CHAPTER 3

Methodology

This study examines the best model using ARFIMAX (p,d,q,X) and (p,d,q,X)–GARCH (p,q) models to predict the Thai Baht gold spot price with exchange rate of THB per USD.

1. Information of data, this research used the secondary data, which is the time series data during the period from September 2001 to September 2011 such as the Thai Baht gold spot price 96.50%, the Thai Baht gold spot price 99.99% and the exchange rate of THB per USD (unit: Baht rate).

2. The research methodology, in this study incorporates descriptive method and econometric analysis techniques to examine.

3.1 Methodology

3.1.1 Calculating Percent Growth Rates

Adjust information of Thai Baht gold spot price 96.50% and Thai Baht gold spot price 99.99% in form of growth rate follow as:

$$\Delta P_{n,t} = \frac{(P_{n,t} - P_{n,t-1})}{P_{n,t-1}} \times 100$$

$$\Delta P_{m,t} = \frac{(P_{m,t} - P_{m,t-1})}{P_{m,t-1}} \times 100$$

where $P_{n,t}$ = the Thai Baht gold spot price 96.50% at time t

$P_{m,t}$ = the Thai Baht gold spot price 99.99% at time t

$P_{n,t-1}$ = the Thai Baht gold spot price 96.50% at time $t-1$

$P_{m,t-1}$ = the Thai Baht gold spot price 99.99% at time $t-1$

3.1.2 Unit root test by using Augmented Dickey-Fuller Test and Phillips Perron Test for test stationary of the data.

1. **ADF test**, test the time series data for stationary follow as:

$$\Delta G_{n,t} = \alpha_1 + \beta_1 t + \delta_1 G_{n,t-1} + \sum_{i=1}^{m} s_i \Delta G_{n,t-1} + \varepsilon_{1t}$$

$$\Delta G_{m,t} = \alpha_1 + \beta_1 t + \delta_1 G_{m,t-1} + \sum_{i=1}^{m} s_i \Delta G_{m,t-1} + \varepsilon_{1t}$$

$$\Delta E_t = \alpha_2 + \beta_2 t + \delta_2 E_{t-1} + \sum_{i=1}^{m} r_i \Delta E_{t-1} + \varepsilon_{2t}$$

where $G_{n,t}$ = the Thai Baht gold spot price 96.50% at time t

$G_{m,t}$ = the Thai Baht gold spot price 99.99% at time t

$G_{n,t-1}$ = the Thai Baht gold spot price 96.50% at time $t-1$

$G_{m,t-1}$ = the Thai Baht gold spot price 96.50% at time $t-1$

E_t = the exchange rate of THB per USD at time t

E_{t-1} = the exchange rate of THB per USD at time $t-1$

α_1, α_2, β_1, β_2, δ_1, δ_2, s, r = parameters

ε_{1t}, ε_{2t} = random error terms

t = trend

The hypotheses for test are following as:

$H_0 : \delta_i = 0$ (non-stationary)

$H_1 : \delta_i < 0$ (stationary) when $i = 1, 2$

If H_0 is accepted then the Thai Baht gold spot price and exchange rate has unit root and non stationary but if H_1 is accepted then the Thai Baht gold spot price and exchange rate has no unit root.

2. Phillips and Perron Test, this test was developed by Phillips and Perron (1988). The model follows as:

$$\tilde{t}_p = t_p(\frac{\omega_0}{B})^{\frac{1}{2}} - \frac{T(B-\omega_0)(s_p(\hat{\varphi}))}{2B^{1/2}e}$$

where $\tilde{t}_p$ = the ratio of p

B = residual of estimate

ω_0 = consistent estimate of the error variance

e = the standard error from the regression test

The hypotheses for test same as ADF-Test are following as:

$H_0 : \tilde{t}_p = 0$ (non-stationary)

$H_1 : \tilde{t}_p < 0$ (stationary) when $p = 1, 2$

If H_0 is accepted then the Thai Baht gold spot price and exchange rate has unit root and non stationary but if H_1 is accepted then the Thai Baht gold spot price and exchange rate has no unit root and stationary.

Table 3.1: Unit Root Test

	Unit Root Test	
	ADF-Test	**PP-Test**
H_0	has unit root	has unit root
H_1	has no unit root	has no unit root
Variables Thai Baht Gold spot price Exchange rate (THB/USD)	If test is accept H_1 ↓ means that the Thai Baht gold price and exchange rate has no unit root.	If test is accept H_1 ↓ means that the Thai Baht gold price and exchange rate has no unit root.

