Forecasting Stock Market Price of Gold, Silver, Crude Oil and Platinum by Using Double Exponential Smoothing, Holt’s Linear Trend and Random Walk

Shuhaidah Abdul Shukor¹, Suliani Firdaus Sufahani¹, Kamil Khalid¹, Mohd Helmy Abd Wahab², Syed Zulkarnain Syed Idrus³, Asmala Ahmad⁴ and Tamil Selvan Subramaniam⁵

¹Department of Mathematics and Statistics, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, Pagoh Campus, 84600 Pagoh, Johor, Malaysia.
²Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.
³Faculty of Applied and Human Sciences, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia.
⁴Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, 75300, Melaka, Malaysia.
⁵Department of Skills and Professionals, Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia.

Corresponding Author Email: suliadi@uthm.edu.my

Abstract: Forecasting is an approach that has been used widely for ages. However, forecasting stock market price is a challenging task to be completed as the data fluctuates rapidly along the time and can be influenced by a variety of factors. Hence, this study aims to forecast the stock market price of gold, silver, crude oil and platinum by using Double Exponential Smoothing, Holt’s Linear Trend and Random Walk. Then, measures the forecast model obtained by using Sum Square Error, Mean Square Error and Root Mean Square Error which later can be used in determining the best forecasting method. Based on the analysis done, the result shows that Holt’s Linear Trend is the better forecasting method compared to Double Exponential Smoothing and Random Walk.

Index Terms: Exponential Smoothing, Forecasting, Holt’s Linear Trend, Random Walk, Stock Market Price.

1. Introduction

Stock market price can be considered as a time series data as it fluctuates around the time and the pattern
of the data can be analysed by using a suitable statistical approach. It is one of the vital aspects that exists in financial institutions. However, forecasting the stock market price is a challenging task to be done. This is because the stock market prices can be influenced by a variety of factors such as company financial status, political events, and natural disaster. Regardless, the subject has been evolving since the first time it was established and has become more difficult than before (Sahoo & Charlapally, 2015). Hence, it becomes an interesting topic to be studied among the academicians and financial researchers.

One of the interesting stock market prices to be studied is the gold price. Gold is well-known as the main lead in the precious metals market and considered as a very rare element with its unique properties (Gencer & Musoglu, 2014; Hussin et al., 2013). Other than that, the silver stock market price also has been recognised since ages as an important monetary exchange due to its value. Only recently that the investors started to use platinum as an alternative by collecting it for future savings and also as investments. Even though these precious metals are commonly used as piece of jewellery, they also can be found in the industrial sector such as automotive and chemical industries as mentioned by Jain and Ghosh (2013). Apart from the precious metals, crude oil also has its own role in affecting the economy and it is widely used as a type of energy resources.

Hence, this study will forecast the stock market price of gold, silver, crude oil and platinum by using several forecasting methods. The methods applied are Double Exponential Smoothing, Holt’s Linear Trend and Random Walk. These methods then will be compared in order to find the best forecasting method based on the data used. There are three accuracy measures that will be used in this study which are Sum Square Error, Mean Square Error and Root Mean Square Error.

2. Literature review

2.1 Double Exponential Smoothing

Double Exponential Smoothing (DES) also known as Brown’s Method is one of the approaches that has been used widely by a lot of researchers since ages (Abdullah et al., 2012; Muhamad & Din, 2015). It is the continuation of the single exponential smoothing method but meant to be used for trend data (Holt, 2004; Wu et al., 2016). DES smooth out the data twice by using only one smoothing constant, $\alpha$ which ranges from zero to one but the determination of the smoothing parameter in this approach might be a challenging task for the researcher (Al-Rahamneh, 2017; Hussain & Jamel, 2013; Muhamad & Din, 2015; Ryu & Sanchez, 2003).

2.2 Holt’s Linear Trend

Holt’s Linear Trend (HLT) or also called as Holt’s model is one of the exponential smoothing family member (Neves & Cordeiro, 2010; Ravinder, 2013; Ryu & Sanchez, 2003). It is one of the methods that works well in analysing and forecasting time series data that has trend features (Holt, 2004; Neves & Cordeiro, 2010; Ravinder, 2013; Wu et al., 2016). One of the main difference between HLT and other exponential smoothing is that it smooths out the trend by using two different smoothing parameters which are $\alpha$ and $\beta$ which later will be used to forecast the future time series without having to use secondary exponential smoothing (Hanke & Reitsch, 1998; Li, 2013; Maçaira et al., 2015; Neves & Cordeiro, 2010; Ryu & Sanchez, 2003).

