Comparison of Double Exponential and Single Exponential Smoothing Accuracy in Krakatau Steel Demand Forecasting Fitted Model

Indry Maretania, Muhammad Rummy Alfadjri, Pradieqta Uli Paramesywarie and Rahmat Nurcahyo
Department of Industrial Engineering, Universitas Indonesia,
Depok, West Java 16424, Indonesia
indry.maretania@ui.ac.id, pradieqta.uli@ui.ac.id,
muhammad.rummy@ui.ac.id, rahmat.eng@.ui.ac.id

Abstract

Krakatau Steel is one of the manufacturing companies in Indonesia that has been experiencing losses for 9 years with the number of US$112 million in 2018. This research discusses forecasting discourse that many companies face while setting a new optimal strategic plan and aims to compare which method is best to use in terms of predicting krakatau steel demand. Data of accumulative steel products were collected from Krakatau Steel annual report with 14 years of historical data from 2005-2019. Double Exponential Smoothing and Single Exponential Smoothing methods were used to predict the demand in 2019. The accuracy was measured by MAPE, MAD, MSD, and MSE where the single exponential smoothing method is found as the best and more accurate than double exponential smoothing. Further improvements have been done to further examine the coefficient value and MAPE value towards the forecast results, still, Single Exponential Smoothing is the more accurate method.

Keywords
Double Exponential Smoothing, Forecast, Single Exponential Smoothing

1. Introduction

Krakatau Steel is a state-owned enterprise headquartered in Cilegon, Banten, Indonesia and it is the largest company in Indonesia that produces steel products and their derivatives. Krakatau Steel has been experiencing losses since 2012. In the 2018 Annual Report, Krakatau Steel's financial burden throughout 2018 reached US$112 million or equivalent to Rp1.57 trillion (exchange rate of Rp14,038 per US dollar). The burden more than Doubled in 2011 to just US$41 million. This situation is further exacerbated by the invasion of imported steel especially from China and its corruption case in 2019. However, there are many ways to overcome those losses such as restructuring debt, selling shares, or selling assets, but the most ideal way is to pay with the results of sales or profit which leads to the optimization of the production by doing an accurate forecasting. From all different types of forecasting methods that exist with different precision and accuracy depending on its case, this research paper aims to address the accuration between Double Exponential Smoothing and Single Exponential Smoothing of forecasting methods into Krakatau Steel company production in order to find the most accurate forecasting method between two different exponential smoothing methods to be able to solve Krakatau Steel's problem.

1.1 Objectives

The objective of the study is to know what method is more accurate to forecast estimated demand steel products in Krakatau Steel for year 2019 based on mean absolute percentage error (MAPE), mean squared deviation (MSD), mean absolute deviation (MAD), and mean squared error (MSE) value from each method.

2. Literature Review

Forecasting is a calculation analysis technique that is done with a qualitative approach as well as quantitative to estimate future events using reference data in the future rather than to minimize the impact uncertainty. Forecasting itself can be the basis for a company's short, medium, and long-term planning. Forecasting is a very important tool

in planning effectively and efficiently. Forecasting is the most important part for every company or business organization in every management decision making. Forecasting itself can be the basis for a company's short, medium, or long-term planning. In forecasting, it takes a little bit of error. To minimize the level of error, it would be better to know which method produces the most accurate forecasting result.

There are various forecasting methods, such as moving average, exponential smoothing, autoregression, ARIMA, neural work, etc. Choosing a forecasting method is influenced by various aspects such as data patterns and the level of forecasting accuracy (Gunaryati, et al.,2018). From Krakatau Steel 2019 demand data shows that demand increased nearly 100% in 2010 then has a fluctuating pattern in the following years.

Forecasting demand for products has been done by Evriyantino, et al.(2019) which aims to predict cement demand using the fuzzy time series method. The research still has shortcomings, namely the fuzzy time series method does not pay attention to the pattern of trend changes in the previous data, so this method is not appropriate for forecasting data with trend patterns.

