has a recurring / seasonal pattern.

Seasonal data estimation continues to be developed, one of is the Holt-Winters exponential smoothing method. In this research, researchers used the Holt-Winters method for estimation.

The Holt-Winters method itself was developed by Holt (1957) and Winters (1960) and better known as the Winters method, this method is a model capable of handling data that has elements of trends and seasonality. Holt-Brown himself was the first character to use exponential smoothing in 1959, known as brown.

Based on the seasonal type, Holt Winters exponential smoothing is divided into 2 types, namely the Multiplicative seasonal model and the additive seasonal model. The difference lies in the data pattern, where the multiplicative seasonal model has a fluctuating seasonal variation data pattern, while the additive seasonal model has a seasonal data pattern. Here's an example of Figure 1 Multiplicative seasonal model and additive seasonal model.

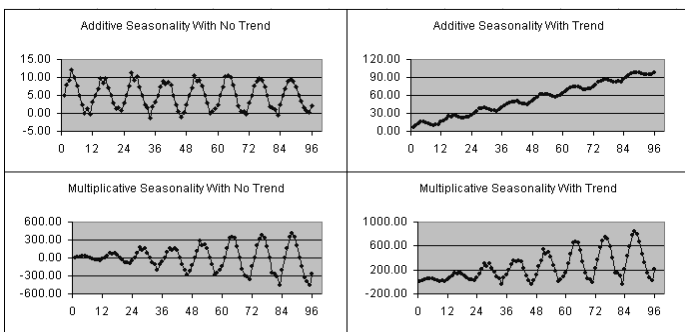


Fig. 1. Comparison of Seasonal Data Additive, Multiplicative

In Figure 1, it can be seen that the Additive pattern shows that the data movement is relatively constant with a trend or no trend, while the multiplicative graph is relatively fluctuating, a decrease and an increase.

The following is the equation of the triple exponential smoothing with the Multiplicative seasonal model and the additive seasonal model

1. Multiplicative seasonal model

a. Level Estimation

$$l_t = \alpha \left(\frac{A_t}{S_{t-p}} \right) + (1 - \alpha)(F_{t-1} - T_{t-1})$$

b. Trend Estimation

$$T_t = \beta (F_t - F_{t-1}) + (1 - \beta)T_{t-1}$$

c. Seasonal Factor Estimation

$$S_t = \gamma \left(\frac{A_t}{F_t} \right) + (1 - \gamma)S_{t-p}$$

d. For doing estimation

$$F_{t+1} = \alpha Y_t + (1 - \alpha)F_t$$

A_t = Actual Data

l_t = Estimation of The level

T_t = Estimation of The Trend

S_t = Estimation of The Seasonal Factor

F_{t+1} = For doing Estimation

2. Additive seasonal model

a. Level Estimation

$$l_t = \alpha(A_t - S_{t-p}) + (1 - \alpha)(F_{t-1} - T_{t-1})$$

b. Trend Estimation

$$T_t = \beta (F_t - F_{t-1}) + (1 - \beta)T_{t-1}$$

c. Seasonal Factor Estimation

$$S_t = \gamma(A_t - F_t) + (1 - \gamma)S_{t-p}$$

d. For doing estimation

$$F_{t+1} = \alpha Y_t + (1 - \alpha)F_t$$

A_t = Actual Data

l_t = Estimation of The level

T_t = Estimation of The Trend

S_t = Estimation of The Seasonal Factor

F_{t+1} = For doing Estimation

C. Accuracy of Estimation Methods

The accuracy of the estimation method is used to assess the extent to which the model that has been made is close to the actual existing data, by comparing the predicted value with the actual value. The estimated error notation (deviation) can be seen as follows:

Estimation error = actual demand - estimated value

There are three methods used in evaluating estimation errors, namely:

1. Mean Squared Error (MSE)

MSE is a method for evaluating estimation by squaring each error, then adding and adding to the number of observations. The method produces moderate errors which are possibly better for the following:

$$MSE = \sum \frac{(Y' - Y)^2}{n}$$

Y' = Prediction Value

Y = Actual Value

n = Total of Data

2. Mean Absolute Error (MAE)

RMSE is a way to evaluate linear regression models by measuring the accuracy of the estimated results of a model. RMSE is calculated by squaring the error, the RMSE formula is as follows:

$$MAE = \sum \frac{|Y' - Y|}{n}$$

Y' = Prediction Value

Y = Actual Value

n = Total of Data

3. Root Mean Square Error (RMSE)

RMSE is a way to evaluate linear regression models by measuring the accuracy of the estimated results of a model. RMSE is calculated by squaring the error, the RMSE formula is as follows:

$$RMSE = \left(\frac{\sum (y_i - \hat{y}_i)^2}{n} \right)^{1/2}$$

RMSE = root mean square error

y = the value of the observation result

\hat{y} = Prediction result of value

i = sequence of data in the database

n = Total of data

III. RESEARCH METHOD

The research was carried out through the planning,

modeling and implementation stages as shown in the following figure:

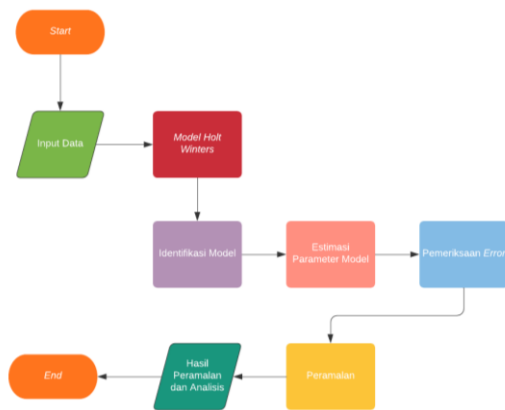


Fig. 1. Research Method

Research Figure 2 describes the research stages as follows:

1. *Input the research dataset*

At this stage, the dataset that the researcher uses is secondary data from the Central Statistics Agency (BPS) website (<https://www.sumbar.bps.go.id/>) which is poverty data in Padang Pariaman Regency per year starting from the 2000 period until 2020.

2. *Model Identification*

Identification of the appropriate Holt-Winters model must pay attention to the refinement method, determine the alpha, beta and cycle for seasonal parameters.

3. *Model Parameters*

In the stage of choosing the right method for model testing, model testing is carried out by entering numbers in the α (mean) and β (trend) columns, provided that both columns must be entered with α values with $0 \geq \alpha \leq 1$

4. *Error Checking*

The resulting pre-application results are measured to determine the level of error using the MAPE (Mean Absolute Percentage Error) method and the RMSE (Root Mean Sum Error) value.

5. *Estimation and analysis*

Estimation and analysis At this stage the model displays estimation results based on actual data on the poverty rate in Padang Pariaman Regency for the next 10 years. The estimated results are in the form of a recommendation to the Padang Pariaman Regency government.

IV. RESEARCH RESULT AND DISCUSSION

A. *Estimation of Model Parameters*

The following is table 1 comparing some of the Holt Winters methods that will be selected as the estimation model.

TABLE 1. Comparison of Several Holt Winter Methods

Estimation	α	β	RMSE	MSE (RMSE ²)
I. Holt Winters No Seasonal				
P1	0,1	0,2	4,08	16.64
P2	0,1	0,3	2,98	8.88
P3	0,3	0,4	2,50	6.25
P4	0,6	0,7	2,35	5.52
P5	0,8	0,0	2,06	4.24
II. Holt Winters Additive				
P6	0,6	0,0	1,59	2.53
III. Holt Winters Multiplicative				
P7	0,6	0,0	1,55	0.63

In table 1 above, it can be seen that the results of the error checking evaluation of several Holt-Winters methods show the smallest error rate in several experiments shown by P7 with RMSE 1.55 and MSE 0.63.

