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Forecasting Kijang Emas Price using Holt-Tend Exponential Smoothing and ARIMA Model

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Abstract: Gold price is volatile since their currency changes rapidly over time. Kijang Emas is famous with an official Malaysian gold bullion coin. In this research, selling price of Kijang Emas is used to forecast. The price is in Ringgit Malaysia units of 1 ounce Kijang Emas is used. The aim of this research is to evaluate two different methods in forecasting Kijang Emas price and to propose the appropriate model in the end of this research. The methods of forecasting are Holt-Trend exponential smoothing and ARIMA are used in this research. Their comparative study is conducted by using error measurements that commonly used in forecasting research. They are mean absolute percentage error (MAPE), mean absolute error (MAE) and root mean squared error (RMSE). The finding of this research is Holt-Trend exponential smoothing model is proposed as an appropriate model for forecasting Kijang Emas price.

Keywords: gold price, forecasting, Holt-Trend exponential smoothing, ARIMA model

I. INTRODUCTION

Gold is a valuable commodity to people around the world and the development of economy in the country. People commonly interest on this yellow metal for use of their jewelry and decoration that has high and luxurious outlook [1]. As rises of economy in each country day by day, the gold price also has been increasing on their value over the world. It is different to the country currency of money that can be dropped in its value which depends on how successful of economy development of that country. Gold price is put in US dollars; so, anything happened on the US dollars, the gold price is also affected. The gold has improved from the traditional way of investing it which is buying jewelries to the modern way that is purchasing it in gold coins and bars shape [2], [3]. The price of gold has changed over the time changes. The information of the gold price inflation is crucial to the people especially for the economist in planning their future economy as followed the standard of international gold price. Gold price cannot be controlled to reach its standard value, but it can be measured and forecasted to predict the future price in the future time [2], [4], [5]. Since the future information of gold price is important to the economist, so that most of the researchers from particular countries did the gold price forecasting researches. Furthermore, Malaysia is also not in a list of country that is involved in this research. Malaysia is famous with an official Malaysian gold bullion coin that is Kijang Emas. Some of researchers in Malaysia have done on the forecasting of Kijang Emas price by using some different methods [3], [6].

The importance of gold price forecasting is to gain the understanding of information on the international monetary policy. When Malaysian economist has enough knowledge on this factor, the economic development may be improved in easy ways. Therefore, our country would be competed with other developed countries and success on the international level. Gold price forecasting is also important to the owner of any company or organization of gold selling to plan their future goal or aim in selling the gold to their customer [4], [7], [8].

Exponential smoothing methods are the most widely used forecasting methods. The formulation of exponential smoothing forecasting methods arose in the 1950s from the original work of [9], [10] and [11], who were working on creating forecasting models for inventory control systems. Exponential smoothing is an intuitive forecasting method that weights the observed time series unequally. The application of exponential smoothing methods has been explored in many areas such as load forecasting [12] and productivity of rice Kumari [13], inventory [14] and simulation study by [15]. Meanwhile, ARIMA model has been used for forecasting gold price [6], [2], [5], [16] and [17].

The Holt-trend exponential smoothing and ARIMA methods in forecasting Kijang Emas prices are the simple and easy approach without complex or difficult processes. Therefore, these two methods are very helpful to Malaysian economist and investor in financial planning in their development of selling the gold to customers. This easier to them to predict the profit and lost in the future based on the forecast Kijang Emas price. Thus, to get the best result of gold price forecasting, the suitable and appropriate methods are needed to make sure the forecast result is accurate to the actual gold price.

II. RESEARCH METHODOLOGY

A. Data Description

Kijang Emas prices data in Ringgit Malaysia are collected from Bank Negara Malaysia website. The long term time series data are used starting from 3rd January 2011 until 13th February 2017 that consists of 1504 data. These data are about six years that consists of five working days per week. Furthermore, there consists of three types of sizes which are 1 ounce, ½ ounce and ¼ ounce. In this research, only 1 ounce of gold is considered that equal to 31.1 grams.

