Projection and Analysis of National Energy Consumption Levels on Indonesia’s Economic Growth Rate through Exponential Smoothing Approach

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Abstract. This study briefly wants to know the value of the projections of Indonesia's total energy consumption and how it affects the economic growth that occurs. This is also in line with the need for preventive actions related to the type of policy that will be carried out by decision makers where in this case the government will have an impact on the economic performance of a region reflected in the data presented in income posts and expenditure from Gross Domestic Product. The forecast method used in this study is the Exponential Smoothing method which emphasizes the procedure of continuous improvement of the latest observation objects. This method consists of three types, namely simple exponential smoothing, holt winters and triple exponential smoothing models which will be seen which model is the best. Based on the projection analysis, it was found that the Holt Winters Smoothing method was the best method of the other methods with R Square value of 0.608, RMSE of 68.446, MAPE of 4.495 and Normalized BIC of 8.888. Based on the projection results for the next n years, total energy consumption has an upward trend with the projection value in 2018 amounting to 1248.76 (thousand barrels of oil equivalent) and experiencing an increase in 2019 amounting to 1273.47 (thousand BOE).

1. Introduction
The condition of the economy and infrastructure is a variable that cannot be separated in analyzing the amount of energy consumption from a region [1]. Economic growth is indeed one of the variables that can be a benchmark for progress or not, growing or not and increasing the income of the community as the owner of factors of production in a region [2]. These factors of production will certainly also talk about Natural Resources, labor, capital, the level of technology used, social systems and attitudes of society which of course have relevance to each other [3]. When the income of people living in an area both on a regional scale and on a national scale has increased, it certainly can be said that the use of production factors which are the basis of economic activity has gone well which has led to the creation of goods and services [4]. The creation of goods and services will lead to the use of production factors so that economic activity will be formed and if smart in its management will have an impact on economic growth in the region [5]. The indicators used to calculate the rate of economic growth are the growth rates of national products, such as the Gross National Product (GNP) for the national level and the Gross Domestic Regional Product (GDRP) for the provincial and district/city levels [6].

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Energy is one indicator in the acceleration of the economy of a region. Support for planning needs and providing good energy is needed so that the economic acceleration can be realized, especially in regions where economic conditions and infrastructure are relatively lagging when compared to other regions in Indonesia [7]. This condition is increasingly relevant with the three main focuses discussed in the Indonesian Energy Outlook in 2015 which were published several years ago, namely the achievement of energy efficiency and conservation, investment value needed to meet energy needs, and projections of energy needs and supply in several regions special [8]. The specific area in question is a region where economic growth and infrastructure are far behind compared to other regions [9].

This is in line with the purpose of this study, namely to determine the projected total energy consumed in Indonesia. Based on the results of total energy projections through the exponential smoothing method, it can be seen whether the total energy consumed by the Indonesian state has a significant influence on its economic growth. Gross National Product (GNP) is one indicator that can be used to measure the rate of economic growth in a country. This GNP is also one indicator to assess whether the economy is going well or vice versa. So that by knowing the projection of the total energy consumption, it will be able to represent how the pattern of economic growth that occurs from a country and can be seen how far the significance of the relationship between these two variables. The hope is that improving the welfare of the community in an area can also be realized through analysis of the projection results of energy needs and their effects on economic growth.

2. Experimental Procedures

In this research, quantitative methods are used to analyze the forecast value of total energy consumption in the country of Indonesia and its effect on economic growth which is illustrated by the value of Gross Domestic Product (GDP). The data used in this study is a time series data consisting of data on total energy consumption and economic growth in the country of Indonesia starting from 2007-2017 as shown in Table 1.

| Year | Total Energy Consumption (Thousand Barrel of Oil Equivalent) | Economic growth (Trillion Rp) |
|------|-------------------------------------------------------------|--------------------------------|
| 2007 | 953,335                                                      | 1,964                          |
| 2008 | 955,042                                                      | 2,082                          |
| 2009 | 975,278                                                      | 2,179                          |
| 2010 | 1,049,013                                                    | 2,314                          |
| 2011 | 1,151,400                                                    | 2,465                          |
| 2012 | 1,230,134                                                    | 2,618                          |
| 2013 | 1,148,474                                                    | 2,77                           |
| 2014 | 1,170,167                                                    | 8,565                          |
| 2015 | 1,144,990                                                    | 8,983                          |
| 2016 | 1,100,618                                                    | 9,435                          |
| 2017 | 1,233,996                                                    | 9,913                          |

The data presented in Table 1 will then be determined by the exponential method which corresponds to the data pattern used based on the R-Square, RMSE and MAPE values. Time series analysis is done to find patterns that have been formed to predict or predict patterns that will be formed in the future. Time series analysis is done by dividing past time series data into several components which will then be projected into the future by looking at several components that influence patterns that have been formed in the past and present, which tend to recur in the future. Some time series analysis models that can be used for prediction, especially from the exponential smoothing method are as follows.