B. *Poverty Estimation Results*

The following is Figure 3 Comparison Graph of Actual Data and Poverty Estimation in Padang Pariaman Regency.

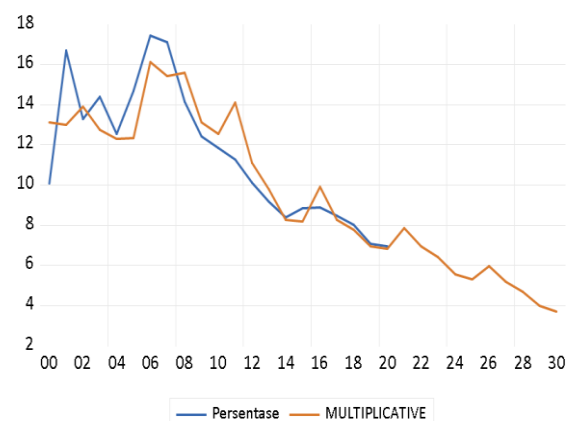


Fig. 3. The Chart of Actual Data and Poverty Estimation in Padang Pariaman Regency

In Figure 3 above, it can be seen that the actual data and estimation results with the Holt-Winters model cross several times in meaning (accurate), so that the Multiplicative P7 method with $\alpha = 0.63$ and $\beta = 0$ is chosen to be the best method for predicting poverty data 10 (ten) next year based on the smallest RMSE and MSE results.

TABLE 2. Comparison of Actual Data and Estimation Data

Year	Actual Data	Estimation Data
2000	10.07	13,12
2001	16.71	12,99
2002	13.31	13,92
2003	14.39	12,74
2004	12.53	12,29
2005	14.67	12,32
2006	17.45	16,10
2007	17.12	15,42
2008	14.15	15,60
2009	12.41	13,12
2010	11.86	12,56
2011	11.26	14,09
2012	10.12	11,10
2013	9.17	9,79

2014	8.39	8,28
2015	8.86	8,17
2016	8.91	9,89
2017	8.46	8,28
2018	8.04	7,77
2019	7.1	6,95
2020	6.95	6,84
2021	-	7,78
2022	-	6,97
2023	-	6,40
2024	-	5,54
2025	-	5,31
2026	-	5,97
2027	-	5,20
2028	-	4,69
2029	-	3,97
2030	-	3,72

Based on the results of estimation using the Holt-Winters Exponential Smoothing model at the beginning of the 2000 training data, Actual data and Estimation data is a difference of 3.72%, then in subsequent years the estimated results study training data so that the difference between actual data and estimation is less than 0 5% of the results in the table are corroborated by testing the error RMSE 1.55 and MSE 2.4025

V. CONCLUSION AND SUGGESTIONS

A. Conclusion

Based on the results of the research and tests carried out, it can be concluded that the use of the Holt Winters Multiplicative Seasonal model, the values of $\alpha = 0.63$ and $\beta = 0$ are the best methods for predicting poverty data in Padang Pariaman Regency in the next 10 (ten) years, this is proven with the smallest RSME error rate obtained by 1.551 and MSE with a value of 2.4025 when compared to the Holt-Winters-No Seasonal method, the value of $\alpha = 0.86$ and $\beta = 0$ RSME = 2.06 and MSE = 4.2436 or the Holt-Winters Additive Seasonal method with α value = 0.63 and $\beta = 0$ RSME = 1.59 and MSE = 2.5281.

The research results showed that the poverty trend in Padang Pariaman Regency in 2021 to 2030 is estimated to decrease by 7.78% in 2021 and 3.72% in 2030 so that P3A social department can evaluate existing policies and expand beneficiaries to community's needs.

B. Suggestion

Some suggestions by researchers for next research will be better, include:

1. The data sample used can be specified per semester, so that the data set obtained is better to increase the accuracy of the resulting estimated.
2. Using other time series models can be done, so as to compare the accuracy of each model.

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