B. Holt-Trend Exponential Smoothing Method

In this research, linear trend model is used. The model is denoted as equation (1) as follows:

$$y_t = \beta_0 + \beta_1 t + \varepsilon_t \tag{1}$$

where:

y_t is the actual value of time series

β_0 and β_1 are parameters

t is time

ε_t is a random error term with mean $E\{\varepsilon_t\} = 0$ and variance $\sigma^2\{\varepsilon_t\} = \sigma^2$.

This method can be applied if the values of the parameters β_0 and β_1 slowly changing over time either decrease or increase trend. However, there has a note that the regression can be used to forecast the future values of y_t if there has neither β_0 nor β_1 is changing over time. Unfortunately, there have two notations that involved in time series forecast that are level (or mean) at time y_t : $\beta_0 + \beta_1 t$ and growth rate (or trend) denoted as β_1 .

This exponential smoothing approach used to forecast Kijang Emas time series data that involving two smoothing constants that are denoted as α and γ [8], [12]. There consists of two estimates that were considered in this method which are the estimate of the level of the time series constructed in time period $T-1$ denoted as ℓ_{T-1} which is commonly called the permanent component and b_{T-1} which commonly called as the trend component that is estimate of the growth rate of the time series constructed in the time period $T-1$. There have mathematical formulas in calculating these two estimates which stated in equation (2) as the level estimate and equation (3) as trend estimate.

$$\ell_T = \alpha y_t + (1 - \alpha)(\ell_{T-1} + b_{T-1}) \tag{2}$$

$$b_T = \gamma(\ell_T - \ell_{T-1}) + (1 - \gamma)b_{T-1} \tag{3}$$

where α : smoothing constant for the level ($0 \leq \alpha \leq 1$)

γ : smoothing constant for the trend ($0 \leq \gamma \leq 1$).

Then, the point forecast made at time T for y_{T+p} is calculated by using the formula (4)

$$\hat{y}_{T+p}(T) = \ell_T + pb_T \tag{4}$$

where p : number of period-ahead forecast ($p = 1, 2, 3, \dots$).

In addition, the error measurements that are sum of squared error (SSE) and mean square error (MSE) at time t as shown in equation (5) and (6) and (7) respectively are used.

$$SSE = \sum_{t=1}^T [y_t - \hat{y}_t(t-1)]^2 \tag{5}$$

$$MSE = \frac{SSE}{T-2} \tag{6}$$

C. ARIMA Method

Box-Jenkins method is a commonly used in forecast technique. In Box-Jenkins method, there have several models that usually suggested as forecasting models either without seasonal or with seasonal. There have autoregressive model (AR), moving average model (MA), ARIMA model that both autoregressive (AR) and moving average (MA) are involved with integrated or differencing dimension while SARMA and SARIMA models used for seasonal forecast.

Box-Jenkins ARIMA model was proposed in this study. According to [18], Box-Jenkins method is valid to use for stationary variables with constant mean and variance over time. The non-stationary problem was solved by the appropriate transformation on

the data. Box-Cox Transformation is conducted on Kijang Emas price data that have non-stationary problem. The general Box-Jenkins model of non-seasonal lag and with seasonal lag showed as the Equation (7) and Equation (8) respectively.

$$\phi_p(B)\nabla^d y_t = \theta_q(B)a_t \tag{7}$$

where $\nabla = \nabla_1 = 1 - B$,

$$\phi_p(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p,$$

$$\theta_q(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q,$$

$$B^j y_t = y_{t-j}.$$

$$\phi_p(B)\Phi_P(B^S)\nabla^d \nabla^D y_t = \theta_q(B)\Theta_Q(B^S)a_t \tag{8}$$

where $\nabla = \nabla_1 = 1 - B$,

$$\phi_p(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p,$$

$$\Phi_P(B^S) = 1 - \phi_1 B^S - \phi_2 B^{2S} - \dots - \phi_p B^{pS},$$

$$\theta_q(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q,$$

$$\Theta_Q(B^S) = 1 - \theta_1 B^S - \theta_2 B^{2S} - \dots - \theta_q B^{qS},$$

$$B^j y_t = y_{t-j}.$$

where ϕ, θ, Φ and Θ are unknown parameters, p is the number of lagged value of y_t which denotes the order of autoregressive (AR) dimensions, while d is the number of times y is differenced, q is the number of lagged values of error terms which denotes the order of moving average (MA) dimension of model and S is for seasonal aspect. The selection of best model was followed as the procedures stated in the algorithm of Box-Jenkins modeling approach [19].

