การศึกษาเปรียบเทียบระหว่างโครงข่ายประสาทเทียมกับแบบจำลองการถดถอยเชิงเส้นในการพยากรณ์อัตราแลกเปลี่ยนที่แท้จริงของเงินบาท

Comparative Study of Artificial Neural Networks (ANN) and Linear Regression Model in Forecasting Thai Baht Real Effective Exchange Rate (REER)

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บทคัดย่อ

งานวิจัยนี้มุ่งที่จะศึกษาความสัมพันธ์ระหว่างตัวแปรอิสระ 6 ตัวที่ได้มาจากกลุ่มของทฤษฎีพื้นฐาน 3 กลุ่มกับตัวแปรตามอันได้แก่อัตราแลกเปลี่ยนที่แท้จริงของเงินบาท โดยเปรียบเทียบความสามารถในการพยากรณ์ค่าอัตราแลกเปลี่ยนที่แท้จริงของเงินบาทนี้ระหว่างวิธีการทางเศรษฐมิติดั้งเดิมกับเทคนิคโครงข่ายประสาทเทียมที่เพิ่งได้รับการพัฒนาขึ้นมาใหม่

โดยในการศึกษานี้ข้อมูลรายเดือนที่ได้รับจากแหล่งข้อมูลภายนอกจะถูกแบ่งเป็นสองกลุ่ม ข้อมูลกลุ่มแรกถูกใช้เพื่อทำให้โมเดลที่จะใช้พยากรณ์ทำการ “เรียนรู้” หรือระบุโครงสร้างความสัมพันธ์ระหว่างตัวแปร ข้อมูลกลุ่มที่สองถูกใช้เป็นค่ามาตรฐานในการเปรียบเทียบความแม่นยำในการพยากรณ์ระหว่างทั้งสองวิธีการ

ผลการศึกษาบ่งชี้ว่าโมเดลทางเศรษฐมิติมีความเหนือกว่าโครงข่ายประสาทเทียมในด้านความแม่นยำของการพยากรณ์ ผลที่ได้นี้ตรงกันข้ามกับผลที่ได้รับจากส่วนใหญ่ของงานวิจัยอื่นๆที่ทำการศึกษาเปรียบเทียบระหว่างสองโมเดลนี้ สาเหตุหนึ่งอาจจะเป็นเพราะว่าโครงข่ายประสาทเทียมเป็น “โมเดลที่ทำการเรียนรู้” ยิ่งมีข้อมูลป้อนให้มากเท่าไร ผลการทำนายของมันก็จะยิ่งแม่นยำมากขึ้นเท่านั้น ในงานวิจัยอื่นหลายๆชิ้น จำนวนของข้อมูลที่ป้อนให้โครงข่ายประสาทเทียมมีเป็นพันๆหรือกระทั่งหมื่นๆช่วงเวลา ในขณะที่งานวิจัยนี้มีเพียง 198 ช่วงเวลาเท่านั้นเนื่องมาจากข้อจำกัดทางด้านพัฒนาการของภาคการเงินในประเทศไทย ดังนั้นจำนวนข้อมูลที่น้อยนี้จึงจำกัดโครงข่ายประสาทเทียมไม่ให้แสดงศักยภาพของมันได้อย่างเต็มที่

Abstract

This study aims to examine the relationship between six independent variables obtained from three groups of background theories and the dependent variable, namely Thai Baht Real Effective Exchange Rate (REER), by comparing the predictive performance for this Thai Baht REER between traditional econometric approach and recently innovated ANN technique.

Monthly data obtained from outside sources is divided into two groups. The first group is used to make the predicting models “learn” or construct the relationship between variables. The second group is employed as a touchstone to compare the forecasting accuracy between the two contesting models.

The result indicates that Linear Regression Model (econometrics) transcends ANN in forecasting performance. This is contrary to the results of many comparative studies

concerning these two predictive methods. One reason could be that ANN was a “learning” model. The higher number of training samples, the better forecasting results. In many cases of other researches, the amount of training samples is thousands, or even ten thousands, while the number of training samples in this study is only 198 due to the limitation in historical financial data in Thailand. Thus, the small size of input data restricts ANN from performing at its highest potential.

Key words: Real Effective Exchange Rate (REER), Linear Regression Model, Artificial Neural Networks (ANN), training samples, testing samples.