After unit root test for ADF test and PP test, the test is accepted H_1 means that the Thai Baht gold spot price and exchange rate has no unit root. Next, the data can be used for long memory approach to find that the data has long term memory or no long term memory.

3.1.2 Test for Long Memory Approach by R/S test, modified R/S test and GPH test for test the data

1. R/S test

The Hurst exponent could be found as:

$$\ln(R/S)_g = \ln(m) + H\ln(g) \qquad \text{when } g = t_1, t_2, \ldots, T$$

The value of Hurst exponent (H) is used to measure correlations between time series. It defines that if H value is 0.5 means the series will be independent or no correlated. If H value is ($0 < H < 0.5$) means the series will be anti-persistent or negative correlated. If H value is ($0.5 < H < 1$) means the series will be a persistent or positive correlated, the process has long memory.

The hypotheses for test are following as:

H_0 : no long term memory

H_1 : long term memory

If H_0 is accept then the Thai Baht gold spot price and exchange rate has no long term memory but if H_1 is accept then the Thai Baht gold spot price and exchange rate has long term memory.

2. Modified R/S test

The modified R/S statistic, Lo was developed from R/S test define as:

$$Q_{n,m} = \hat{R} / \hat{\sigma}_{n,m}(q)$$

where $$\hat{R} = \{\max_{1 \le i \le n,m} \sum_{t=1}^{i} (x_t - \bar{x}) - \min_{1 \le i \le n,m} \sum_{t=1}^{i} (x_t - \bar{x})\} \quad \text{when } t = 1, 2, ..., T$$

$$\hat{\sigma}_{n,m}^2(q) = \sigma_{n,m}^2 + 2\sum_{t=1}^{k} \omega_j(q)\gamma_j$$

Define that $\sigma_{n,m}^2$ = the sample variance of the Thai Baht gold spot price 96.50% with exchange rate of THB per USD and the Thai Baht gold spot 99.99% with exchange rate of THB per USD (unit: Baht rate)

$\bar{x}$ = the mean of data

γ_j = lag-j autocovariance for the data

The hypotheses for test are following as:

H_0: no long term memory

H_1: long term memory

If H_0 is accept then the Thai Baht gold spot price and exchange rate has no long term memory but if H_1 is accept then the Thai Baht gold spot price and exchange rate has long term memory.

3. GPH Test

The GPH test was developed by Geweke, J. and S. Porter-Hudak (1983) defines as:

$$\ln\left[\hat{I}(\lambda_j)\right] = c + d\ln\left[2\sin(\frac{\lambda_j}{2})\right]^2 + e_j \quad \text{when } j = 1, 2, \ldots, m$$

where $$\hat{I}(\lambda_j) = \frac{1}{2\pi}\left[\sum_{i=-(T-1)}^{T-1}\hat{\gamma}_i \cos(i\lambda_j)\right]$$

The hypotheses for test are following as:

H_0: no long term memory

H_1: long term memory

If H_0 is accept then the Thai Baht gold spot price and exchange rate has no long term memory but if H_1 is accept then the Thai Baht gold spot price and exchange rate has long term memory.

After test long memory of the data and the result shows that the data has long term memory then the data can be used the ARFIMAX and ARFIMAX-GARCH models to find the best model.

3.1.3 The general form of ARFIMAX (p,d,q,X) model

The model was introduced by Granger and Joyeux (1980) and Hosking (1981). The model could be written as:

$$a(L)(1-L)^d(y_n - X_t B) = b(L)\varepsilon_t \quad \text{when } \varepsilon_t \sim i.i.d.N(0,\sigma_\varepsilon^2)$$

$$a(L)(1-L)^d(y_m - X_t B) = b(L)\varepsilon_t \quad \text{when } \varepsilon_t \sim i.i.d.N(0,\sigma_\varepsilon^2)$$

where $(1-L)^d$ = the fractional differencing operator

d = the fractional integration parameter

y_n = the Thai Baht gold spot price 96.50%

y_m = the Thai Baht gold spot price 99.99%

X_t = the exchange rate of THB per USD (unit: Baht rate)