In selecting an appropriate ARIMA model, some procedures are considered. The procedures were started by plotted the time series of gold price. Then, the stability of variance was focused either it is stable or not by checking the values of upper control limit (UCL), lower control limit (LCL) or lambda, λ which are in the range of 1 or not. If they were in the range of value of 1, so that it was stationary and variance is stable. However, if there had non-stationary data and unstable variance problem is occurred, so transformation was applied. In this study, Box-Cox transformation was used and its criteria of chose the suitable type of transformation are presented in Table 3.2 shows the values of λ and appropriate transformations that have been used [18], [19], [20]. Then, after the variance was stable, so that, autocorrelation, ACFs and partial autocorrelation, PACs was obtained. Model identification based on the autocorrelation function, ACFs and partial autocorrelation function, PACFs plots is shown in Table 3.3. The checking of mean either it was stationary or not by evaluated the ACFs and PACFs plots. If there had no decay to zero or it decayed very slowly, so it was non-stationary on the mean. Thus, regular and seasonal differencing was applied to improve the mean to stationary [13], [19] and [21]. Then, after the mean was already stationary, identification and selection of suitable model was conducted. Estimate parameter values were obtained. Then the residuals diagnostics checking either it was uncorrelated or not was also applied. This approach was checked by used the time series, ACFs and PACFs residual plots. If the residuals were uncorrelated, the checking on parameters that they were uncorrelated was obtained by used its own ACFs and PACFs plots too as uncorrelated residuals checking.

Meanwhile, in checked the significant of parameters and significant of model, hypothesis testing on the parameters significance and Box-Ljung test were applied respectively. In Box-Ljung test, there have comparison on the values of alpha, α and p-value. If p-value is larger than α value, then H_0 is concluded. The hypothesis test is null hypothesis, H_0 : The model does not exhibit lack of fit (the model is adequate) versus the alternative hypothesis, H_a : The model exhibits lack of fit (the model is inadequate). Meanwhile, for parameters hypothesis testing, if p-value is smaller than α value, then H_a is concluded. The hypothesis testing is null hypothesis, H_0 : The parameters are not significant versus the alternative hypothesis, H_a : The parameters are significant

Then, if residuals were uncorrelated and parameters are significant and uncorrelated, forecast was run. However, if they correlated and not significant, modification of model was applied by chose other models and the step was repeated from estimate the parameter value to get suitable model to develop the forecast.

D. Forecast Accuracy

Forecast accuracy usually is evaluated by measuring the error of each model. The error measurements that usually used and most popular among the previous researchers in forecast accuracy are mean absolute percentage error (MAPE), mean absolute error (MAE) and root mean squared error (RMSE).

Thus, those three error measurements were used in measured the errors of each model from both methods which are trend exponential smoothing and Box-Jenkins method that used in this study. The lowest the values of these error measures, the better the model developed. The formulas in measuring these error measurements are shown in Equation (9), Equation (10) and equation (11) of MAPE, MAE and RMSE respectively,

$$MAPE = \frac{100}{n} \sum_{t=1}^n \left| \frac{y_t - \hat{y}_t}{y_t} \right| \tag{9}$$

$$MAE = \frac{1}{n} \sum_{t=1}^n |\hat{y}_t - y_t| \tag{10}$$

$$RMSE = \sqrt{\frac{\sum_{t=1}^n (\hat{y}_t - y_t)^2}{n}} \tag{11}$$

where y_t is actual value, \hat{y}_t is forecast value, n is the total number of data and t is number of time

III. RESULTS AND DISCUSSIONS

Kijang Emas prices were analyzed by plotting the time series plot to determine any pattern that was presented. As shown in Figure 1 below, there has decreasing and increasing trend on the time series plot. Furthermore, there have no specific seasonal and stationary patterns on Kijang Emas prices data.