Background and Rational

Currency exchange rate is one of important factors for any modern economy as the world becomes more globalized and international trade has increased in volume and significance. Moreover, it also has direct impacts on national economic performance as currency exchange rate determines levels of import and export which, in turn, affect price level, unemployment, national income and economic growth.

There are two types of exchange rate. One is nominal exchange rate (or bilateral exchange rate) which is the value of domestic currency relative to currency of another country, such as Thai Baht/U.S. Dollar. The other is real effective exchange rate (REER) which is the weighted average of domestic currency value relative to currency of all trading partner countries.

There are many factors that affect currency exchange rate. Several researches have been conducted in this particular area with various input variables. This study, however, seeks to examine particular set of independent variables based on three groups of economic theories concerning currency exchange rate.

The first group is Monetary Approach. The latest developed model of this group is Real Interest Differential (RID) Model. The model was developed by Jeffrey A. Frankel in 1979. RID model earns great recognition around the world for its ability to forecast exchange rate movement to a large extent. Although the popularity of the model slightly diminished later by the study of Isaac and De Mel (Isaac and De Mel, 1999) which concluded that Frankel’s validation of the RID model was pure historical accident, the more recent study of Peterson (Peterson, 2005), however, found that the model was well able to explain the exchange rate movements to a certain degree.

The second group is the Law of One Price. Its main concept is that, if markets are efficient, the price of identical goods or services must be the same regardless of markets they are traded. The origin of this concept can be traced back to French economists in

1760’s to 1770’s., who applied the “law” to international trading markets. This group consists of five economic theories which are the Purchasing Power Parity (PPP) Theory, the Fisher Effect (FE) Theory, the International Fisher Effect (IFE) Theory, the Interest Rate Parity (IRP) Theory and the Forward Rate Parity (FRP) Theory

The last group is Portfolio Balance Approach. This concept was one of the most active areas of research during the 1970s' renaissance of exchange rate theories. It has a high influence on economists nowadays by its theoretical support of the sterilized intervention as a third instrument, besides monetary and fiscal policy, that can be employed by authorities to influence currency exchange rates and other economic variable.

Traditionally, any researches examining relationship between variables are conducted by using econometric method. Time series models are constructed and the estimation for coefficient of relationship between each input variables and the dependent variable are obtained. This approach has limitation as it takes into account only linear relationships while many of relationships between economic variables are non-linear.

This problem can be overcome by the advent of Artificial Neural Networks (ANN). It is a computer model developed to emulate the human pattern recognition function or neural networks. ANN is a non-linear model that can be trained to map past and future values of time series data and thereby identify hidden structure and relationship of the data. Many researchers have been induced by ANN’s freedom from restrictive assumptions such as linearity that are often required to make traditional mathematical models such as econometric workable.

Because of limitations of the traditional forecasting method, non-linear alternative like ANN becomes increasingly popular nowadays. This study intends to employ this new technique to the case of Thai currency, and contest it against an econometric method in order to find out whether ANN is superior as it should be or not and what are the reasons for that.

Purpose of the Study

1) To employ ANN and econometric model in prediction the value of Thai Baht real effective exchange rate.

2) To compare the predictive performance between ANN models, as a modern development, and traditional econometric approach.

