Production Planning Forecasting using Single Moving Average and Exponential Smoothing Method in PT. Semen Indonesia

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Abstract

PT Semen Indonesia (Persero) is a prominent state-owned cement producer in Indonesia. As a leading company, PT Semen Indonesia needs to keep improving its activity strategies, starting from the production planning. Therefore, this research discusses the appropriate production forecasting method. The production data is collected in an annual period which is collected from PT Semen Indonesia operational overview in the annual report. Steps of PT Semen Indonesia production planning forecasting are literature study, data collecting, identification of forecasting methods, comparison of forecasting methods, and result analysis. Based on the data characteristics, Single Moving Average and Exponential Smoothing Method were chosen to predict the production in the year 2021. The accuracy level of the method was measured by using MAD, MSD, and MAPE with Single Exponential Smoothing as the best production planning forecasting result.

Keywords
Production Planning, Forecast, Moving Average, Exponential Smoothing Method

1. Introduction
PT Semen Indonesia (Persero) is one of the leading companies in the cement industry of Indonesia. In order to maintain its position as one of the leading companies, PT Semen Indonesia needs to have solid planning in its key activities, which starts in the production planning. The lack of accuracy in production planning may result in losses, such as overstock or out-of-stock. Therefore, it is required to have an appropriate forecast method that can be used in production planning.

In order to have an accurate forecast, the availability of data about real production in previous years is crucial. Previous research related to production forecasting with several different methods has been conducted. We found that most of the time, the moving average method gave the least error to the forecasting. Therefore, since these methods depend on the type of data that is used, we'd like to approach this case with two different methods; single moving average and exponential smoothing. By comparing two different methods, it best provides which one is more suitable and realistic in this particular case of PT Semen Indonesia.

1.1 Objectives
This paper aims to provide more information as reference in forecasting a more realistic target of cement production in 2021 by using two different methods; Single Moving Average and Exponential Smoothing based on the historical data of 2011 - 2020.

2. Literature Review
In the present associations, which are subject to abrupt changes and where all requirements of the business sector need accurate and practical reading into the future, the forecasts are becoming exceptionally crucial since they are the indication of survival and the language of business (Bozarth *et al*, 2016). Forecasting refers to the activity of predicting

future outcomes by taking present and past events into consideration. Forecasting is a decision-making tool that assists businesses to cope with the impact of the future's uncertainty by analyzing historical data and trends. The objective is to foresee the future of the production quantity and inventory management in order to balance the conflict of not wanting to hold too much stock and the desire to make items or goods always available when required (Suwan-Achariya *et al*, 2012). The practice of forecasting allows businesses to plan their best courses of action in the form of production planning as the main objective of these activities is to increase efficiency. Other than forecasting, a mathematical model of Integer Linear Programming can be developed to optimize a production schedule as well as personnel scheduling (Nurcahyo, 2016).

Forecasting methods can be divided into qualitative and quantitative methods. Qualitative methods are used when the situation is vague and little data is available. Typically, such circumstances have a long-term nature. Forecasting for such cases involves intuition and experience. In many cases, companies must rely on expert views and customer's opinions. On the other hand, quantitative methods are used when historical data is available, such as existing products, existing technology, or existing markets. Generally, these methods are based on statistics and can be classified into causal forecast and time series analysis (Dmitry *et al*, 2019).

Forecasting methods such as moving average and exponential smoothing has been used in several studies. Different forecasting methods can provide different forecast quality and accuracy. In order to estimate the quality of a forecast, some measures are used including Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD), and Mean Absolute Percentage Error (MAPE). These measures of different methods can be compared in order to determine the most accurate result.

In a research done in 2017 by Siregar, three types of exponential smoothing methods were compared to forecast palm oil production. For further development, this study suggests studying other methods that can produce forecasts with smaller error values. In 2017, Laksana compared the single moving average with the single exponential smoothing method in a research done to develop a forecasting system for a new car. The result stated that the single moving average method is the best method as it produces lower error value. In a research done in 2020, Agustian also compared the simple moving average method with the exponential smoothing method to predict future prices of seaweed and the result indicates that the moving average method is the best alternative. Similar research was also done by Irawan in 2020, the result of comparing the two methods is that the exponential smoothing presents lower values of error.