2.3 Random Walk

Random Walk (RW) is one of the forecasting approaches that can be used. It has been lingering around the statistical filed ever since the Meese and Rogoff’s pioneering work on exchange rate predictability
which led to numerous research (Adhikari & Agrawal, 2014; Lv et al., 2016; Moosa & Burns, 2014). According to Agwuegbo et al. (2010) and Kendal (1953), stock market prices that follows the RW model means that the changes in prices are independent to one another as the gains and losses. The independence assumption in the data that follows RW model is considered as valid so long as the information regarding the previous behaviour of the data is not be used to increase the expected gains (Agwuegbo et al., 2010).

3. Methodology

3.1 Double Exponential Smoothing

Double Exponential Smoothing (DES) is one of the exponential smoothing methods that can be used for trend data. It consisted of one smoothing constant $\alpha$. This method can be computed based on the following (1) to (5) as seen in Muhamad and Din (2015):

$$S_t = \alpha y_t + (1 - \alpha)(S_{t-1})$$  (1)

$$S'_t = \alpha S_t + (1 - \alpha)(S'_{t-1})$$  (2)

$$\alpha_t = 2S_t - S'_t$$  (3)

$$b_t = \frac{\alpha}{1-\alpha}(S_t - S'_t)$$  (4)

$$F_{t+m} = \alpha_t + b_t \times m$$  (5)

where:

$y_t$ : The actual value at time $t$

$S_t$ : Exponentially smoothed value of $y_t$ at time $t$

$S'_t$ : Double exponentially smoothed value of $y_t$ at time $t$

$\alpha$ : Smoothing constant with value between 0 and 1

$b_t$ : Adjustment factor

$F_{t+m}$ : Forecast value at time $t+m$ for $m=1,2,3,...$

3.2 Holt’s Linear Trend

Holt’s Linear trend also an exponential smoothing method which works well with trend data. It has two different smoothing constant which are $\alpha$ for level and $\beta$ for trend. The forecast value can be computed by using the following (6) to (8) as shown in Neves and Cordeiro (2010):

$$\hat{y}_{t+h} = l_t + bh_t$$  (6)

$$l_t = \alpha y_t + (1-\alpha)(l_{t-1} + b_{t-1})$$  (7)
\[ b_t = \beta (l_t - l_{t-1}) + (1 - \beta) b_{t-1} \quad (8) \]

where:

\( \hat{y}_{t+h} \) : Forecast for the value of \( y_t \) for the next period \( t+h \)

\( l_t \) : Estimate of level at period of time \( t \)

\( b_t \) : Estimate of growth (slope) at period of time \( t \)

\( \alpha, \beta \) : The smoothing constant with values between 0 and 1

3.3 Random Walk

Random Walk (RW) is one of the methods that can be used in forecasting stock market price. This method enabled researchers to assume that the latest data are the best referral in order to forecast future data. Based on the study from Agwuegbo et al. (2010), the model can be computed mathematically as shown in (9) and (10):

\[ S_n = X_0 + X_1 + X_2 + \ldots + X_n \quad (9) \]

\[ S_n = S_0 + \sum_{j=1}^{n} X_j \quad (10) \]

where:

\( S_n \) : The location of stock process at time \( n \)

\( S_0 \) : The starting point

\( X_n \) : The independent random variables

\( X_j \) : The independent and identically distributed random variables where each take either value -1, +1 or 0

3.4 Accuracy Measures

There are three different accuracy measures that are applied in this study which are Sum Square Error (SSE), Mean Square Error (MSE) and Root Mean Square Error (RMSE). The computation of these measures are shown in (11) to (13):

\[ SSE = \sum_{t=1}^{n} (y_t - \hat{y}_t)^2 \quad (11) \]

\[ MSE = \frac{1}{n} \sum_{t=1}^{n} (y_t - \hat{y}_t)^2 \quad (12) \]
$$\text{RMSE} = \sqrt{\frac{1}{n} \sum_{t=1}^{n} (y_t - \hat{y}_t)^2}$$