Exponential smoothing is a forecasting method on time series data by giving weights to previous data to predict the following data value (Fahlevi, et al., 2018). There are three types of exponential smoothing methods, namely: single, double, and triple. Single exponential is used on data that has a stable fluctuating pattern, double exponential is used on data that has a trending pattern, and triple is used on data that has trend and seasonal patterns. (Nurvianti, et al., 2019)

Previous studies have demonstrated that Double Moving Average is more accurate than the Double Exponential Smoothing when it is used to forecast demand of disposable medical items. It showed that the MAPE and RMSE obtained from the Double Moving Average is smaller than the Double Exponential Smoothing method (Sinaga, H., & Irawati, N., 2018). Hartono, A., Dwijana, D., & Handiwidjojo, W. (2012), conducted a research that shows if Single Exponential Smoothing is better than the Exponential Smoothing Adjusted for Trend (Holt's Method) to forecasting the sales in car parts shop "Prodi" when on the other hand Holt's method was found to be the best method to forecast the Malaysia population compared to Single Exponential Smoothing, Double Exponential Smoothing, ARRES Techniques (Aimran, A., & Afthanorhan, A., 2014). Another study with the exponential smoothing method ever applied by Widjajati, et al.(2017) by comparing the triple method with the event based method. The pattern of product sales data used shows a seasonal or trend pattern. The results show that the triple exponential method produces forecasting values with the smallest error rate compared to the event based method.

Forecasting results will be compared to the actual data collected from krakatau steel annual report for two time series forecasting methods value based on four measures of accuracy of the fitted model: MAPE (Mean Absolute Percentage Error), MAD (Mean Absolute deviation), MSD (Mean squared deviation), and MSE (Mean Square Error) in which smaller values generally indicate a better fitting model. Primely forecasting ability if it has less MAPE value out of 10 and has the ability of good forecast if MAPE value less than 20 (Heizer & Render, 2014) as MAPE provides information on whether the generated forecast result has high or low percentage error.

As choosing the right method for forecasting time series data depends on the data pattern to be used. The following are the types of data patterns (Hanke & Wichern, 2009): Horizontal pattern applies when the data goes down around a fixed value. Tren Pattern applies when the data shows an up or downtrend in the long run, around a fixed average value. Horizontal and Tren Pattern are depicted in Figure 1.

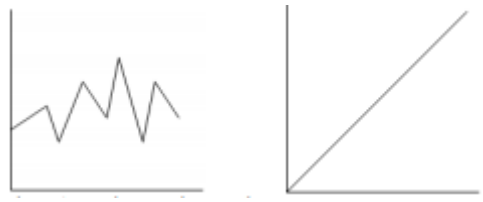

Figure 1. Horizontal Pattern & Tren Pattern

Seasonal pattern applies when the data has a trend that repeats itself at certain times. Cycle pattern is influenced by the business cycle or the economic ups and downs in the long run. The Seasonal and Cycle pattern are depicted in Figure 2.

Figure 2. Seasonal Pattern & Cycle Pattern

3. Methods

The method connected in this study is considered a quantitative method. Quantitative estimating strategy is utilized to investigate issues related to numbers and measurements. The Double Exponential Smoothing and Single Exponential Smoothing are cases of time series strategies. Time series method or strategy could be an expectation approach based on the conduct of authentic information to be anticipated into the long haul by utilizing factual and numerical conditions. This think about begins with a inquire about on writing for issue tackling and closes with conclusion, for more points of interest, this data has been deciphered into the taking after flowchart:

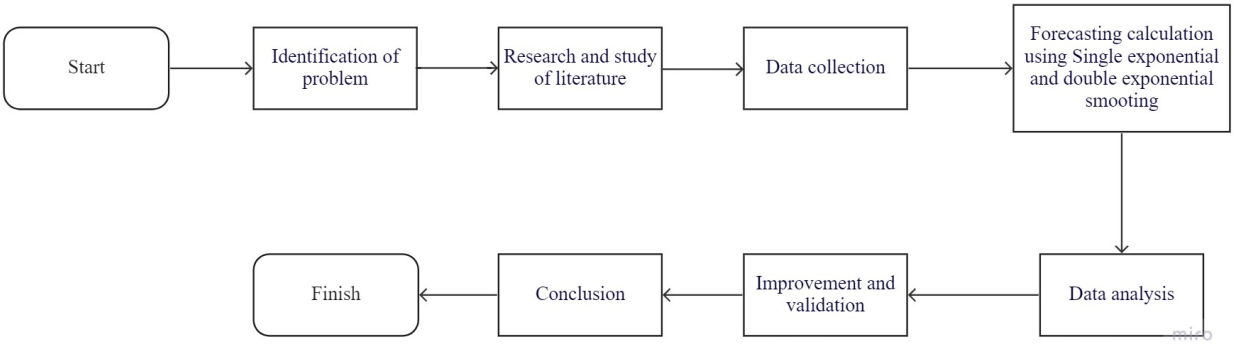

Figure 3. Study Flowchart

4. Data Collection

These are the accumulative demand data from all of the steel product kinds that are collected from the Krakatau Steel annual report. Data in 2005-2018 will be used in the forecasting calculation using Double Exponential Smoothing and Single Exponential Smoothing method to predict the demand in 2019. Data in 2019 will be used as real-life data in the accuracy comparison between the result of the 2019 forecast in the Double Exponential Smoothing method and Single Exponential Smoothing method.

Table 1. Krakatau Steel Demand (Retrieved from annual report)

Years	Krakatau Steel Demand (in Tonnes)
2005	732.298
2006	991.732
2007	944.702
2008	1.021.840
2009	1.005.935

2010	1.914.360
2011	2.072.322
2012	2.307.870
2013	2.375.957
2014	2.316.121
2015	1.941.844
2016	2.237.920
2017	1.900.075
2018	2.142.133
2019	1.795.675

5. Results and discussion

5.1 Numerical Results

To examine the accuracy of the forecasting model, it can be compared with the actual existing data. For this purpose, we use demand data for 2019 as a comparison. In that period, can be seen from table 2 and 3, the forecasting results obtained using the Double Exponential Smoothing and Single Exponential Smoothing are 2.227.479 tonnes and 2.130.742 tonnes respectively. If the two values are compared with the actual data of 1.795.675 tonnes, it can be seen that the deviation is 335.067 for Single Exponential Smoothing and 431,804 for Double Exponential Smoothing. The smallest deviation is the Single Exponential Smoothing method, so there is a slight difference between the results of the study with the actual data. However, it is still concluded that the best method is the method with the smallest MAPE, MSD, MAD, and MSE values. Namely the Single Exponential Smoothing with the respective MAPE, MSD, MAD, and MSE value can be seen in table 2. Hence, since the Single Exponential method is the best method to forecast demand in krakatau steel, we can also obtain information regarding the krakatau steel demand data pattern which implies the demand data follows a horizontal pattern.

Table 2. Comparison between Single Exponential and Double Exponential results for years 2019

Method	MAPE	MAD	MSD	MSE	Forecast
Single Exponential	1,23664E+01	2,20761E+05	9,88990E+10	1,1227E+11	2130742
Double Exponential	1,73204E+01	2,51170E+05	1,06872E+11	1,86455E+11	2227479

Table 3. Forecast comparison between real data and results from Single Exponential and Double Exponential methods

Period	Actual Data	Single Exponential	Double Exponential
2019	1.795.675	2.130.742	2.227.479

5.2 Graphical Results

The following figure 5 and 6 are graphs generated between Single and Double Exponential methods. Actual represent

the actual krakatau steel demand which was retrieved from the annual report. Fits or fitted value are points estimates of the mean response for given values of the predictors and calculated using regression equation and the variable setting. Forecast is the point where the forecasted value is spotted in the graph. 95% PI is the prediction interval that represents a range that is likely to contain a single future response for a selected combination of variable settings. It is also use to assess the precision of the predictors, with 95% PI, you can be 95% confident that a single response will be contained in the interval given in the settings of the predictors. Calculation using optimal ARIMA for predicting forecast, use α = 0,949534 for SES while DES use combination of α = 0,888070 and β = 0,110643. Also shown from the numerical results above that Single Exponential is the most accurate method, it can be concluded that the data has stable demand fluctuating pattern or horizontal pattern although there is a significant increase in 2010.

