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Original Article

Comparison of Linear Regression Method and Holt-Winters Method in Oil and Gas Export Volume Forecasting in Indonesia

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Abstract *- The COVID-19 pandemic caused a decline in oil and gas exports from Indonesia in 2019. After some months, the Covid-19 pandemic started to improve slowly. This had an impact on the economy's recovery, which led to an increase in oil and gas exports once more. This article will use the Linear Regression approach and the Holt-Winters method to forecast the amount of oil and gas exported from Indonesia. In particular, the Holt-Winters method is subdivided into the Holt-Winters multiplicative and Holt-Winters additive. Comparing these three approaches, it is evident that the multiplicative Holt-Winters method is superior to the Linear Regression and Holt-Winters additive methods, which approach out-of-sample data for oil and gas volume forecasting in 2018. This is also directly related to the predictive power of the Holt-Winters multiplicative method, which may approach the actual data for six years longer than other methods. The Mean Absolute Error (MAE) of the three approaches indicates that the multiplicative error of the Holt-Winters method is less than that of the other two ways. Therefore, it may be inferred that the Holt-Winters multiplicative technique is superior for predicting Indonesian oil and gas exports.*

Keywords *- Oil and Gas Exports, Holt-Winters Method, Regression Method, Forecasting.*

1. Introduction

Indonesia has an abundance of natural resources. One of these natural resources is petroleum and natural gas. The results of Indonesia's natural resources for oil and gas commodities are the basis of its comparative advantage, allowing these commodities to be traded abroad. [4].

International trade is the exchange of diverse outputs in the form of products and services generated by a country for export and importation of goods and services from abroad to satisfy domestic requirements[7]. In this situation, international trade might be considered an export and import activity. Specifically, the use of oil and gas in international trade is the export of oil and gas from Indonesia to foreign nations. This is intended to stimulate economic growth in Indonesia and expand domestic and international markets. [12].

Until at least 2018, the volume (value) of Indonesia's oil and gas exports exhibited an upward tendency in their historical development. The world was struck by the Covid-19 epidemic toward the end of 2019, resulting in restrictions on activities, particularly economic operations. That year, Indonesia's oil and gas exports declined[9]. After some time, the Covid-19 epidemic began to recover gradually, which affected the economy's recovery such that oil and gas exports resumed their upward trajectory. However, Indonesia's oil and gas exports have yet to return to pre-Covid-19 levels.

To foresee a drop in oil and gas exports, it is important to project the development of oil and gas exports in Indonesia for the subsequent year. Predicting the number of oil and gas exports has attracted much attention in prior research. In Indonesia, research on oil and gas exports and imports was conducted between 1996 and 2016 to predict the development of oil and gas exports and imports in Indonesia[13]. Using data from 1990 to 2020 using the box Jenkins approach, oil and gas exports from other countries, such as Greece, were also calculated[5]. Then, oil and gas exports in Brazil were conducted from 2001 to 2017 using the Holt-Winters method for forecasting[10].

The regression approach, in addition to the time series method, can be utilized in predicting. G. Aydin (2015) completed a study that forecasted world oil production statistics from 2015 to 2020 utilizing *a linear regression model, logarithmic regression model, power regression model, exponential regression model, inverse regression model*, and dan

S regression model. Results indicate that the *Inverse Regression Model* can generate the most accurate forecast with the minimum MAPE value. [2].

For forecasting, regression approaches can also be compared to time series methods such as ARIMA. Similar to the study by M. Sabry et al. (2007) that compared the logistic regression approach and ARIMA for predicting traffic volume. From 1990 to 2003, fourteen years of traffic volume data were collected. Data from 1990 to 2001 were used to develop the model, and data from 2002 to 2003 were used to compare the predictive accuracy of logistic regression and ARIMA approaches. Therefore, the ARIMA model is the superior method for forecasting traffic volume among the two methods employed. [11].

There are also studies comparing the linear regression method and the Holt-Winters method in addition to ARIMA. One of these researchers is Hudzaifah Hasri et al. (2021), who employ both approaches in their study. This study used the MAD and MAPE values to determine the model selection accuracy. [6]. Therefore, in this research, the linear regression approach and the holt winters method will be utilized to forecast the amount of oil and gas exported from Indonesia. By analyzing which MAE value is less and which forecasting results are closer to the outcome data, it will be determined which of these two approaches is most appropriate for forecasting the volume of oil and gas exports in Indonesia.