(13)

where:

\(y_t\) : Actual value at period time \(t\)
\(\hat{y}_t\) : Forecast value at period time \(t\)
\(n\) : Total number period time \(t\)

4. Data and results

The study analysed the stock market price of gold, silver, crude oil and platinum. The data were collected from January 2000 until December 2016 each month with 204 observations which were acquired from Yahoo! Finance website. Then, the data will be forecasted for the next four months by using DES, HLT and RW. The best forecasting method will be determined based on the lowest forecast error acquired from the analysis. The accuracy measures used are Sum Square Error (SSE), Mean Square Error (MSE) and Root Mean Square Error (RMSE).

4.1 Double Exponential Smoothing

Double Exponential Smoothing (DES) require a smoothing coefficient \(\alpha\). Solver in Excel are used in determining the best smoothing constant with the lowest error value. The \(\alpha\) value used for gold, silver, crude oil and platinum stock market price are 0.5677, 0.5814, 0.3824 and 0.4536 respectively. Fig. 1 to Fig. 4 shows the time series plot of the stock market price of gold, silver, crude oil and platinum and forecasted points after applying DES.

![Gold Price](image.png)

Fig. 1 Time series plot of gold stock market price using DES.

Fig. 1 and Fig. 2 shows that the stock market price for gold and silver will continue to increase for the next four months. Gold price in Fig. 1 continue to increase up to $320 mark whereas silver price keeps increasing up to $45. While Fig. 3 and Fig. 4 shows that the stock market price of crude oil and platinum continues to decrease over time toward zero line.
Fig. 2 Time series plot of silver stock market price using DES.

Fig. 3 Time series plot of crude oil stock market price using DES.

Fig. 4 Time series plot of platinum stock market price using DES.

4.2 Holt’s Linear Trend Smoothing

Holt’s Linear Trend Smoothing (HLT) is a suitable method to be used when there are trend lies within the data. HLT require two different smoothing constant which are $\alpha$ and $\beta$. The $\alpha$ value obtained from the Solver for gold, silver, crude oil and platinum stock market price are 1, 1, 0.8600 and 0.9488 respectively. While the $\beta$ value for gold, silver, crude oil and platinum stock market price are 0, 0,
0.0075 and 0 respectively. Fig. 5 to Fig. 8 shows the time series plot of the stock market price of gold, silver, crude oil and platinum and the forecasted points after applying HLT to the data.

Fig. 5 Time series plot of gold stock market price using HLT.

Fig. 6 Time series plot of silver stock market price using HLT.

Fig. 7 Time series plot of crude oil stock market price using HLT.

Similar to DES, the gold and silver price shows increments in their forecasted values while crude oil and platinum shows reduction as can be seen in Fig. 5 to Fig. 8. However, the slope of the increment in gold and silver stock price in DES are steeper compared to HLT. In Fig. 5, the gold price forecasted to be increase up to $245. As for silver, Fig. 6 shows that the price will increase up to $41 in the next four
months. Fig. 6 shows that the crude oil price will decrease steadily until $6. While Fig. 8 shows that the stock market price for platinum will keep decreasing to zero line.

![Platinum Price](image)

Fig. 8 Time series plot of platinum stock market price using HLT.

### 4.3 Random Walk

Random Walk (RW) is one of the methods that has been used widely in forecasting stock market price. This method assumed that the latest data are the best guide in predicting the next points. Fig. 9 to Fig. 12 shows the time series plot for the stock market price of gold, silver, crude oil and platinum and their forecast points when applying RW into the data.

![Gold](image)

Fig. 9 Time series plot of gold stock market price using RW.
Fig. 10 Time series plot of silver stock market price using RW.

Fig. 11 Time series plot of crude oil stock market price using RW.

Fig. 12 Time series plot of platinum stock market price using RW.

The pattern of the forecast points obtained for the gold, silver, crude oil and platinum stock market price when applying RW to the data are similar to the forecast points obtained in DES and HLT. Fig. 9 shows that the gold price are increasing along the time up to $242. While the price of silver in Fig. 10 shows also shows and increment up to $42 for the next four months. Fig. 11 shows the crude oil price are reducing steadily to $6. Lastly, Fig. 12 shows the platinum price are keep decreasing along the zero line.
4.4 Comparison of Forecasting Methods

The forecasting values for each stock market price will be obtained once the analysis from each method is completed. Table 1 shows the actual versus forecasted values based on each forecasting methods which are DES, HLT, and RW.