2.1 Simple Exponential Smoothing

The equations used for exponential smoothing singles are as follows:

\[ S_t = aX_t + (1-a)S_{t-1} \]  \[ (1) \]
where:

\( S_t \) = Value of smoothing forecasting for the period
\( \alpha \) = Smoothing parameters for trends
\( X_t \) = Actual value in period t

2.2 Holt Exponential Smoothing

The equations used for exponential smoothing singles are as follows:

\[
S_t = \alpha X_t + (1 - \alpha)(S_{t-1} + b_{t-1}) \quad (2)
\]

\[
b_{t-1} = \beta (S_t - S_{t-1}) + (1 - \beta)b_{t-1} \quad (3)
\]

\[
Y_{t+m} = S_t + b_t m \quad (4)
\]

Where:

\( b_t \) = Value of smoothing trend
\( m \) = The number of periods predicted
\( \gamma \) = Trend smoothing parameter

2.3 Triple Exponential Smoothing

The equations used in this method are as follows:

\[
S_t = \alpha X_t + (1 - \alpha)(S_{t-1} + \varphi b_{t-1}) \quad (5)
\]

\[
b_{t-1} = \beta (S_t - S_{t-1}) + (1 - \beta)\varphi b_{t-1} \quad (6)
\]

\[
Y_{t+m} = S_t + \sum_{i=1}^{m} \varphi^i b_i \quad (7)
\]

Based on several some methods above, the next step will be determined the value of projections for the next 6 years for the total variable energy consumption in Indonesia.

3. Results and Discussion

Furthermore, it will be seen how testing the exponential projection model that is by following this data which consists of simple exponential smoothing testing, Holt Winters Exponential Smoothing and Triple Exponential Smoothing as shown in Table 2, 3 and 4 below:

**Table 2. Simple Exponential Smoothing Model**

| Model | Number of Predictors | Model Fit statistics | Lung-Box Q(10) | Number of Outliers |
|-------|----------------------|----------------------|-----------------|-------------------|
| Energy_Model_1 | 0 | -1.07 | 4.998 | 53.007 | 10.609 | 133.379 | 0.736 | . | 0 | . | 0 |

**Table 3. Holt Winters Exponential Smoothing Model**

| Model | Number of Predictors | Model Fit statistics | Lung-Box Q(10) | Number of Outliers |
|-------|----------------------|----------------------|-----------------|-------------------|
| Energy_Model_1 | 0 | -4.31 | 4.495 | 51.373 | 8.735 | 101.094 | 0.806 | . | 0 | . | 0 |
Table 4. Triple Exponential Smoothing Model

| Model         | Number of Observations | Number of Predictions | Model Fit Statistics |(Box Q18 | Number of Outliers |
|---------------|------------------------|-----------------------|----------------------|---------|-------------------|
| EnergyModel_1 | 0                      | 0                     | 0.608                | .000    | .000              |

Based on the three types of exponential methods above, the Holt Winters exponential smoothing method is the right projection method because it has the largest R Square value of 0.608, the smallest RMSE, MAPE is relatively smaller compared to other methods and BIC normalized values are also relatively larger if compared to other methods and visualization of the projection as shown in Figure 1 and Table 6.

**Figure 1** Visualization of the projection results of the Holt Winters Exponential Smoothing method

Based on this picture we can see that there is an uptrend of total energy consumption symbolized by the number, and the data in this study starting from 2007 are symbolized by date on the graph. The projection results from this model are shown in Table 5.

Table 5. The projection results of the Holt Winters Exponential Smoothing method

| Year | Forecast (Thousand Barrel of Oil Equivalent) | LCL     | UCL     |
|------|----------------------------------------------|---------|---------|
| 2018 | 1248.76                                      | 1081.26 | 1416.25 |
| 2019 | 1273.47                                      | 1047.81 | 1499.12 |
| 2020 | 1298.17                                      | 1026.45 | 1569.90 |
| 2021 | 1322.87                                      | 1011.76 | 1633.98 |
| 2022 | 1347.56                                      | 1001.45 | 1693.68 |
| 2023 | 1372.25                                      | 994.30  | 1750.19 |

Seen based on Figure 1 and Table 6 above the Holt Winters model Exponential Smoothing has a projection value that approaches the actual value for the next few years. It is seen for 2018 as the first year the projection of actual data has a projected value of Indonesia’s total energy consumption of 1248.76, 1273.47 in 2019 and 1298.17 in 2020 and followed by several years in the future expressed in units of thousand Barrel of Oil Equivalent (BOE).

**4. Conclusion**

Based on the R square value 39.2% the resulting regression equation is influenced by other variables and the holt winters exponential smoothing method is an appropriate model with the R square value smaller than the other methods. This is also in line with the value of RMSE, MAPE, and BIC normalized values which are relatively smaller compared to other exponential smoothing models.
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