ε_t = error term

3.1.4 The general form of ARFIMAX (p,d,q,X)-GARCH (p,q) model

The model was introduced by Granger and Joyeux (1980) and Hosking (1981). The ARFIMAX (p,d,q,X) model can be written as:

$$a(L)(1-L)^d(y_n - X_t B) = b(L)\varepsilon_t \quad \text{when } \varepsilon_t \sim i.i.d.N(0,\sigma_\varepsilon^2)$$

$$a(L)(1-L)^d(y_m - X_t B) = b(L)\varepsilon_t \quad \text{when } \varepsilon_t \sim i.i.d.N(0,\sigma_\varepsilon^2)$$

The standard GARCH (p,q) model that the GARCH (1, 1) proposed by Bollerslev (1986) can be written as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \psi_1 \sigma_{t-1}^2$$

where σ_t^2 = the variance of error term

α_0 = constant

$\alpha_1\mu_{t-1}^2$ = last period's volatility

$\psi_1\sigma_{t-1}^2$ = last period's variance

where $\alpha_0 > 0$ and the constraints $\alpha_1 \geq 0$ and $\psi_1 \geq 0$ are needed to ensure $\sigma_{t-1}^2 > 0$ or strictly positive conditional variance. This model assumes that the positive shocks ($\mu_t > 0$) and negative shocks ($\mu_t < 0$) have the same impact on the conditional variance. The α_1 is the ARCH effect which indicates the short run persistence of shocks and ψ_1 is the GARCH effect which indicates the long run persistence of shocks.

3.1.5 Information Criteria: Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC)

The Akaike (1974, 1976) and Bayesian (1978) information criteria for selecting the most parsimonious correct model are respectively.

Akaike: $$c_n(h) = \frac{-2\cdot\ln(L_n(h))}{n} + \frac{2h}{n}$$

Bayesian: $$c_n(h) = \frac{-2\cdot\ln(L_n(h))}{n} + \frac{h\cdot\ln(n)}{n}$$

where $L_n(h)$ = the maximized value of the likelihood function for the estimated model.

h = number of parameters used.

n = the sample size.

The lowest value of both AIC and BIC using to select the best (p,d,q,X) and ARFIMAX (p,d,q,X)-GARCH (p,q) models for predict the Thai Baht gold spot price with exchange rate volatility.

3.1.6 The Mean Absolute Error (MAE)

The MAE used to measure how close forecasts or predictions are to the eventual outcomes. In form of the MAE follows as:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|p_i - t_i\right|$$

where p_i = the prediction

t_i = the true value.

This research was used the MAE measure the error of the Thai Baht gold spot price with exchange rate volatility based on the ARFIMAX (p,d,q,X) and ARFIMAX (p,d,q,X)–GARCH (p,q) models.

3.1.7 The Mean Absolute Percentage Error (MAPE (%))

The formula of MAPE follows as:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{S_t - R_t}{S_t}\right|$$

where S_t = the actual value

R_t = the forecast value.

n = the date of forecast

If the MAPE value is less than 10%, it is a highly accurate forecast. If the MAPE value is between 10% and 20%, it is a good forecast. If the MAPE value is between 20% and 50%, it is a reasonable forecast. If the MAPE value is greater than 50%, it is an inaccurate forecast.

