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Forecasting Exchange Rate between Thai Baht and the US Dollar Using Time Series Analysis

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***Abstract*—**The objective of this research is to forecast the monthly exchange rate between Thai baht and the US dollar and to compare two forecasting methods. The methods are Box-Jenkins' method and Holt's method. Results show that the Box-Jenkins' method is the most suitable method for the monthly Exchange Rate between Thai Baht and the US Dollar. The suitable forecasting model is ARIMA (1,1,0) without constant and the forecasting equation is $\hat{Y}_t = Y_{t-1} + 0.3691\ (Y_{t-1} - Y_{t-2})$ When Y_t is the time series data at time t, respectively.

***Keywords*—**Box–Jenkins Method, Holt's Method, Mean Absolute Percentage Error (MAPE).

I. Introduction

THAILAND'S exchange rate is currently changing to the floating exchange rate that the floating value of the Baht has the movement according to the Foreign-Exchange Market under the condition of Bank of Thailand's intervention mechanism as long as necessity. However, the exchange rate has been fluctuated more and more because it meets the demand of variable in the economic changing. Influencing to every segment of the international business transactions will increase more risks, due to the value of the Baht is changing dramatically. The government sector has to keep an eye on the exchange rate movement all the time for the propose of protection stability of the value of the Baht and Thailand economic system. Therefore, both the government sector and private sector have turned to pay attention to study further about the changing of variable rate movements. This is why the attempt to use the exchange rate forecasting makes the most benefit, but the least risk. Moreover, the study of the economic factors is taken the parts of determining the exchange rate movement in the term of variety relations [1].

The value of money or the exchange rate is the most important for the economic conditions because at the present time, quite a lot of goods in one country exporting to another country, their prices might be up and down in the conditions of the exchange rates. It's the causes of changing in exporting and importing price values even travel or study overseas might be vary according to the change of the Baht, too. The weakness of the Baht makes a good benefit to the businessmen who get the USD incomes, especially the exporters, due to the exporting revenues are able to exchange more and more in the Baht. By contrast, in the importers' views, the weakness of the Baht takes the disadvantages because of the need to use more amounts of the Baht in the exchange as the USD for the importing expenses. In the case of the strength of the Baht gives the advantages to the existing expenses as the USD, for example the tourists or the parents who want to send their children to study overseas, because the expenses will be lower in the value of the Baht. Although, it will be disadvantage for the exporters because the value of USD is became lower in the Baht. The exchange rate movements have been influencing to the entrepreneurs' incoming and outgoing money or loss of money in the terrible business situation. In the middle of the fluctuating environment of the Baht has been effecting to the investment returns. In Thailand, major monetary exchange for trade in goods and services is the USD. Therefore, the Baht and the USD currencies' fluctuation as one risk is taken an interest on discussion.

Besides, the foreign investment, especially assets, commodities, or warrants relating to the commodities, such as Foreign Investment Fund (FIF), Gold futures, Silver Futures, or Oil Futures must also face the problems in the fluctuating environment of the rate of exchange. Although, the foreign investments are in the term of the Baht, the value of USD may influence the risk /reward ratio of the portfolio as well [2].

According to the discussion point, we find it's particularly interesting to compare the two methods, between Box-Jenkins' and Holt's; which one is the suitable exchange rate forecasting technique between the Baht and the USD, the well-known world currency.

II. Literature Review

A. Box–Jenkins Method

Time series demand models have as main aim the simulation of the demand trend for a given time period, on the basis of a known data base concerning the modeled variables.

From a theoretical point of view, a time series is a stochastic process, i.e. an ordered sequence of random variables, where the time index t takes on a finite or countable infinite set of value. Mean and variance of the stochastic process are used to describe it together with two functions: the Auto Correlation Function (ACF) ρ_k, k being the lag, and the Partial Auto Correlation Function (PACF) π_k, k being the lag.

The ACF is a measure of the correlation between two variables composing the stochastic process, which are k temporal lags far away; the PACF measures the net correlation between two variables, which are k-temporal lags far away.