Research Methodology

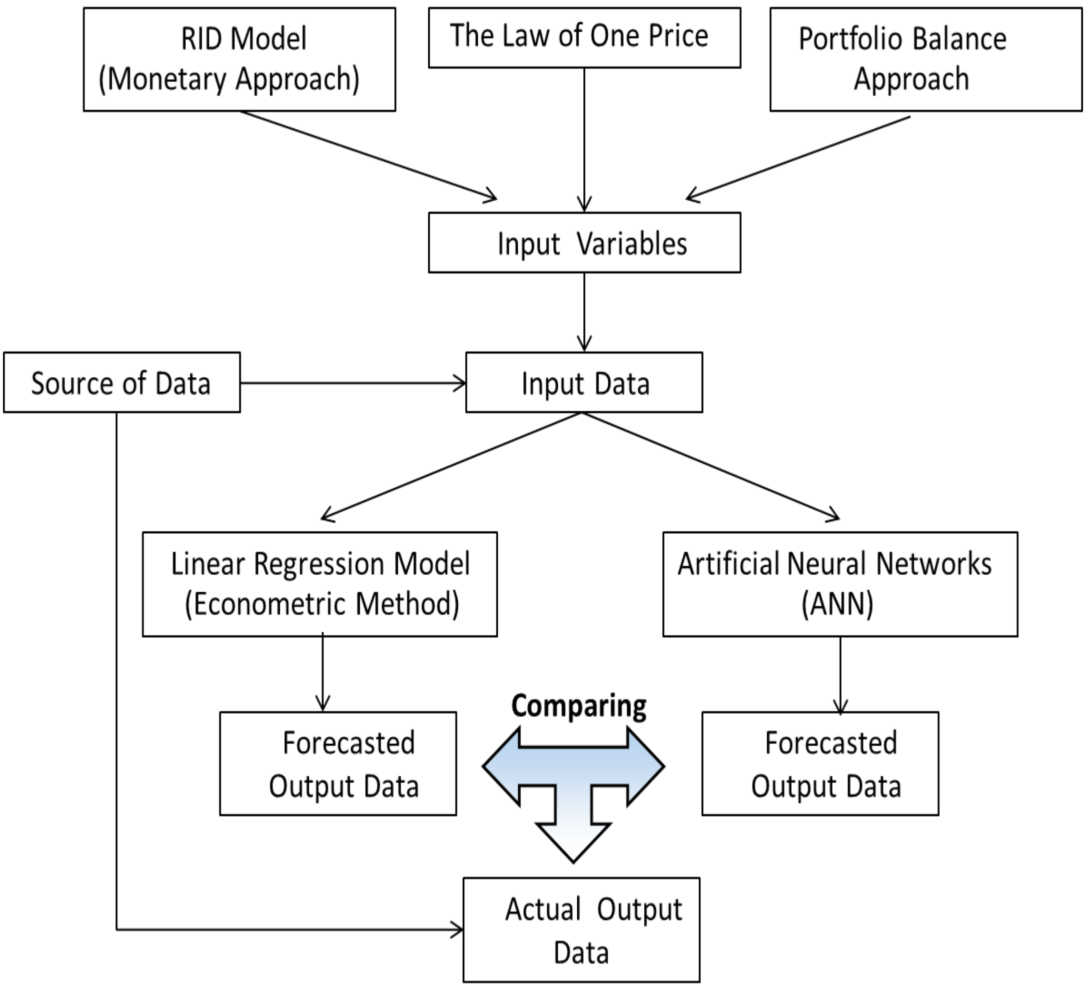

Figure 1 Research Design

Figure 1 shows our research design. From three groups of relevant theories, we can select input variables for our model. Then we gather real data concerning these variables from sources of data like the Bank of Thailand, the Stock Exchange of Thailand etc. and use it as our input data. The same set of this input data will be analyzed by both Linear Regression Model and ANN. Each method will give us its own set of forecasted output data which will be used to compare with actual output data obtained from sources of data. And finally we can figure out which approach performs better in the term of forecasting error.