2. Research Methodology

2.1. Linear Regression

Regression analysis is a statistical technique for modeling and examining the association between a response or dependent variable and one or more predictor or independent variables. Frequently, the end outcome of a regression analysis study is a model that may be used to predict the future value of the response variable given a certain value of the predictor variable.

The formula for a simple linear regression model with a single predictor variable is:

$$y = \beta_0 + \beta_1 x \tag{1}$$

Where y is the answer, x represents the predictor, and β_0 and β_1 are unknown factors[8].

2.2. Holt-Winters

The Holt-Winters approach has two primary variations: *Additive* and *Multiplicative*. When the magnitude of the seasonal component remains constant over time, the *Additive* technique is more appropriate. In contrast, the *Multiplicative* method is more appropriate when the size of the seasonal component varies over time.
The following describes the Holt-Winters *Additive* method for one-step forecasting (*One Step Forecast*).

$$\hat{y}_{t+1|t} = l_t + hb_t + s_{t-m+1} \tag{2}$$

$$l_t = \alpha(y_t + s_{t-m}) + (1-\alpha)(l_{t-1} + b_{t-1}) \tag{3}$$

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \tag{4}$$

$$s_t = \gamma(y_t - l_{t-1} - b_{t-1}) + (1-\gamma)s_{t-m} \tag{5}$$

While the Holt-Winters *Multiplicative* approach to one-step forecasting (*Step Forecast*) is described as follows:

$$\hat{y}_{t+1|t} = (l_t + hb_t)s_{t-m+1} \tag{6}$$

$$l_t = \alpha\frac{y_t}{s_{t-m}} + (1-\alpha)(l_{t-1} + b_{t-1}) \tag{7}$$

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \tag{8}$$

$$s_t = \gamma\frac{y_t}{(l_{t-1} - b_{t-1})} + (1-\gamma)s_{t-m} \tag{9}$$

Where $\hat{y}_{t+1|t}$ is the equation for forecasting and l_t is the approximate *Level* at the time t. Commonly, this parameter α is referred to as the *Smoothing* parameter for a *Level* limited between 0 and 1. b_t is the estimated *Trend* at time t. As well as α, β parameter *Smoothing* for *Trends* bounded by 0 and 1. s_t is a *Seasonal* prediction of time t, with γ as the *Smoothing* parameter for *Seasonal*, whose range is between 0 and 1[1].

2.3. Mean Absolute Error

Comparative statistical analysis of estimation or prediction models $(P_i; i = 1,2,3, \dots, n)$ with various experiments $(O_i; i = 1,2,3, \dots, n)$ is one of the foundations for demonstrating the performance of a climate and environmental science model. Typically, the prediction error of a particular model is defined as $e_i = P_i - O_i$. The error or model size will be indicated on the graph. $(e_i\,; i = 1,2,3, \dots, n)$. Mean Absolute Error (MAE) with the following formula is one of the error sizes. [14]

$$MAE = [n^{-1} \sum_{i=1}^{n} |e_i|] \quad (10)$$

3. Results and Discussion

3.1. Preliminary Data Analysis

This research uses monthly data from the Central Statistics Agency (BPS) from 2012 to 2017 regarding the volume of oil and gas exports in Indonesia. [3]. The information is presented in the following table.

Table 1. Data on Oil and Gas Export Volume in Indonesia (Thousand Tons) in 2012-2017

Month	Years					
	2012	2013	2014	2015	2016	2017
Jan	4.187,4	3.524,3	3.247,5	3.553,8	3.475,1	3.499,1
Feb	4.236,8	3.434,2	3.465,3	3.365,6	3.574,8	3.329,6
Mar	4.525,5	3.809,9	3.527,2	3.873,7	3.999,2	3.864,1
Apr	4.382,9	3.363,8	3.456,2	3.742,2	3.433,3	2.634,8
May	4.631,8	3.957,2	3.232	3.605,7	3.711,4	3.473,7
Jun	4.037,6	3.788	3.750,4	3.817,1	4.143,1	3.420,2
Jul	4.066,1	3.330,6	3.377,1	3.622,5	3.435,2	3.281,3
Aug	3.610,5	3.645,2	3.553,9	3.875,6	3.804,9	3.716,9
Sep	3.808,5	3.398,6	3.697,3	3.882,4	3.576,4	4.015,4
Oct	3.498,1	3.481,6	3.527,7	3.695,3	3.136,2	3.955
Nov	3.564,5	3.696,6	3.125,3	4.247,2	3.336,9	3.437,6
Dec	3.896,2	4.611,8	3.783,2	3.683,6	3.702,3	3.877,4