ARMA (Auto Regressive Moving Average) models are a class of stochastic processes expressed as [3]:

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$$x_t - \sum_{i=1}^{p} \phi x_{t-i} \;\; = \;\; a_{t-} \sum_{j=1}^{q} \theta_i \, a_{t-j}$$

where ϕ and θ are model parameters; p and q are the orders of the AutoRegressive (AR) and Moving Average (MA) processes respectively. If the B operator such as $X_{t-1} = BX_t$ is introduced, the general form of an ARMA model can be written as:

$$\phi(B) \cdot x_t = \theta(B) \cdot a_t$$

Estimation of these models requires some conditions to be verified: the series must be stationary and ACF and PACF must be time-independent. Variance non-stationarity can be removed if the series is transformed with the logarithmic function. Mean non-stationarity can be removed by using the operator ∇ = 1-B applied d times in order to make the series stationary. Such transformations lead to an ARIMA (AR Integrated MA) model:

$$\nabla^d \phi(B) \cdot x_t = \theta(B) \cdot a_t$$

The above model is also called univariate because only one variable, depending on its past values, is inserted.

For a given set of data, the Box-Jenkins approach (Box and Jenkins, 1970) is the most known method to find an ARIMA model that effectively can reproduce the data generating the process. The method requires a preliminary data analysis to verify the presence of outliers and then the identification, estimation and diagnostic checking steps. The identification stage provides an initial ARIMA model specified on the basis of the estimated ACF and PACF, starting from the original data; particularly, the characteristics of ACF and PACF allow the identification of the model order:

1. if the autocorrelations decrease slowly or do not vanish, there is non-stationarity and the series should be differenced until stationarity is obtained; then, an ARIMA model can be identified for the differenced series;
2. if ACF ρ_k is zero for k>q and PACF is decreasing, then the process underlying the series is an MA(q);
3. if PACF π_k is zero for k>p and ACF is decreasing, then the process underlying the series is an AR(p);
4. if there is no evidence for an MA or an AR then an ARMA model may be adequate.

Several statistical tests have been developed in the literature to verify if a series is stationary; among these, the most widely used is the Dickey-Fuller test [4] which requires the estimation of the following model:

$$x'_t = \phi x_{t-1} + b_1 x'_{t-1} + \ldots + b_p x'_{t-p}$$

where X'_t denotes the differenced series $X_t - X_{t-1}$. The number of lagged terms in the regression, p, is usually set to be 3. Then, if the original series Xt has to be differentiated, the estimated value of ϕ will be close to zero, while if X_t is already stationary, the estimated value of ϕ will be negative

The model estimation is carried out after an initial model has been identified; generally, model parameters are estimated by using least squares or maximum likelihood methods.

Finally, different diagnostic tests can be performed. For large sample size, if the order of the AR component is p, the estimate of the partial autocorrelations π_k are approximately normally distributed with mean zero and variance 1/N for k>p, where N is the sample size. Then, it should be verified if the residuals of the calibrated model belong to a white noise process. To this aim, the significance of the residual autocorrelations is often checked by verifying if they are within two standard error bounds, $\pm 2/\sqrt{N}$, where N is the sample size [5]. If the residual autocorrelations at the first N/4 lags are close to the critical bounds, the reliability of the model should be verified.

Another test is that of Ljung and Box [6], defined as:

$$Q = N \cdot (N+2) \cdot \sum_{k=1}^{m} (N-k)^{-1} \left[\rho_{\hat{a}}(k)\right]^2$$

where are the autocorrelations of estimation residuals and k is a prefixed number of lags. For an ARMA (p, q) process this statistic is approximately χ^2distributed with (k-p-q) degrees of freedom if the orders p and q are specified correctly.