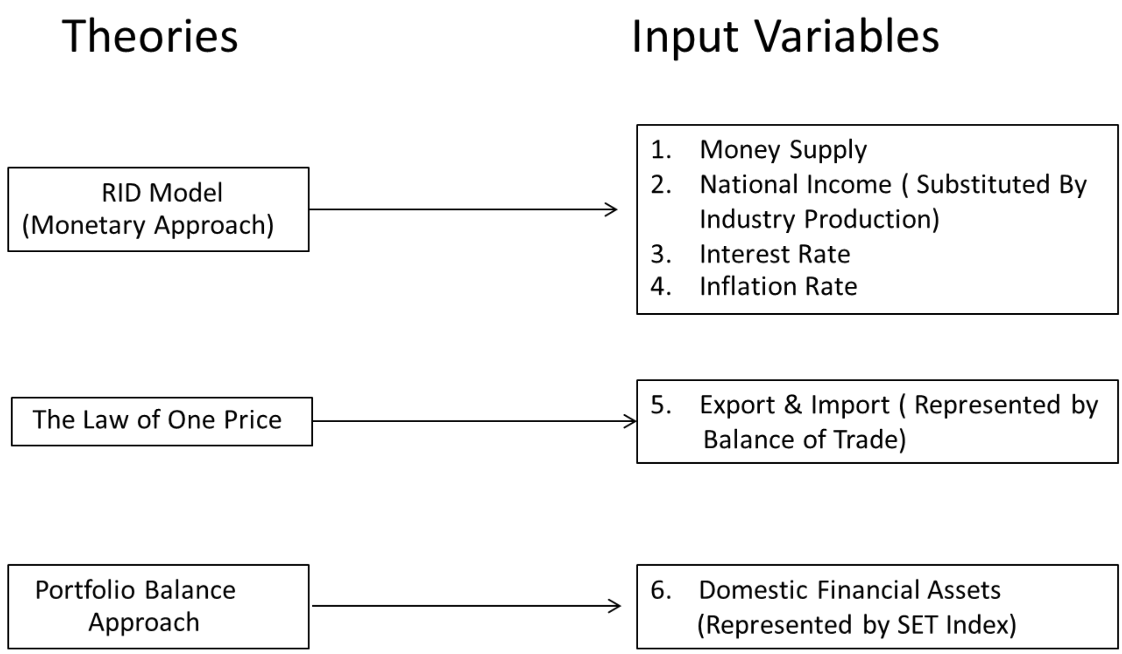

Figure 2 Theoretical supports of independent variables

The dependent variable of this study is Thai Baht REER. There are six independent variables acquired from three groups of theories. (Figure 2) Four of them, which are money supply, national income, interest rate and inflation rate are derived from RID Model. National income data in Thailand, however, is quarterly while other data used in our analysis is monthly. Therefore, it is substituted by industry production data.

Many of input variables obtained from the Law of One Price are identical to those from RID Model. Therefore, we can add only one more variable from this law to be employed in our study which is balance of trade (export to import). The last variable, which is domestic financial assets represented by SET Index, is from Portfolio Balance Approach.

Data used in this paper are monthly, 216 periods from July 1997, which is the first month Thailand adopted floating exchange rate system, to June 2015. The data is divided into two groups in order to perform the contest. The first group is training samples, including 198 periods from July 1997 to December 2013. They are used to make the predicting models "learn" or construct the relationship between variables. The second group is testing samples, including 18 periods from January 2014 to June 2015. They are employed as a touchstone to compare the forecasting accuracy between the two contesting models.

Data for money supply is represented by Thailand money supply M1 from trading economics website. Data for interest rate is represented by average interbank overnight lending rate from the Bank of Thailand. Inflation data is represented by Thailand core inflation rate from trading economics website. Also, data of Thailand industry production and

Thailand balance of trade is collected from trading economics website. SET index historical data is obtained from the Stock Exchange of Thailand. Thai Baht REER data is recorded by the Bank of Thailand.

Econometric Model

OLS regression analysis model is given as below to measure out coefficients of independent variables, namely money supply, interest rate, inflation rate, industrial production, balance of trade and SET index.

$$REER_t = \beta 0 + \beta 1\ MS_t + \beta 2\ IR_t + \beta 3 IF_t + \beta 4\ IP_t + \beta 5\ BT_t + \beta 6\ SET_t + \varepsilon\ t$$

Where:

$REER_t$: Thai Baht real effective exchange rate at time t
MS_t : money supply at time t
IR_t : interest rate at time t
IF_t : inflation rate at time t
IP_t : industrial production in a period between t -1 to t
BT_t : balance of trade in a period between t -1 to t
SET_t : SET Index at time t
$\beta 0$: intercept of the equation
$\beta 1, \beta 2, \beta 3, \beta 4, \beta 5, \beta 6$: coefficients of MS_t ,IR_t, IF_t , IF, BT_t and SET_t
ε t : error terms of the equation

The main aim of this method is to find the relationship between each independent variables and a dependent variable. However, we need to test for existence of unit roots in the time series to avoid spurious regression first. The technique employed is Augmented Dickey-Fuller (ADF) test to determine whether the variables of equation above are stationary in first difference. Unit root test with ADF is used to solve the autocorrelation by adding first difference lagged value in the variable (Gujarati, 2008).

If our variables don't enclose unit roots and are stationary, the next step is OLS estimation method. The OLS is employed to structure regression model which includes the coefficient of relationships between each independent variables and our dependent variable and their error terms. Then, this structure regression model is employed to forecast the forecasted samples of REER.

On the other hand, if our variables enclose unit roots and are non-stationary, cointegration analysis is implemented to determine co-movement between a set of time-series variables in long-run. The technique used is Engle-Granger Two Steps Approach. The Ordinary Least Squares (OLS) model is formulated and then the residuals are tested for unit root. While the residuals contain no unit root, it is stationary and so is cointegrated. (Gujarati, 2008) Cointegrated variables may be drift apart temporarily, but must converge systematically over time. Hence, any model that imposes a deterministic long-run relationship between a set of integrated economic variables, which allow those variables to deviate over the short term, will show cointegration. (Jongwanich, 2009) This OLS model is then used to forecast our forecasted sample of Thai Baht REER. Finally, these forecasts will be compared with the actual value of REER for the same period.