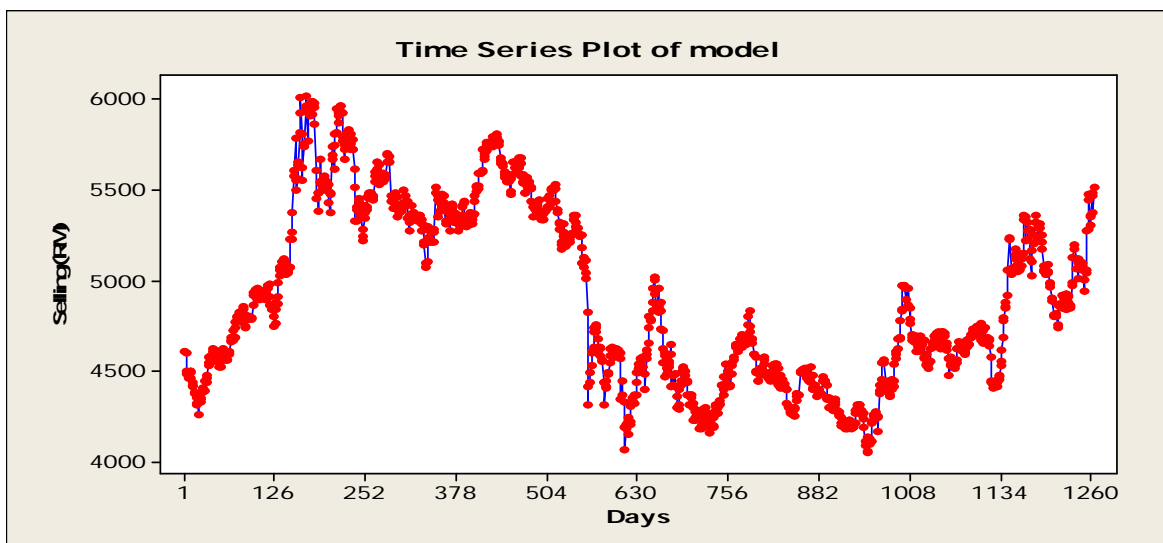


Figure 1: Time Series Plot of Kijang Emas Selling Prices

A. Forecasting by using Holt-Trend Exponential Smoothing

Model $y_t: \beta_0 + \beta_1 t$ have been developed by used linear regression method that was produced by statistical packages and the result was presented in Table 1.

Table 1: Linear Regression of Kijang Emas Price

Variable	Coefficients	Standard Error	t Stat	P-value
Intercept	5247.2165	24.98635661	210.0032671	0
X	-0.544272129	0.034218336	-15.90586213	4.65E-52

The regression model is $y_t: 5247.2165 - 0.5443t$. The constants value of the level and trend estimates which are alpha, α and gamma, γ were solved by statistical packages used to become the optimal values. They are 0.5070 of alpha and zero value for gamma.

B. Forecasting by Using ARIMA Model

Hypothesis testing and Ljung-Box test were applied to check the significance of parameters and p -values of Ljung-Box. The model that has both significant on hypothesis statistics test and Ljung-Box test is only one model that is ARIMA(4,1,4) model since the p -values of parameters(0.00) is less than significant value which is 0.05 and p -values of Ljung-Box test is larger than 0.05 at all lags of 12, 24, 36 and 48. Thus, alternative hypothesis, H_a is concluded for parameters hypothesis testing. (Hyndman and Athanasopoulos, 2014).

Thus ARIMA(4,1,4) model is selected in this method. The next step to check either the model that is selected is appropriate to be used for further forecast or not, the residual correlation of ARIMA(4,1,4) model was checked by applying ACF and PACF that presented in Figure 2 and Figure 3. It is shown that the residual of ARIMA(4,1,4) model is uncorrelated since there has no any cut off on ACF and PACF plots of the residuals.