B. Holt's Method

A technique frequently used to handle a linear trend is Holt's method. It's Method. A technique frequently used to handle a linear trend is Holt's method. It smooths the trend by using different (alpha and beta) smoothing constants [7]. Three equations are used:

$$L_t = \alpha Y_t + (1 - \alpha)\,(L_{t-l} + T_{t-l})$$

$$T_t = \beta\,(L_t - L_{t-1}) + (1 - \beta)\,T_{t-1}$$

$$F_{t+p} = L_t + pT_t$$

where L_t = the new smoothed value; α= the smoothing constant for the data ($0 < \alpha < 1$); Y_t = the new observation or actual value of series in period t; β = the smoothing constant for trend estimate ($0 < \alpha < 1$); T_t = the trend estimate; P = the periods to be forecast into the future, F_{t+p} = the forecast for p periods into the future.

The initial values for the smoothed series and the trend must be set in order to start the forecasts [8]. In this research, the first estimate of the smoothed series was assigned a value equal to the first observation. The trend was then estimated to equal zero. Accuracy of Holt's exponential smoothing method requires optimal values of alpha (α) and beta (β). The optimal alpha and beta values were selected on the basis of minimizing the MSE. As in simple and double exponential smoothing methods, this r method also required a tracking signal to monitor pattern changes.

III. Results and Analysis

Paper used the monthly Thai baht and US dollar exchange rate. All the data were collected from the bank of Thailand.

Data were collected for the period January 2002 to December 2013.There were overall 132 observations; paper used data till December 2012 to build the model, while remaining data were hold for checking the accuracy of the forecasting performance of the model.

A. Estimation of Box–Jenkins Method

From the graph in Fig. 1 shows the graph of the observe data which gives the general idea about the time series data, and the components of time series present. The trend of the time series data exhibits a stair case trend and has no seasonal variation (not periodic).

The sample autocorrelation of the original series in Fig. 2 failed to die quickly at high lags, confirming the non-stationarity behaviour of the series which equally suggests that transformation is required to attain stationary. Consequently, the difference method of transformation was adopted and the first difference (d=1) of the series was made. The plot of the stationary equivalent is given in Fig. 3 while the plots of the autocorrelation and partial autocorrelation functions of the differenced series are given in Figs. 4 and 5, respectively.

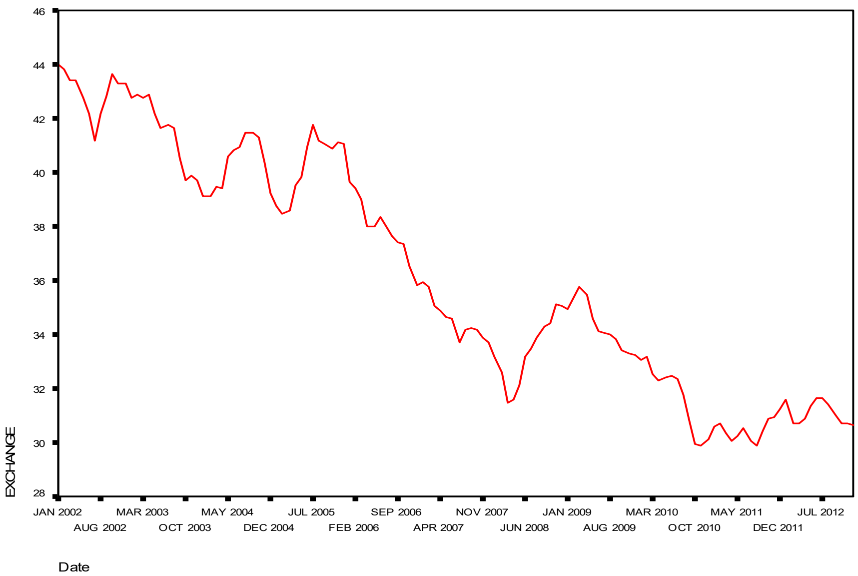

Fig. 1 Graph of Thai Baht and US Dollar Exchange Rate for the period Jan 2002 - Dec 2012