The software employed for econometric analysis in this study is Eviews 7.

ANN model

The software used for our ANN analysis is DTREG version 10.8.0 by Phillip H. Sherrod. The type of model built is General Regression Neural Networks (GRNN). Type of input layer is pass-through. Type of hidden layers is logistic. Type of output layer is linear. The number of input connections is 6 which represent each independent variable from our model. The initial learning rate is 0.01 and the maximum number of training iteration allowed is 100,000. The error function used to evaluate the forecast is Root Mean Square Error (RMSE).

The Empirical Result of the study

Econometric model

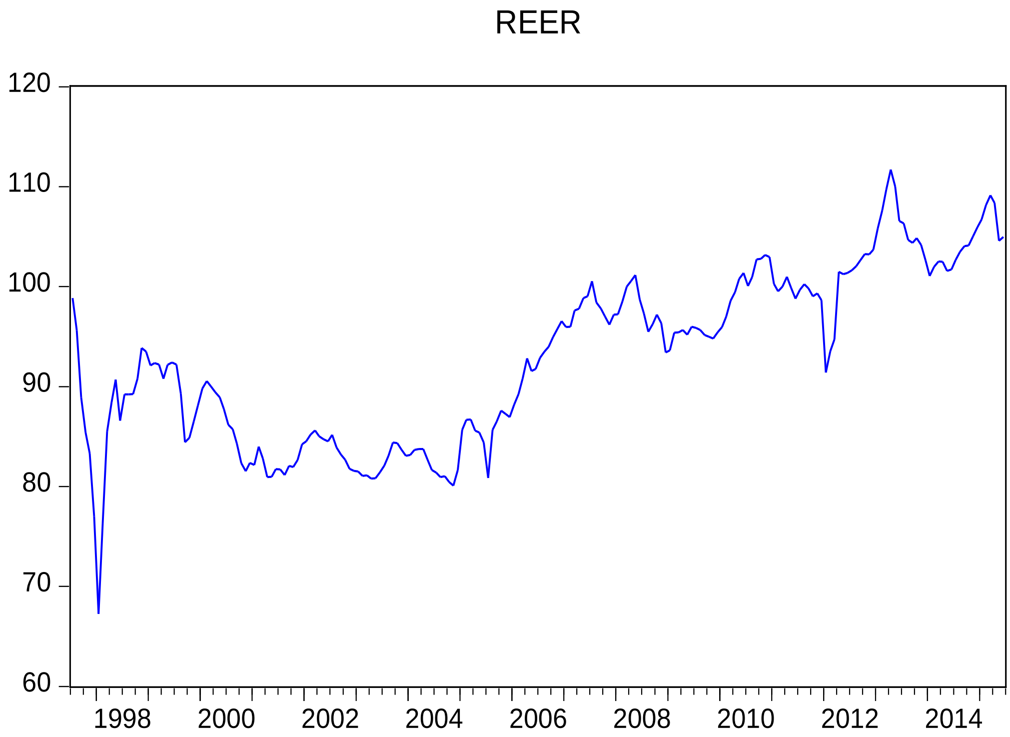

Figure 3 REER of Thai Baht from July 1997 to June 2015
Source: Computed Result

In this study, the data is monthly, 216 periods from July 1997 to June 2015. Figure 3 shows the value of our output variable; the Thai Baht REER, during that period. The maximum value is 111.70 in 2013 and the minimum value is 67.27 in 1998. Mean of data is 92.7772, standard deviation is 8.5908 and median is 93.4950.

First step in our econometric analysis is unit root test by implementing Augmented Dickey-Fuller (ADF) technique. All of input variables and an output variable are tested for stationary. Table 1 shows the result of this test. At 5% confidence level, all of variables are stationary at zero order.

Table 1 Unit Root Test for 7 variables

Unit Root Test
Level (I(0))
Trend and Intercept

Variable	ADF Test Statistics	Probability	Test Critical Value (5%)
REER	-4.422483	0.0025	-3.432917
MS	-3.791438	0.0190	-3.432917

IR	-5.773339	0.0000	-3.433036
IF	-4.454224	0.0023	-3.434299
IP	-5.344663	0.0001	-3.432799
BT	-4.613206	0.0013	-3.433036
SET	-4.051706	0.0087	-3.432799

Because all of variables are stationary at zero order, we can continue to OLS analysis without the need to perform cointegration test. From OLS estimation analysis, R square value is not so high (0.609264). Theoretically, the very high R square value together with the insignificance of some input variables indicate multicollinearity, therefore, we can conclude that this kind of problem does not exist in our model.