The data in Table 1 is then analyzed using two methods, namely the Linear Regression method and the Holt-Winters method, in order to provide a more accurate forecast as the out sample approaches. The following graph depicts the combination of various strategies.

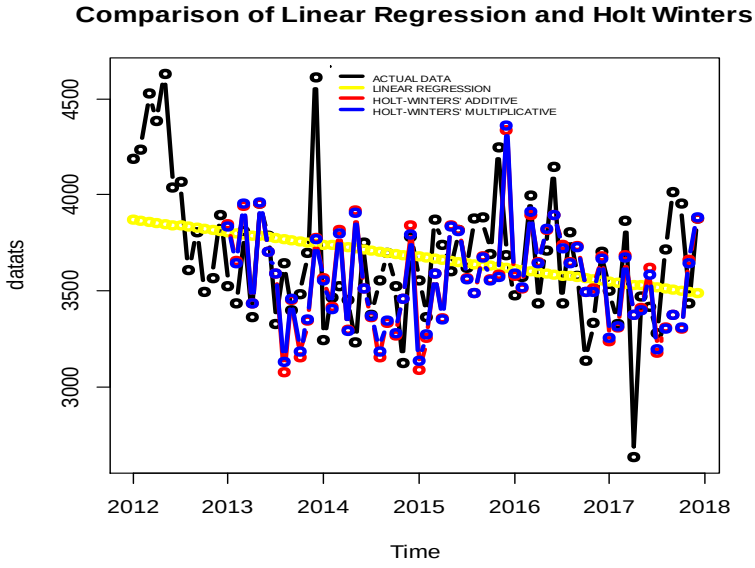

Fig. 1 Comparison of Oil and Gas Export Volume Predictions in Indonesia (thousand tons) Using Linear Regression and Holt-Winters Methods for 2018

3.2. Linear Regression Method

This method employs data on oil and gas export volumes as the dependent variable (y) and the length value of y as the independent variable (x).

The data in Table 1 are processed with the R program to get the following linear regression equation:

$$y = 3876{,}428 - 5{,}355187x \quad (11)$$

The following graph displays the predicted results for the following year based on equation 11.

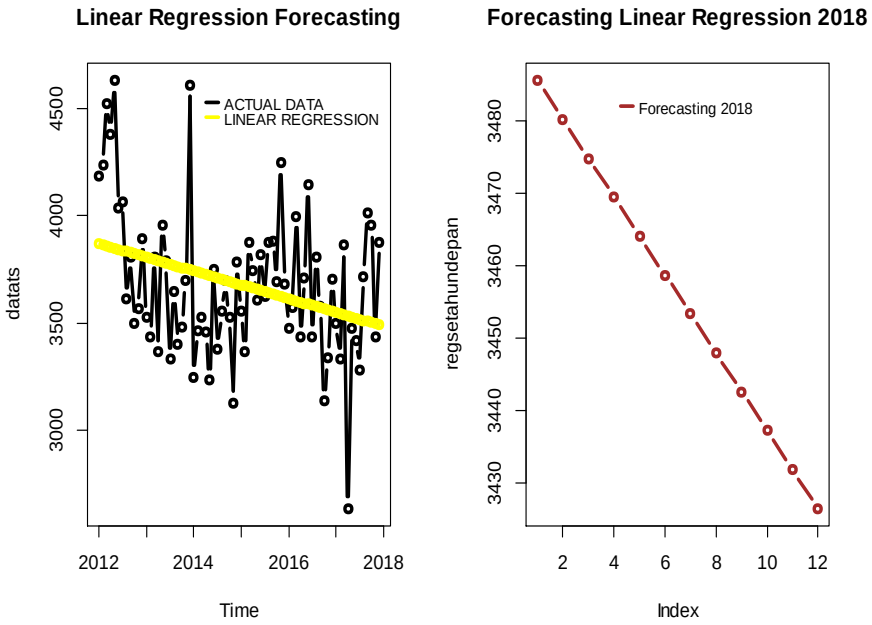

Fig. 2 Prediction of Indonesia's Oil and Gas Export Volume (in Thousand Tons) for 2018 Using Linear Regression