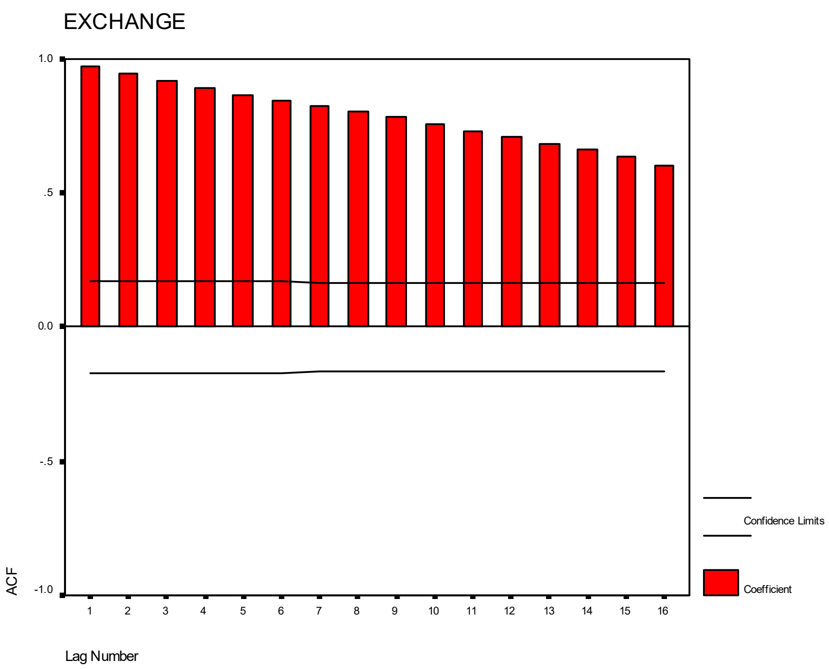

Fig. 2 Plot of autocorrelation functions of the original series

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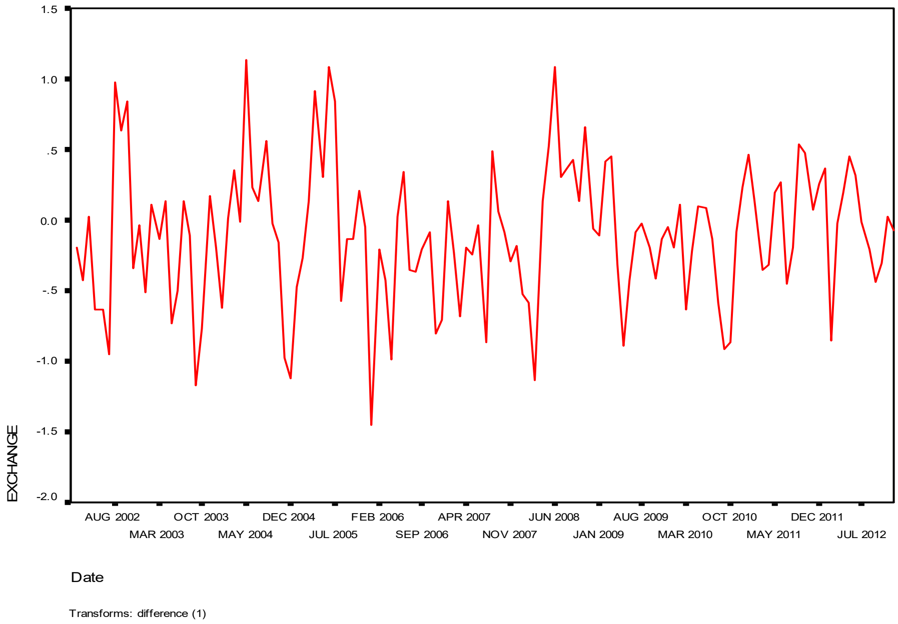