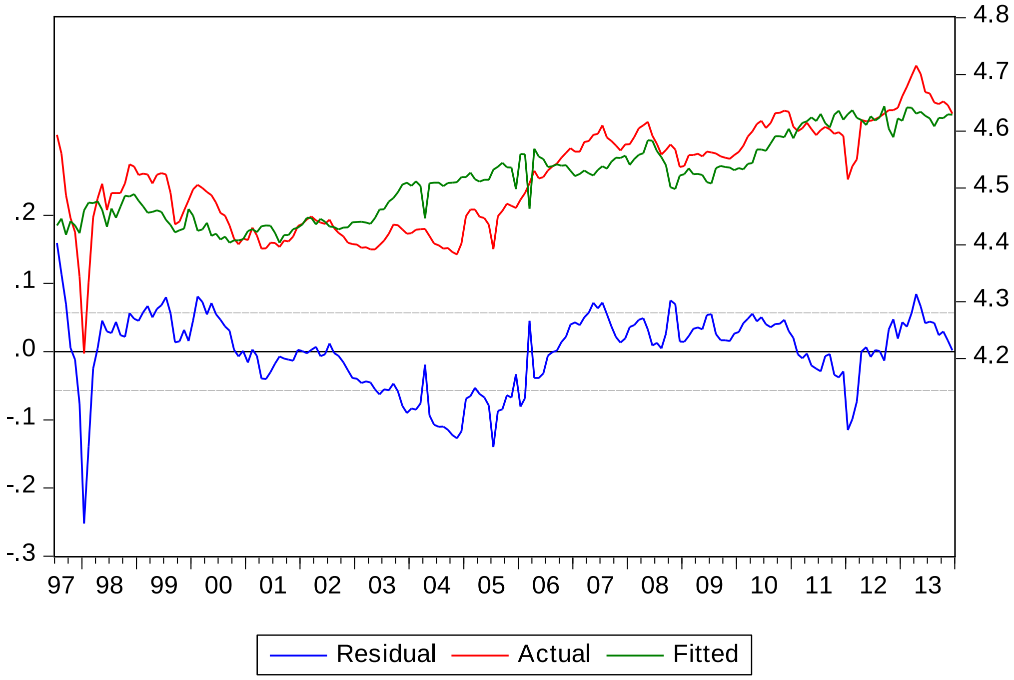

Figure 4 Residual from OLS analysis (Base Case)

Source: Computer Result

From the analysis, however, the Durbin-Watson statistical value is very low (0.268697) which indicates the presence of autocorrelation as, theoretically, if the Durbin-Watson statistical value is closer to 2.0000 value, it will be less likely to have autocorrelation problem. Moreover, when we look at residual graph in Figure 4, we can see that the residual possesses a highly cyclical pattern which confirms that the autocorrelation is quite strong. Implementing the forecast under this condition tend to yield an unreliable result.

One way to improve this problem is to regress residual to residual (-1) in order to calculate for ρ coefficient value. The analysis gives this coefficient value of 0.844969. This

ρ coefficient is then used to make an amendment to our input and output data. The amended data will then be analyzed by OLS estimator. The result shows that the autocorrelation problem is much improved as the Durbin-Watson statistical value is now 1.142348, much higher than that of the base case.

Another way to relieve autocorrelation difficulty is by implementing The Cochrane-Orcutt Iterative Method. Under this feature, Eviews 7 will try to accomplish the real ρ by running several iterations in which the error term will become less and less until it reaches the optimal value. From the analysis, we find that the Durbin-Watson statistical value is 1.521919 which is higher than that of Residual to Residual (-1) Case.

