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# The Use of Response Surface Analysis to Obtain Optimum Values of Smoothing Parameter in Holt-Winter Modelling

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**----------*ABSTRACT*----------**

*Response Surface Methodology is used to find the most optimum smoothing values of Holt-winters method. Data used is the price of natural rubber SMR20 in Malaysia. Natural rubber really helps in Malaysia's economic growth, where the price does reflect performance and quality of the product. Therefore, the prediction on price of natural rubber is one of the interests to government and financial minister in specific to manage nation's financial matters. Monthly price of natural rubber data January 2000 to December 2015 was obtained from Malaysian Rubber Board official website. Holt-winter Additive and Holt-winter Multiplicative method are used to forecast price of natural rubber and Response Surface Methodology is used to optimize the smoothing values of Holt-winters. In addition, MAPE is used to validate the accuracy of each smoothing values for both Holt-winter Additive and Holt-winter Multiplicative. The result showed that Holt-winter Multiplicative model with,* $\alpha = 0.99$, $\beta = 0.03$ *and* $\gamma = 0.44$*performed as the best model for forecasting price of natural rubber SMR20 in Malaysia.*

***KEYWORDS:*** *forecasting, SMR20, Response Surface Analysis, Holt-winter*

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## I INTRODUCTION

According to United Nations Conference on Trade and Development (UNCTAD), natural rubber (NR) comes from latex yielding plants called *HaveaBrasillensis*. Natural rubber is commercially an important component in manufacturing a variety of products in the transportation, industrial, consumer and medical sector due to its elasticity, toughness and resilience [1].

Due to the large volatility in price of the natural rubber, it is compulsory to forecast the upcoming price of natural rubber by using the reliable statistical method. The decisions of the current production are strongly depending on the prevailing future prices [2].Therefore, the importance in accurate of forecasting model on price of natural rubber become more critical, especially for producers, traders and consumers who are involved in natural rubber industry. The high accuracy in price forecasts were particularly important to facilitate the decision-makers to make efficient decision making as there was considerable time-lag between making output decisions and the actual output of the commodity in the market [3].

Research on seasonal time series and transfer function modelling for natural rubber forecasting in India [5].The methods used are ARIMA and Transfer Function. The result shows that the accuracy measure for Transfer Function is 19.5 which is considerably small. They later did another study about application of SARIMA model for the forecasting of the production of natural rubber in India. The methods used are Linear Trend Equation, Additive Decomposition Model, Holt-winter Seasonal Exponential Smoothing Model and Seasonal ARIMA Model.The result shows that Additive Decomposition Model is the most suitable forecasting method for the production of natural rubber in India [4,5].

Response surface analysis is a collection of mathematical and statistical techniques for empirical model building. By careful design of experiments, the objective is to optimize a response which is influenced by several independent variables. The application of Response Surface Method to design optimization is aimed at reducing the cost of expensive analysis methods and their associated numerical noise. Respond surface can be used generally in three categories and one of them is optimization of the response [6].

Response Surface Analysis has been used widely to solve optimization problems. Each study has different problem but using similar method in their study. They set minimum and maximum value for each factor, and then apply Response Surface in finding either maximized or minimized value for response variable [7,8,9].

The research objectives for this study are. First, to apply Holt-Winters model on a set of a time series data. Second, to analyze Response Surface Analysis in finding the most optimum value of α, β, and γ in Holt-winters models.Third, to compare the best model for forecasting a taken data by using Holt-Winters modelling.Finally, to forecast the future value of the taken data.

## II MATERIALS AND METHODS

In this research, the materials will be used is the past data of average monthly price of Standard Malaysia Rubber 20. The data is taken from Malaysia Rubber Board website which is from January 2000 until December 2016. The data from January 2016 to June 2016 will be used as validation where it will be compare with the forecast data.

The past data will be used to forecast the data for twelve months which from January 2016 until December 2016. The methods will be used for this research is Holt-winters Additive and Holt-winters Multiplicative model. The method is appropriate for time series data which have at least 50 observations. Holt-winters model also known as Double Exponential Smoothing. The Holt-winters model is widely used in time series analysis at which it can takes any underlying trend and seasonal component into account irrespectively of whether the data is additive or multiplicative in nature [10].