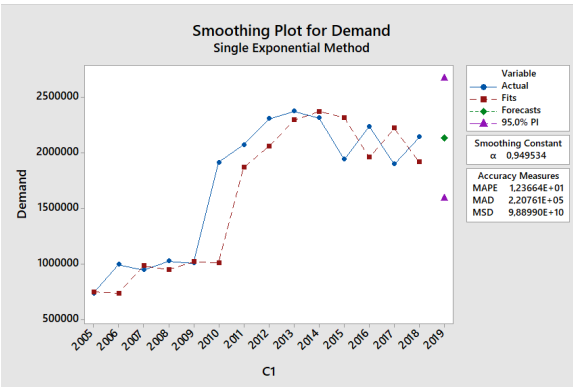

Figure 4. SES graph

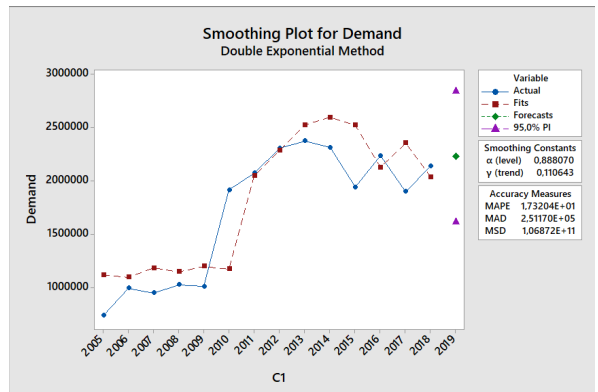

Figure 5. DES graph

5.3 Proposed Improvements

Despite single exponential smoothing having the smallest MAPE, MSD, MAD, and MSE value, it can be seen that the prediction results still have a fairly large deviation value. Even though forecasting cannot be used as a definite standard for a company to operate and manufacture, forecasting is still very important to represent demand as closely as possible to ensure the effectiveness and efficiency of a company's production plan.

To improve or enhance the forecasting results, we need to test work on this method by combining different parameter or coefficient values for each method. In the single exponential, the α test will be carried out, then the double exponential method will be tested for the combination of α and β. Target of this test is to see and examine the effect of coefficient values on forecasting results as well as examine the MAPE for each coefficient.

5.4 Validation

5.4.1 Testing SES Parameter Value

The α test results for 2019 demand are shown in table 4. Table 4 shows the MAPE and forecast value for testing the coefficient value for forecasting 2019 krakatau steel demand between 0,1 to 0,9. The test results show that the MAPE value tends to decrease when the coefficient value increases from 0,1 to 0,8. Otherwise, in testing 0,9 coefficient value, the MAPE increased but the difference in the increase is not too high. The smallest MAPE value was obtained on the test α = 0,8 with a value of 1,53575E+01, while the largest MAPE value was obtained on the test α = 0,1. According to the method evaluation, a smaller MAPE value is better and more accurate. However, from table 4, we can see that the most accurate or forecast value closest to the actual data is when the α value is 0,1. In other words, the highest MAPE gives the most actual forecast result.

Table 4. SES coefficient value testing

α	MAPE	Forecast
0,1	2,74684E+01	1.707.415
0,2	2,06613E+01	1.970.655
0,3	1,82586E+01	2.062.997
0,4	1,72781E+01	2.086.020
0,5	1,64468E+01	2.088.503
0,6	1,58000E+01	2.089.602
0,7	1,53998E+01	2.094.975
0,8	1,53575E+01	2.105.476
0,9	1,55593E+01	2.121.048

5.4.2 Testing DES Parameter Value

DES testing is carried out in 2 stages, first stage testing the α value when β is fixed, then α value with the smallest MAPE is used to test the β value to find the best β value. Based on the results of testing α value when β = 0,1, obtained the best α value at 0,8. The results of testing β value when α = 0,8 are shown in table 6.