The forecasted values obtained from each forecasting methods are then compared with the actual stock market prices. This is vital to determine the accuracy of each method. Based on these values, the error of each forecasting methods can be acquired based on the differences between actual and forecasted values.

Several accuracy measures will be used in order to compare both of the methods and then determine the best forecasting models between DES, HLT and RW. The forecast value obtained from each model will be compared with the actual data or known as out-of-sample data. Table 2 shows the summary of accuracy measures obtained.

Table 1: Actual versus forecasted values.

|       | Obs  |       |       |       |
|-------|------|-------|-------|-------|
|       | 205  | 206   | 207   | 208   |
| Gold  | Actual | 229.32 | 248.06 | 229.72 | 223.80 |
|       | DES   | 258.55 | 279.43 | 300.30 | 321.17 |
|       | HLT   | 240.73 | 242.01 | 243.28 | 244.56 |
|       | RW    | 240.18 | 240.91 | 241.63 | 242.36 |
| Silver| Actual | 36.61  | 38.00  | 49.67  | 54.23  |
|       | DES   | 41.76  | 42.68  | 43.60  | 44.52  |
|       | HLT   | 41.20  | 41.31  | 41.41  | 41.52  |
|       | RW    | 41.26  | 41.43  | 41.60  | 41.77  |
| Crude Oil| Actual | 6.06  | 6.14  | 5.58  | 5.29  |
|       | DES   | 5.77  | 4.70  | 3.63  | 2.57  |
|       | HLT   | 6.25  | 6.20  | 6.15  | 6.10  |
|       | RW    | 6.23  | 6.14  | 6.04  | 5.95  |
| Platinum| Actual | 1.70  | 1.68  | 1.64  | 1.19  |
|       | DES   | 1.09  | 0.79  | 0.49  | 0.19  |
|       | HLT   | 1.29  | 1.15  | 1.00  | 0.86  |
|       | RW    | 1.23  | 1.02  | 0.82  | 0.61  |

Table 2: Summary of accuracy measures.

|       | Gold  | SSE  | MSE  | RMSE |
|-------|-------|------|------|------|
| DES   | 16301.14 | 4075.285 | 63.83796 |
| HLT   | 781.8214 | 195.4554 | 13.98053 |
| RW    | 655.6096 | 163.9024 | 12.80244 |
| Silver| DES   | 179.4912 | 44.87281 | 6.698717 |
| HLT   | 261.6117 | 65.40293 | 8.087208 |
| RW    | 146588.6 | 36647.15 | 191.4344 |
The ones in bold in Table 2 shows the lowest error when compared between each forecasting method, HLT and DES in each stock market price which are gold, silver, crude oil and platinum. Generally, the lower the error the better the forecasting methods. For the gold stock market price, the best approach in forecasting the data is by applying RW as it has the lowest error when compared to DES and HLT. As for silver, DES shows that it is better than HLT and RW. While crude oil and platinum both proved that HLT is better forecasting methods than DES and RW. Based on Table 1 shown, conclude that HLT is the best better forecasting method as two (crude oil and platinum) out of four (gold, silver, crude oil and platinum) stock prices proved that HLT has lower error compared to the others.

5. Conclusion

The stock market price of gold, silver, crude oil and platinum are forecasted in this study by using DES, HLT and RW. The model obtained then will be compared by using several accuracy measures which are SSE, MSE and RMSE. Then, the best forecasting method will be obtained based on the accuracy measures computed. The lower the error value, the better the method.

Based on the result shown, HLT is chosen as the best forecasting method compared to DES and RW. This is because HLT obtained lower error value than DES and RW in two (crude oil and platinum) out of four data used. It indicates that the forecasted values are closer to the actual data. Hence, conclude that this method is suitable to be used in forecasting the stock market price as it is sensitive to data that fluctuates rapidly as mentioned by Muhamad and Din (2015).

In conclusion, the accurate forecast is important as it helps the company in preparing for their strategic decision by referring to the stock market price fluctuations. Future researchers can try to improve the study by using several different forecasting methods to determine which method works best.

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