3.3. Metode Holt-Winters

There are two types of the Holt-Winters method: *Additive* and *Multiplicating*. The two graphs below depict the next year's forecasts based on Holt-Winters Additive and Holt-Winters Multiplicative.

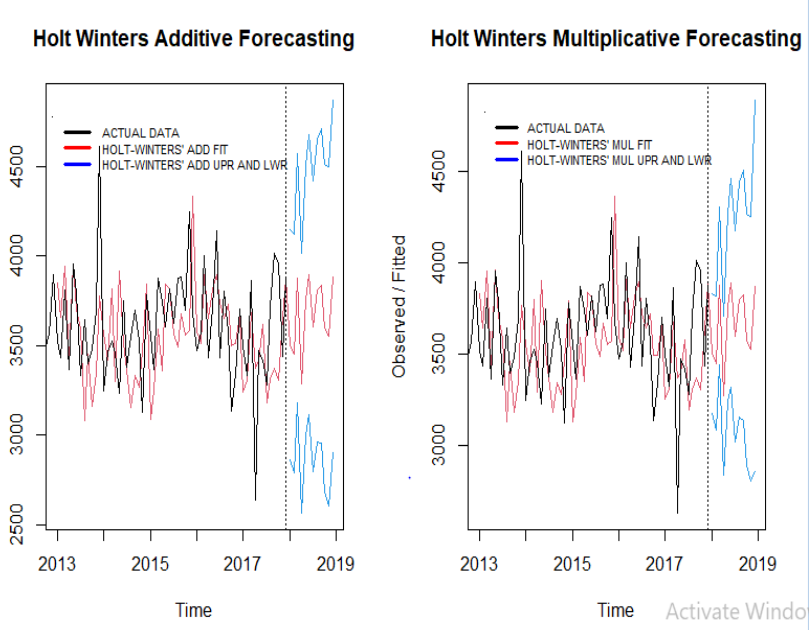

Fig. 3 Prediction of Indonesia's Oil and Gas Export Volume (in Thousand Tons) for 2018 Using the Holt-Winters Method

3.4. Out-Sample Data

Out-sample data are used to determine the accuracy of forecasts for the subsequent period. The 2018 oil and gas out sample data are as follows:

Table 2. Data-of sample data for Indonesia's oil and gas exports in 2018 (thousand tons)

Month	Year 2018	Month	Year 2018
Jan	3.373,9	Jul	2.971,4
Feb	3.460,5	Aug	2.960
Mar	2.972,3	Sep	2.533,4
Apr	2.677,1	Oct	2.974,4
May	3.414,3	Nov	2.630,4
Jun	3.459,1	Dec	3.628,8

3.5. Comparison of Linear Regression and Holt-Winters. Forecasting Methods

The comparison of the three methods of forecasting will be presented in the table below.

Table 3. Comparison of Oil and Gas Export Volume Predictions for Indonesia in 2018 (thousand tons) Using Both Methods