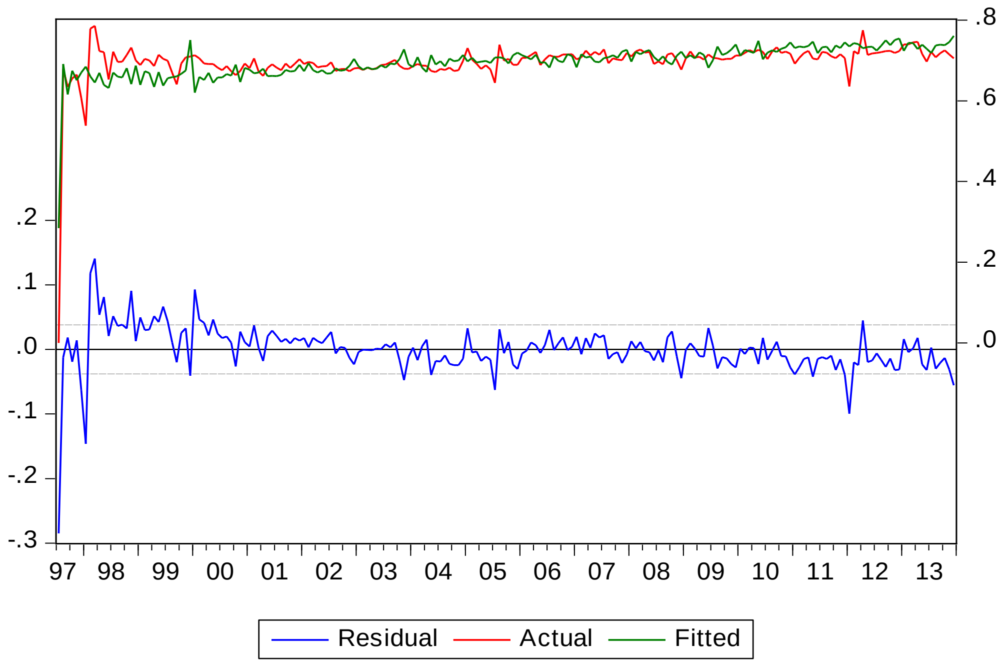

Figure 5 Residual from OLS analysis (Residual to Residual (-1) Regression Case)
Source: Computer Result

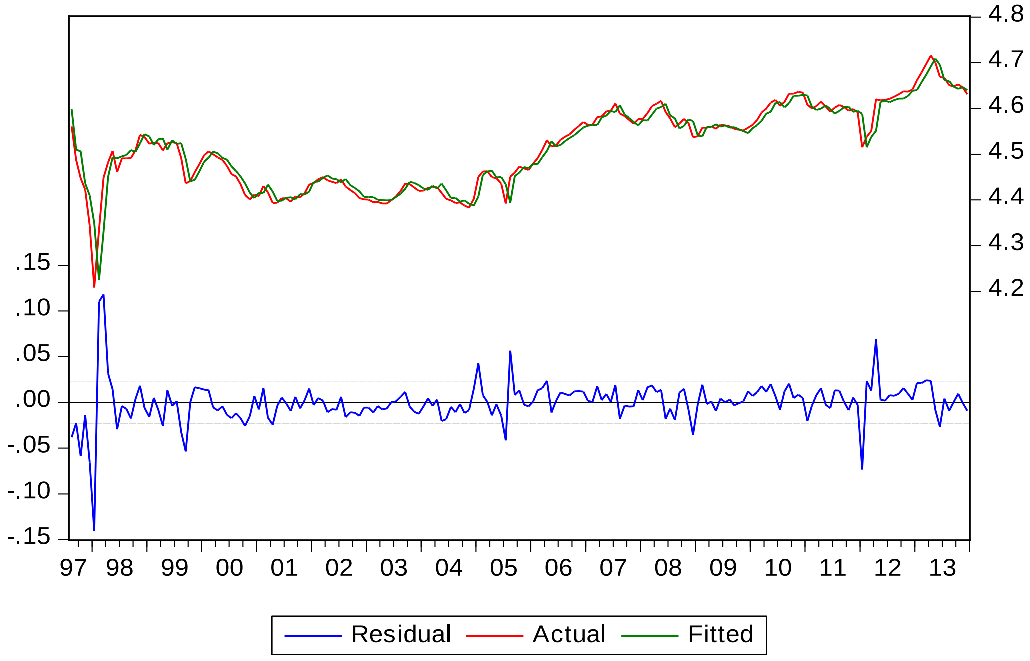

Figure 6 Residual from OLS analysis (The Cochrane-Orcutt Iterative Method Case)

Source: Computer Result

Figure 5 and 6 are the residual curves of OLS analysis after implementing residual to residual (-1) method and The Cochrane-Orcutt Iterative Method respectively. We can see that the cyclical patterns as in the base case now disappears which indicates that autocorrelation condition has been relieved.