In this study, Holt-winter Additive will be given fixed value 0.01, 0.25, 0.50, 0.75 and 0.99 for smoothing value alpha, beta and gamma. The result of each combination will be recorded. The forecast equation for Holt-winter Additive is shown below:

$$FIT_{t+n} = L_t + nT_t$$

Then, the same method will be applied to Holt-winter Multiplicative. Then, the result of Holt-winters Additive and Holt-winters Multiplicative will be compared via MAPE value to determine the better model to be used as forecasting model for price of natural rubber SMR20 data. Smaller Mean Absolute Percentage Error, MAPE value indicates more accurate forecast.The forecast equation for Holt-winter Multiplicative is shown below:

$$FIT_{t+n} = (L_{t-1} + nT_{t-1})S_{t-s+p}$$

Response Surface Analysis is later applied to minimize the value of MAPE value to find the most optimum value of α, β and γ for Holt-winters model. Response Surface Analysis has a close connection with linear regression analysis. Usually, a low-order polynomial such as first order and second order model is used. In this study, only first order model without interaction is used.

$$\eta = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

## III RESULTS AND DISCUSSIONS

The data of average monthly price of Standard Malaysia Rubber 20 (SMR20) is being analyzed by using Minitab Software**.** The steps and procedures to carry out the Holt-winters model are applied to the data series to fulfill the objective of the research.Holt-winters modelling is applied repeatedly on the data by using different value of parameters α, β and γ, which are, 0.01, 0.25, 0.50, 0.75 and 0.99 and the MAPE value is recorded. So, there are 125 MAPE. Then, Response Surface Analysis will be applied to MAPE value and the most optimum combination of smoothing parameters will be determined before the better model can be chose and the price of natural rubber SMR20 in Malaysia can be forecasted.

For Holt-winter additive, the optimal smoothing values obtained are alpha equal to 0.99 with beta equal to 0.01 and gamma equal to 0.75. Figure 4.1 shows time series plot of actual versus fitted values using Holt-winter additive modelling. The MAPE value for this combination is 5.78.For Holt-winter multiplicative, the optimal smoothing values obtained are alpha equal to 0.99 with beta equal to 0.01 and gamma equal to 0.50. Figure 4.2 shows time series plot of actual versus fitted values using Holt-winter multiplicative modelling. The MAPE value for this combination is 5.11.

From Response Surface Analysis, the optimal smoothing values obtained are alpha equal to 0.99 with beta equal to 0.04 and gamma equal to 0.95 for Holt-winters Additive. The MAPE value for this combination is 5.75. On the other hand, for Holt-winters Multiplicative, the optimal smoothing values obtained are alpha equal to 0.99 with beta equal to 0.03 and gamma equal to 0.44. The MAPE value for this combination is 5.06.As Holt-winters Multiplicative has the lower MAPE value, Holt-winters Multiplicative was chosen to further the study. Figure 1, Figure 2 and Figure 3 show the relation between alpha, beta, gamma and MAPE.