Month	Linear Regression	Holt Winters Additive			Holt Winters Multiplicative			Actual Data
		Upr	Fit	Lwr	Upr	Fit	Lwr	
Jan	3.485,5	4.149,307	3.506,195	2.863,083	3.505,565	3.505,565	3.180,479	3.373,9
Feb	3.480,144	4.123,741	3.455,155	2.786,570	3.452,835	3.452,835	3.084,568	3.460,5
Mar	3.474,789	4.572,909	3.877,619	3.182,329	3.877,107	3.877,107	3.446,427	2.972,3
Apr	3.469,434	4.012,457	3.289,279	2.566,100	3.277,102	3.277,102	2.841,902	2.677,1
May	3.464,079	4.506,372	3.754,165	3.001,959	3.758,459	3.758,459	3.243,510	3.414,3
Jun	3.458,724	4.676,284	3.893,955	3.111,627	3.892,242	3.892,242	3.323,704	3.459,1
Jul	3.453,368	4.420,738	3.607,233	2.793,729	3.599,452	3.801,808	3.022,917	2.971,4
Aug	3.448,013	4.654,017	3.808,324	2.962,632	3.801,808	3.801,808	3.159,946	2.960
Sep	3.442,658	4.713,638	3.834,781	2.955,925	3.824,161	3.824,161	3.138,879	2.533,4
Oct	3.437,303	4.512,282	3.599,321	2.686,361	3.579,687	3.579,687	2.890,793	2.974,4
Nov	3.431,948	4.497,339	3.549,367	2.601,396	3.531,066	3.531,066	2.809,972	2.630,4
Dec	3.426,593	4.869,913	3.886,054	2.902,195	3.874,484	3.874,484	2.859,086	3.628,8

The Holt-Winters multiplicative method is used to forecast oil and gas volumes rather than the Linear Regression method or the Holt-Winters additive method, as shown in Table 3.

3.6. Mean Absolute Error (MAE)

The forecasting method's accuracy can also be seen based on the Mean Absolute Error (MAE) as follows.

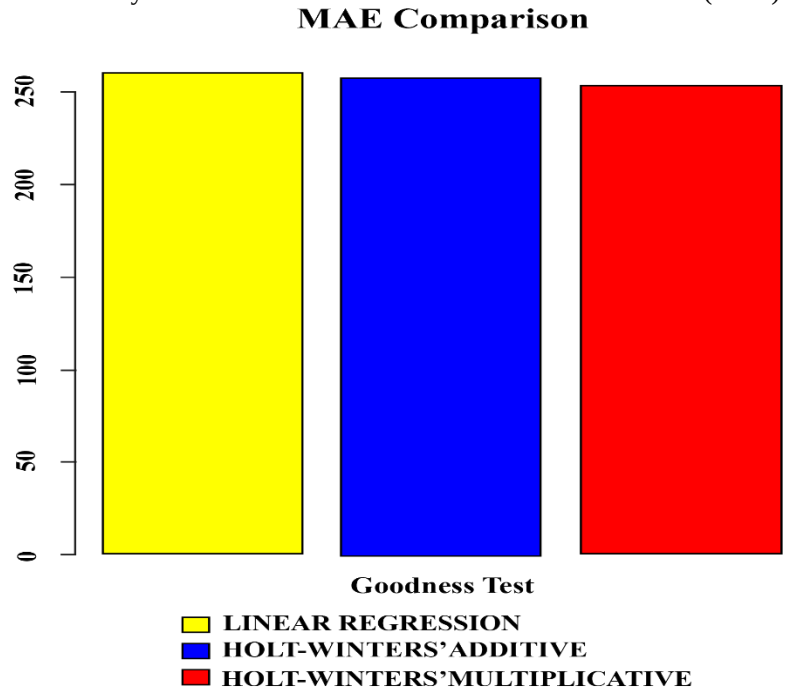

Fig. 4 MAE Oil and Gas Export Volume in Indonesia (in Thousand Tons) in 2018 Compared Using Holt-Winters and Linear Regression

According to Figure 4, the MAE value of Holt-Winters multiplicative is less than that of Linear Regression and Holt-Winters additive. Therefore, the Holt-Winters multiplicative method provides more accurate forecasts than other approaches.

4. Conclusion

In a comparison of Indonesia's two methodologies for predicting oil and gas exports, namely, It is possible to forecast using the Holt-Winters multiplicative method, which is more accurate than the Holt-Winters additive method and the Linear Regression method when using out-of-sample data, such as information on the volume of oil and gas exports in 2018. This is also directly related to the predictive performance of the Holt winters multiplicative method, which can approximate actual data for six years.

Moreover, it can be seen from the Mean Absolute Error (MAE) of the three ways that the Holt-Winters multiplication error is smaller than the errors produced by the other methods. Therefore, it is possible to conclude that the Holt-Winters multiplicative method is superior in terms of its ability to forecast oil and gas exports in Indonesia.

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