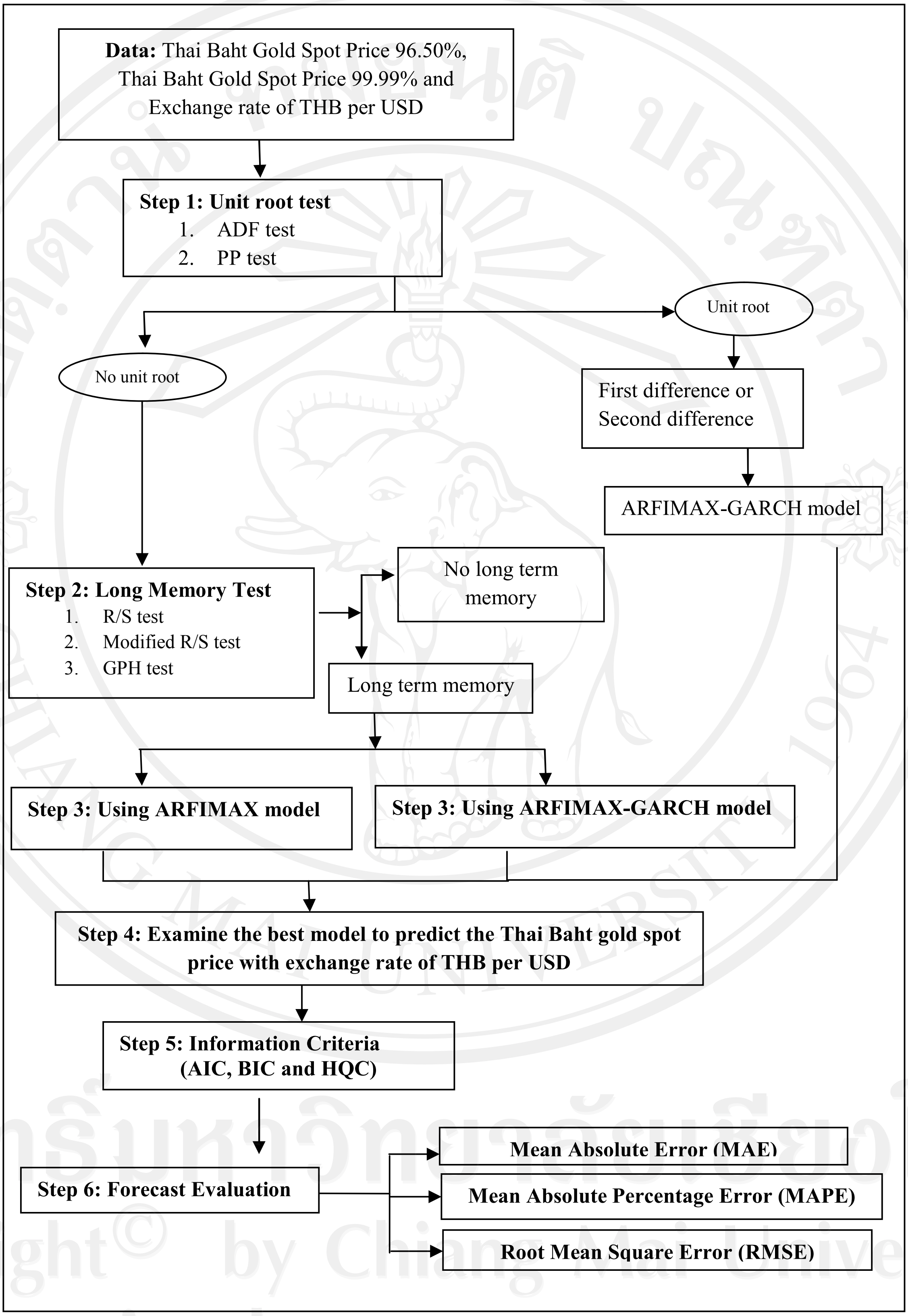

Figure 3.1: Scope of research methodology

Figure 3.1 shows the scope of the research methodology which can be divided into 6 steps follow as:

First step adjusts the data such as the Thai Baht gold spot price 96.50%, the Thai Baht gold spot price 99.99% and exchange rate of THB per USD in form of the growth rates. Then, test the data using the unit root test which is the Augmented Dickey-Fuller Test (ADF test) and Phillips Perron Test (PP Test). If test is not significant, we should be first difference the data and using ARFIMAX-GARCH model. Otherwise, if test the data has no unit root means we can do the next step.

Second step is to estimate the volatility of the Thai Baht gold spot price 96.50% with exchange rate of THB per USD and the Thai Baht gold spot price 99.99% with exchange rate of THB per USD using long memory test which is R/S test, Modified R/S test and GPH test. If the data has no long memory, we should find the new data. Otherwise, if the data has long term memory then we carry on with the next step.

Third step using ARFIMAX (p,d,q,X) and ARFIMAX (p,d,q,X)-GARCH(p,q) models for study the volatility and relationship between the Thai Baht gold spot price 96.50% with exchange rate of THB per USD and the Thai Baht gold spot price 99.99% with exchange rate of THB per USD.

Fourth step is to examine the best model for predicts the Thai Baht gold spot price with exchange rate of THB per USD.

Fifth step select the best model between ARFIMAX (p,d,q,X) and ARFIMAX (p,d,q,X)-GARCH(p,q) models using the minimum value of Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC) and Hannan-Quinn information criterion (HQC)

Finally, forecast evaluation of the best model between ARFIMAX (p,d,q,X) and ARFIMAX (p,d,q,X)-GARCH(p,q) models using the value of MAE and MAPE (%).