Table 5. Testing α value when β is fixed

α	β	MAPE
0,1	0,1	1,97908E+01
0,2	0,1	1,93134E+01
0,3	0,1	1,83113E+01
0,4	0,1	1,72999E+01
0,5	0,1	1,60058E+01
0,6	0,1	1,48048E+01
0,7	0,1	1,41517E+01
0,8	0,1	1,41444E+01
0,9	0,1	1,41886E+01

Table 6. DES coefficient value testing

α	β	MAPE	Forecast
0,8	0,1	1,41444E+01	2.205.868
0,8	0,2	1,43325E+01	2.152.603

0,8	0,3	1,44987E+01	2.112.060
0,8	0,4	1,47809E+01	2.092.276
0,8	0,5	1,52209E+01	2.092.061
0,8	0,6	1,56965E+01	2.105.359
0,8	0,7	1,61147E+01	2.125.327
0,8	0,8	1,65068E+01	2.146.693
0,8	0,9	1,693866E+01	2.166.514

Table 6 shows the MAPE and forecast value for testing the coefficient value when α = 0,8 for forecasting demand of steel products between 0,1 to 0,9. The test results show that the MAPE value tends to increase when the coefficient value is increasing from 0,1 to 0,9. The smallest MAPE value was generated in the test β = 0,1 while the largest MAPE value was obtained in the test β = 0,9. However, from table 6, we can see that the closest forecast value to the actual data is when the β value is 0,5.

6. Conclusion

Based on the results of the study in choosing the most accurate forecasting method between Double Exponential Smoothing and Single Exponential Smoothing to forecast demand in Krakatau Steel, it can be concluded that the Single Exponential Smoothing shows closer forecasts result to the corresponding actual data with a difference about 335.067 tonnes. This can also be proven by the MAPE, MSD, MAD, and MSE values that are smaller than the Double Exponential Smoothing so that it shows more accuracy than the Double Exponential method with the details MAPE value 1,23664E+0, MAD value 2,20761E+05, MSD value 9,88990E+10, and MSE value 1,1227E+11. However, as the deviation value is still significantly far from the actual data, improvement needed to give the most accurate or as close result as possible to the actual data. For single exponential smoothing, obtained that the closest forecast is when the coefficient has the highest MAPE value while double exponential smoothing, obtained that the closest forecast is when the coefficient has MAPE value in between the lowest and the highest. According to the validation analysis, the smallest MAPE does not always give the closest forecast result but single exponential smoothing still gives the closest forecast value. We encourage the enterprise to always take considerations and examine others' forecast value results even though the MAPE value exceeds 20%.

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Biographies

Indry Maretania is a current second year undergraduate student majoring in Industrial Engineering at Universitas Indonesia. She was born in Jakarta, March 7th 1999. Her research interests are generally related to Engineering Management, Human Systems Engineering / Ergonomics, Management Science, and Financial Economics.

Muhammad Rummy Alfadjri is a current second year undergraduate student majoring in industrial engineering at universitas indonesia. He was born in Jakarta, October 6th 2001. Currently active as board member of organization development for Universitas Indonesia UI MUN Club and participating in managing various Model United Nations events. His research interests are mostly related to Project management, Supply Chain Management, Industrial Feasibility Analysis, Finance, Investment, and Economics.

Pradieqta Uli Paramesywarie is a current second year undergraduate student majoring in industrial engineering at universitas indonesia and quite active in social projects. She was born in Jakarta, May 12th 2001. Her research interests are mostly related to Customer Relationship Management, Project Management, Business Intelligence, Supply Chain Management, and Business Process Reengineering.

Rahmat Nurcahyo is currently active as academic staff in the Industrial Engineering Department, Universitas

Indonesia. Mr. Rahmat was born in Jakarta, June 2nd 1969. He started his higher education in Mechanical Engineering, Universitas Indonesia and graduated in 1993. Then, he continued his study in University of New South Wales and earned his master degree (M.Eng.Sc.) in 1995 and doctoral degree in Faculty of Economics, Universitas Indonesia. Mr. Rahmat has taught several courses in Industrial Engineering UI, including Industrial Psychology, Industrial Economy, and Total Quality Management. Mr. Rahmat is International Register of Certificated QMS Auditors