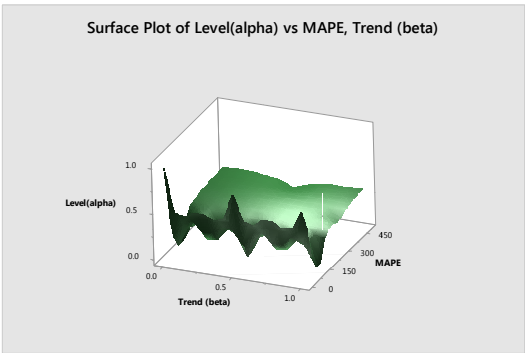


**Figure 1: Alpha versus beta and their mutual effect on MAPE.**

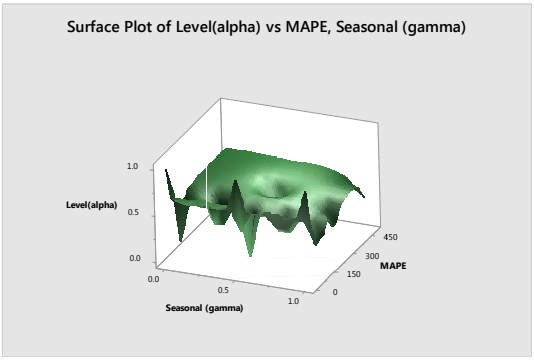


**Figure 2: Alpha versus gamma and their mutual effect on MAPE.**

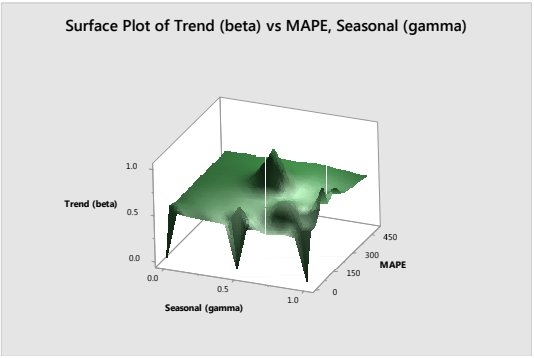


**Figure 3: Beta versus gamma and their mutual effect on MAPE.**

Before forecasting the price of natural rubber SMR20 in Malaysia, the model is validated by comparing forecasted price and actual price. The actual price of natural rubber SMR20 in Malaysia from January to June 2016 was used for validation. Since Holt-winters Multiplicative model gave lower MAPE value than Holt-winters Additive model, it will be used to forecast the price of rubber. Table 1 shows the comparison of actual versus predicted price of natural rubber SMR20 in Malaysia from January to June 2016.

**Table 1:Comparison between actual and predicted price of natural rubber SMR20**

| Date | Actual Price of Natural Rubber SMR20, RM | Predicted Price of Natural Rubber SMR20, RM | Error |
|---|---|---|---|
| January | 488.89 | 513.91 | -25.02 |
| February | 454.03 | 501.39 | -47.36 |
| March | 516.98 | 541.75 | -24.77 |
| April | 572.43 | 581.99 | -9.56 |
| May | 542.98 | 542.05 | 0.93 |
| June | 510.62 | 524.52 | -13.90 |

The difference between actual and predicted price of natural rubber SMR20 in Malaysia was compared by looking the prediction error. The largest difference is by RM47.36. However, the difference in price can be considered small and tolerable because the price of rubber is in hundreds of Malaysian ringgit.

The forecasting of price of natural rubber SMR20 in year of 2016 is done by using Holt-winter Multiplicative model. The result is shown in Table 2 and Figure 1. The predicted value shows that the price of natural rubber SMR20 in Malaysia is going to have a peak in April drops until October.

**Table 2: Forecast of price of natural rubber SMR20.**

| Year | Months | Forecast of Price of Natural Rubber |
|---|---|---|
| 2016 | January | 513.91 |
| 2016 | February | 501.39 |
| 2016 | March | 541.75 |
| 2016 | April | 581.99 |
| 2016 | May | 542.05 |
| 2016 | June | 524.52 |
| 2016 | July | 533.75 |
| 2016 | August | 530.84 |
| 2016 | September | 501.93 |
| 2016 | October | 493.73 |
| 2016 | November | 506.29 |
| 2016 | December | 502.53 |

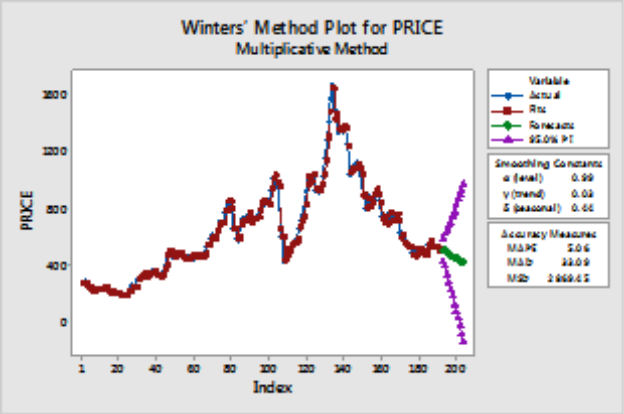


**Figure 4: Time series plot of actual versus predicted monthly price of natural rubber SMR20 from January of 2000 to December of 2016.**

## IV CONCLUSIONS

The study conducted has fulfilled the objectives of the research.The first objective is to apply Holt-Winters model on a set of a time series data. This objective has been met by applying Holt-winter on the price of natural rubber SMR20 in Malaysia.

The second objective is to apply Response Surface Analysis in finding the most optimum value of α, β, and γ in Holt-winters models. This objective has been met by finding the most optimum smoothing values which are 0.99, 0.03 and 0.44 for alpha, beta and gamma respectively for Holt-winter Multiplicative. As for Holt-winter Additive, the most optimum smoothing values are 0.99, 0.04 and 0.95 for alpha, beta and gamma respectively.

The third objective is to purpose the best model for forecasting a taken data by using Holt-Winters modelling. This objective is met after the optimum value for alpha, beta and gamma obtained. MAPE value for both Holt-winter Additive and Multiplicative are compared and the better one is chosen to be the best model for forecasting price of natural rubber SMR20.The last objective is to forecast the future value of the taken data. This objective also has met by forecasting price of natural rubber from January until December 2016 by using Holt-winters Multiplicative model.The limitation of this research is that the Response Surface design usually computed by using SAS software but in this study, the software used is Minitab because there is no access to SAS software.

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