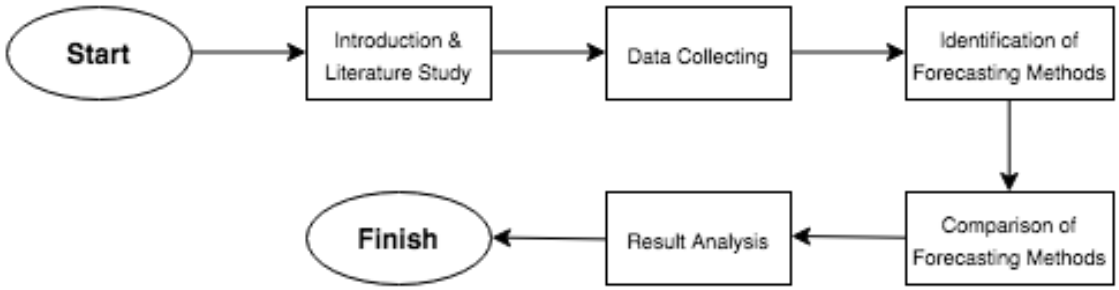

Figure 1. Flow chart of the research

3. Methods

Several steps of research methodologies will be conducted in order to analyze the production in PT Semen Indonesia. Sequentially, all of the steps are summarized as follows:

1. Introduction and Literature Study
   The literature study that will be carried out is related to the topic of this research. This study will focus on defining quantitative forecasting, especially Single Moving Average and Exponential Smoothing Method.
2. Data Collecting
   The data that will be used in this study is the historical domestic production data in PT Semen Indonesia (Persero) Tbk. The time period that will be used in this research is the annual period from the year 2011 until 2020. This data will be converted into a plot for further analysis.

3. Identification of Forecasting Methods
   The next step of the research is to identify some appropriate types of forecasting methods for the production data according to its characteristics. Once found, all these methods will be executed.
4. Comparison of Forecasting Methods
   In order to find the most accurate forecasting method, comparisons between methods will be carried out. The accuracy level will be determined by calculating the amount of Mean Absolute Deviation (MAD), Mean Square Deviation (MSD), and Mean Absolute Percentage Error (MAPE). Since the data contained in this research is low-volume data, MAD has a big impact in determining the best method.
5. Result Analysis
   After comparing all of the methods, the best forecasting method with the smallest margin of error in MAD, MSE, and MAPE will be chosen.

4. Data Collection

The data presented below is the domestic production of cement in thousand tons. The data is collected from the annual report of PT Semen Indonesia (Persero) in the year 2011 until 2020. This historical data will be used as the base information to forecast the production target in 2021.

Table 1. PT Semen Indonesia Production Data

Period	Domestic Production (in Thousand Tons)
2011	19,812
2012	22,846
2013	25,559
2014	26,398
2015	26,504
2016	25,884
2017	28,658
2018	28,566
2019	38,280
2020	32,599

5. Results and Discussion

5.1 Graphical Results

Based on the data plot, it can be seen that the data is stationary. It means that the value of the data is located in the current average range where the data will decrease but soon increases again. Referring to the information mentioned before, the method options can be selected, that is Single Moving Average, Single Exponential Smoothing Method, and Double Exponential Smoothing Method. All of the selected methods are going to be executed in this research in order to find the most accurate forecasting method. Two methods are implemented to determine the forecast of the production target in 2021:

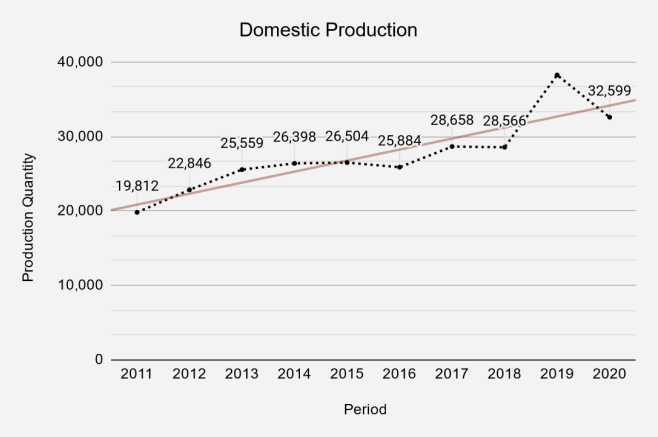

Figure 2. Time Series Plot

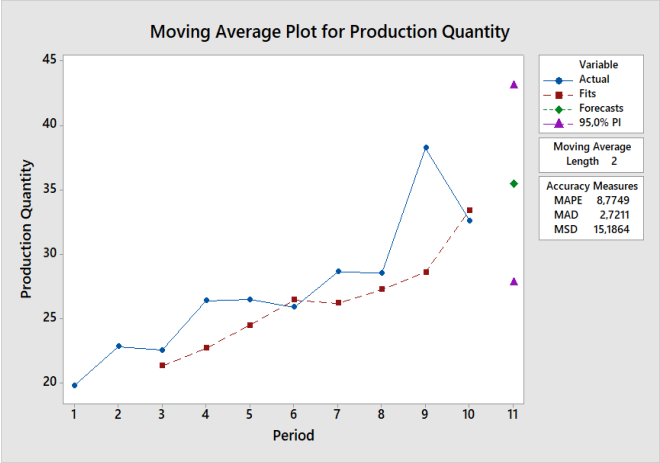

Figure 3. Moving Average Method

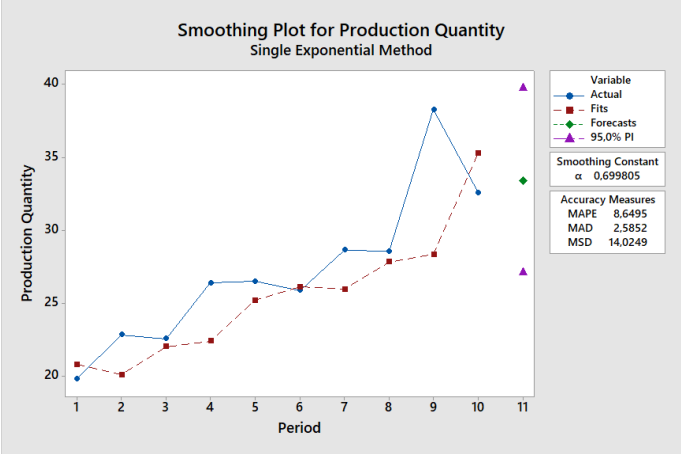

Figure 4. Single Exponential Method

The first method that was used is the Moving Average in which the weights assigned to the observations are equal and are based on past data. We find that it is best to divide the data into two periods which result in the MA length of 2. The second method is Single Exponential Smoothing. This method is an averaging method that weighs data and reacts more to changes. By using the help of Minitab software, aside from being able to manually select the parameters, the single exponential smoothing equations are executed with an automated optimal parameter that produces the least error. In this case, the value of α that is determined by the software is 0,69.

5.2 Numerical Results

After analyzing the historical data using the single moving average and the double exponential smoothing method, we obtained the forecasted result of the production target for 2021 which are 35,439 and 33,409 thousand tons respectively.

Table 2. Forecast result

Production Target	Single Moving Average (in thousand tons)	Single Exponential Smoothing (in thousand tons)
Forecast	35,439	33,409
Upper Limit	43,077	39,743
Lower Limit	27,801	27,076

5.3 Validation

For quantitative forecasting methods, forecast quality can be known by interpreting the value of MAD, MSD, and MAPE. Based on statistical analysis done before, the accuracy measures are stated in the following table.

Table 3. Forecasting accuracy measures

	Single Moving Average	Single Exponential Smoothing
MAPE	8,779	8,6495
MAD	2,7211	2,5852
MSD	15,1864	14,0249

Normally, MAPE is more valuable than MAD since MAPE states the percentage error in the forecasting of the actual result during a certain period. MAPE will provide information on whether the percentage error is too high or too low. According to the MAPE value range stated in table 2, both methods are in the range of 10-20% which can be interpreted as having good forecasting model ability. Following that, by comparing the value of MAD and MSD of both methods we can see that single exponential smoothing has a lower value of both measurements. Therefore, we can conclude that the forecast done by using the single exponential smoothing is slightly more accurate than the forecast done by using the single moving average method.

In fact, no prediction or forecast has an accuracy rate of 100% as every prediction must have an error. The smaller the error rate generated, the better the forecast. With an error rate of less than 5%, it means that the forecasting already has an accuracy rate of more than 95% and the results can be said to be accurate (Sinaga, 2018).

Table 4. MAPE value range

MAPE Value Range	Interpretation
< 10 %	Very good forecasting model ability
10 - 20 %	Good forecasting model ability
20 - 50 %	Decent forecasting model ability
> 50 %	Bad forecasting model ability

5.4 Proposed Improvements

To provide more information as a reference in forecasting a more realistic target of cement production in 2021, we proposed PT Semen Indonesia to use a single exponential smoothing method. By implementing a single exponential method, it is believed that it will provide a more realistic baseline and approach in forecasting, based on past historical data. Thus, it is still required to compare and analyze the forecasted numbers with the actual data once it has been implemented.

6. Conclusion

With the completion of analyzing the best production planning forecasting methods to be implemented in PT Semen Indonesia, it can be concluded that:

1. The result of production forecasting from the year 2011 until 2020 using Single Moving Average is 35.439 with MAPE amounting to 8.779, MAD 2.7211, and MSD 15.1864. On the other hand, the forecasting result using Single Exponential Smoothing is 33, 409 with MAPE amounting to 8.6495, MAD 2.5852, and MSD 14.029.
2. A method with the smallest error level can be assumed as the most appropriate method to be implemented. From the information and data processing above, it can be determined that Single Exponential Smoothing is the best reference to forecast the production target of PT Semen Indonesia in 2021.

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Biographies

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Rahmat Nurcahyo is currently active as an academic staff in 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 at the 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 the International Register of Certificated QMS Auditors.