Fig. 3 Graph of first differenced of data

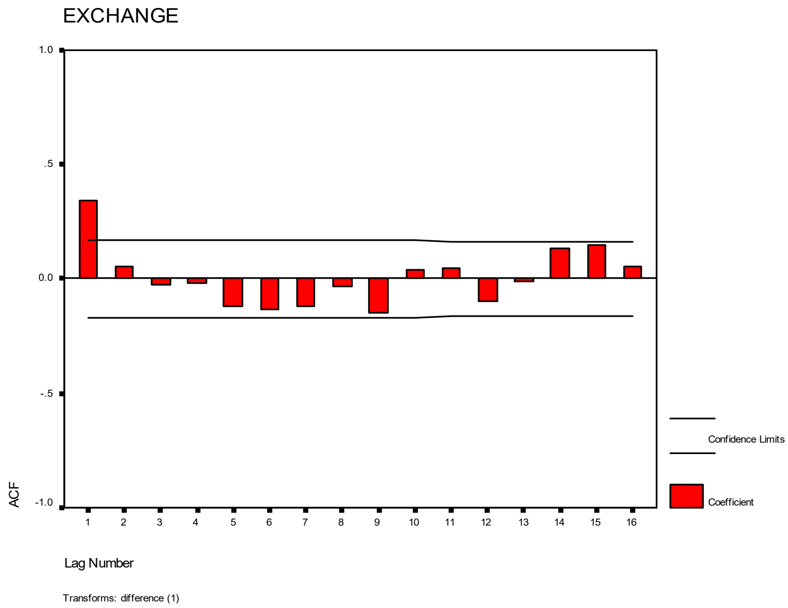

Fig. 4 Graph of first differenced autocorrelation function

The first order difference was enough to make the data stationary. Therefore ARIMA (*p,1, q*) could be identified. The alternating positive and negative ACF suggestion autoregressive process. (Fig. 4) Using the PACF with a significant spike at lag 1, ARIMA (1, 1, 0) was identified (Fig. 5). Table I shows the estimates of the ARIMA (1,1, 0) model.

This is shown in Table I. Small p-value indicate that the coefficients of the selected model are significant.

TABLE I
ESTIMATES OF ARIMA (1, 1, 0) MODEL

Variable	Coefficient	T-Statistic	Prob.
Ar(1)	0.3691	4.5363	0.0000
Log Likelihood	-86.361968		
Aic	174.72394		
Sbc	177.59913		