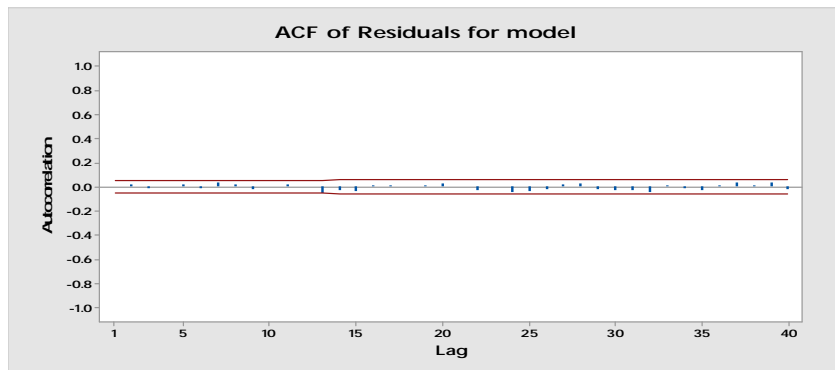


Figure 2: Autocorrelation (ACF) Plot of Residual of ARIMA(4,1,4) Model

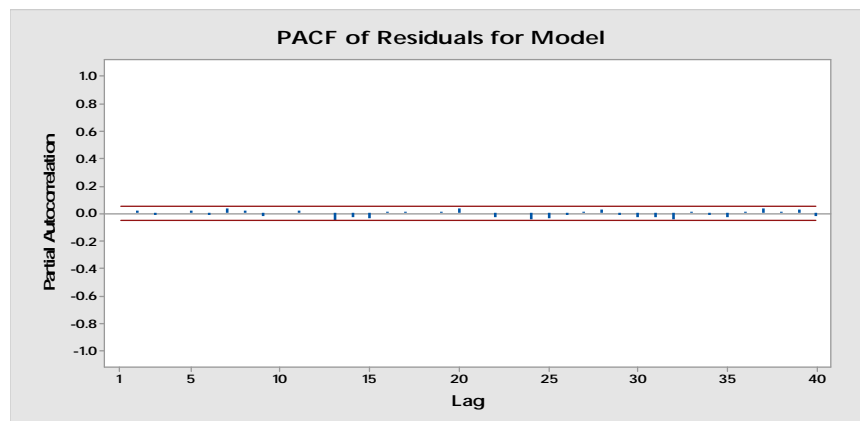


Figure 3: Partial Autocorrelation (PACF) Plot of Residual of ARIMA(4,1,4) Model

C. Forecast Accuracy

Table 2 shows the values of forecast accuracy based on RMSE, MAE and MAPE. The error measurements of mean absolute percentage error (MAPE), mean absolute error (MAE) and root mean squared error (RMSE) show that the lower values are on Holt-Trend Exponential Smoothing model. Mean absolute percentage error (MAPE) of Holt-Trend Exponential Smoothing model shows 1% meanwhile for ARIMA(4,1,4) model shows 3.4% which is the Holt-Trend Exponential Smoothing model is more appropriate model.

Table 2: Forecast Accuracy

Error Measurement	Holt-Trend Model	ARIMA(4,1,4) Model
RMSE	73.3133	222.6979
MAE	53.3793	184.7019
MAPE	0.00975	0.0342

IV. CONCLUSION

As conclusion, the three objectives of this research are achieved. Firstly is to propose exponential smoothing and ARIMA models. Secondly, to evaluate the forecast performance between Holt-Trend exponential smoothing and ARIMA models on forecasting Kijang Emas selling prices. This objective was achieved where the result is one model has been developed by used Holt-Trend exponential smoothing and one model from ARIMA model which is ARIMA(4,1,4) was selected. Comparative study have been done to achieve the third objective which is to propose the appropriate model in forecasting Kijang Emas selling prices. The finding of this study is the appropriate method of forecasting Kijang Emas price is Holt-Trend exponential smoothing.

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