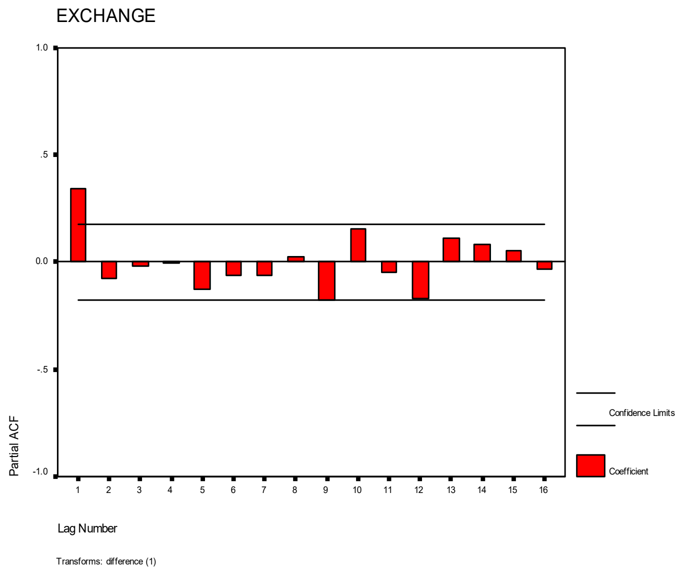

Fig. 5 Graph of first differenced partial autocorrelation function

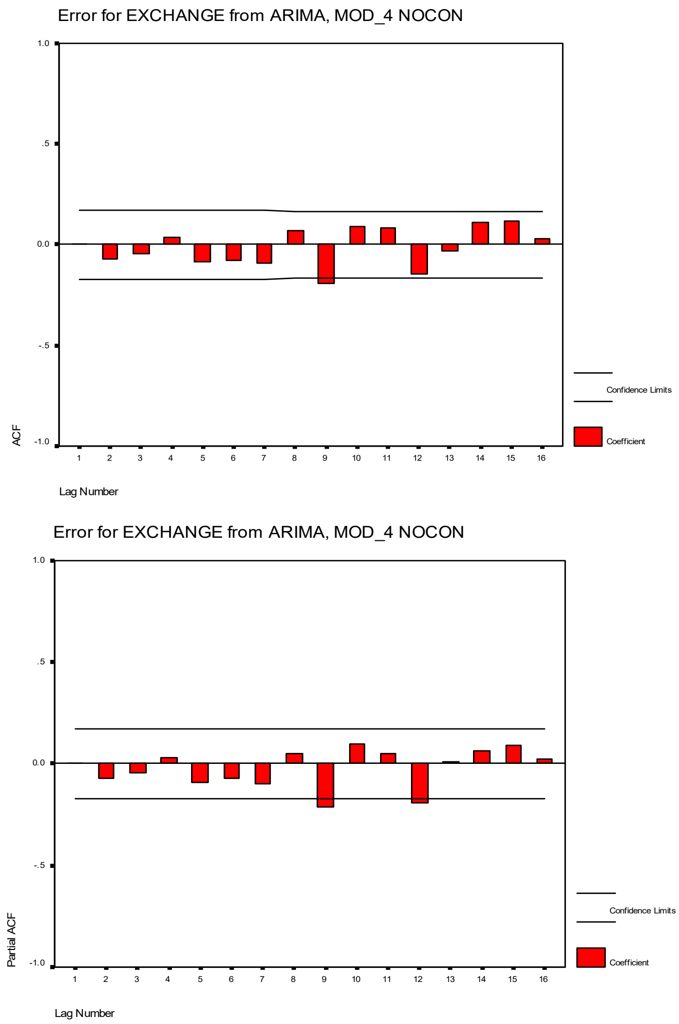

Fig. 6 Residual ACF and PACF up to the 16 lags

The model equation is:

$$\hat{Y}_t = Y_{t-1} + 0.3691\ (Y_{t-1} - Y_{t-2})$$

After estimating parameters for this model the adequacy of the model was checked by their residuals. Fig. 6 represents the diagnostic values of the residuals. From this figure we can conclude that residuals are independently and identically distributed sequence with mean zero and constant variances. Box-Pierce and Ljung-Box tests show high p-value associated with the statistic shown in Table II.

TABLE II
BOX-LJUNG TEST

Box-Ljung statistic	LAG	Prob.
19.271	16	.255

Finally, based on the above results, the ARIMA (1, 1, 0) model was found adequate to represent the considered time series data on contribution of exchange rate between Thai baht and the US dollar and used for forecasting purpose

B. Estimation of Holt's Linear Smoothing Model

At first, we have to obtain the value of the smoothing parameters that give the minimum mean square error for the model. The desired value of alpha and beta are estimated as α=1, β=0.01 which minimizes the SSE of 32.14818

Thus our Holt's linear model becomes:

$$L_t = Y_t$$

$$T_t = 0.01\ (L_t - L_{t-1}) + (0.99)\ T_{t-1}$$

$$F_{t+p} = L_t + pT_t$$

Forecast:, $F_{t+p} = L_t + pT_t$ this model is used to forecast the future values.

C. Forecasting Accuracy

There are several methods of measuring accuracy and comparing one forecasting method to another, we have selected Mean Absolute Percentage Error (MAPE). The MAPE are as follows:

TABLE III
MEAN ABSOLUTE PERCENTAGE ERROR

	ARIMA	Holt's
MAPE	2.9981	4.1290

Table III shows that the Mean Absolute Percentage Error is less in ARIMA as compared to Holt's.

IV. CONCLUSION

To forecast the monthly Determining Thai Baht and US Dollar Exchange Rate and to compare two methods of forecasting, the Box-Jenkins' method, Holt's method and combined forecast based on regression method are used. The method which gives the lowest Mean Absolute Percent Error (MAPE) is the most suitable method. Results show that the Box-Jenkins' method is the most suitable method for the monthly Determining Thai Baht and US Dollar Exchange Rate.

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