From Table 2, it can be seen that The Cochrane-Orcutt Iterative Method Case possesses the closest-to-2.00 value which indicate that it has the lowest autocorrelation among three cases. Therefore, we will choose the OLS estimation with The Cochrane-Orcutt Iterative Method as a representative of econometric approach to conduct a forecasting for REER.

Table 2 Durbin-Watson Statistical Values for three cases of OLS

Case	Base Case	Residual to Residual(-1 Regression Case	The Cochrane-Orcutt Iterative Method Case
Durbin-Watson Statistics	0.268697	1.142348	1.521919

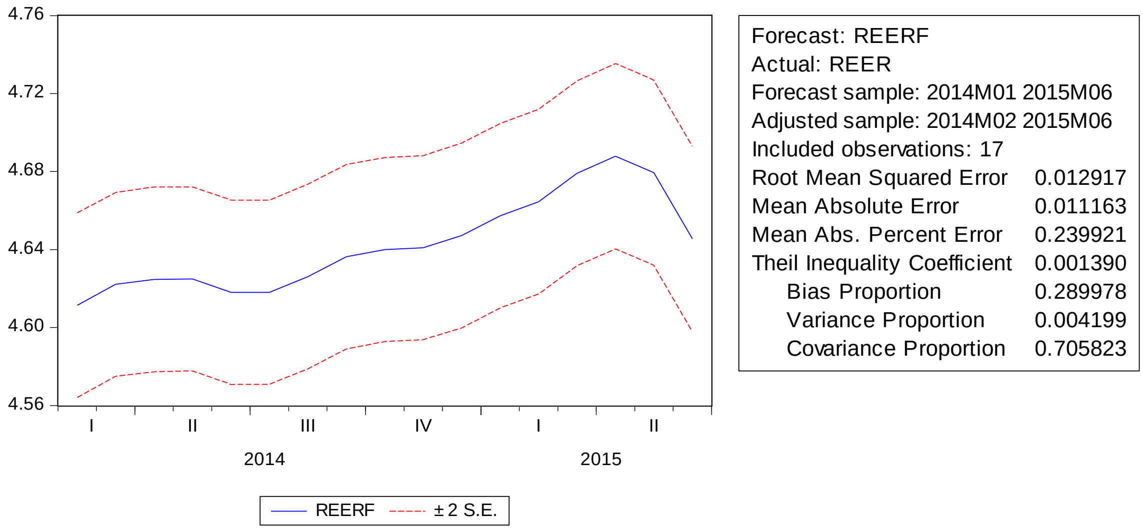

Figure 7 Forecasting Report for OLS estimator (The Cochrane-Orcutt Iterative Method Case)
Source: Computer Result

Figure 7 is the forecast result for Econometric method. We can see that RMSE value is 0.012917. This number will be compared with the result from ANN analysis later.

ANN model

From Table 3, Figure 8 and Figure 9, the forecasting result for econometric approach and ANN are compared with the actual data. We can see that the econometric forecast of REER value is much closer to the actual REER value than the ANN forecast. This finding is confirmed by computer analysis, in which the Root Mean Squared Error (RMSE) of ANN forecast is 0.0166759, which is higher than 0.0129170 of econometric approach. (See Table 4) This leads to the conclusion that Linear Regression Model (Econometrics) has a better predictive performance than ANN model for this particular case.

Table 3 Forecasting Results for the compared methods

Period	REER(Actual)	REER(Forecasted-Econometric)	REER(Forecasted-ANN)
1	4.615912283	4.6103030	4.6328536
2	4.624874769	4.6222540	4.6351326
3	4.630155439	4.6231820	4.6352190
4	4.629667658	4.6243800	4.6364659
5	4.620846665	4.6154120	4.6404757
6	4.622125627	4.6128750	4.6413173
7	4.631422557	4.6212650	4.6439912
8	4.639474990	4.6350540	4.6471978

9	4.644775441	4.6364600	4.6473855
10	4.645448032	4.6368210	4.6488675
11	4.654341230	4.6395930	4.6507242
12	4.662967285	4.6465230	4.6518349
13	4.670208582	4.6532580	4.6531903
14	4.683519152	4.6658140	4.6544329
15	4.692539832	4.6733780	4.6556525
16	4.685551298	4.6640560	4.6568667
17	4.650047945	4.6435950	4.6580722
18	4.653674595	4.6302770	4.6592583

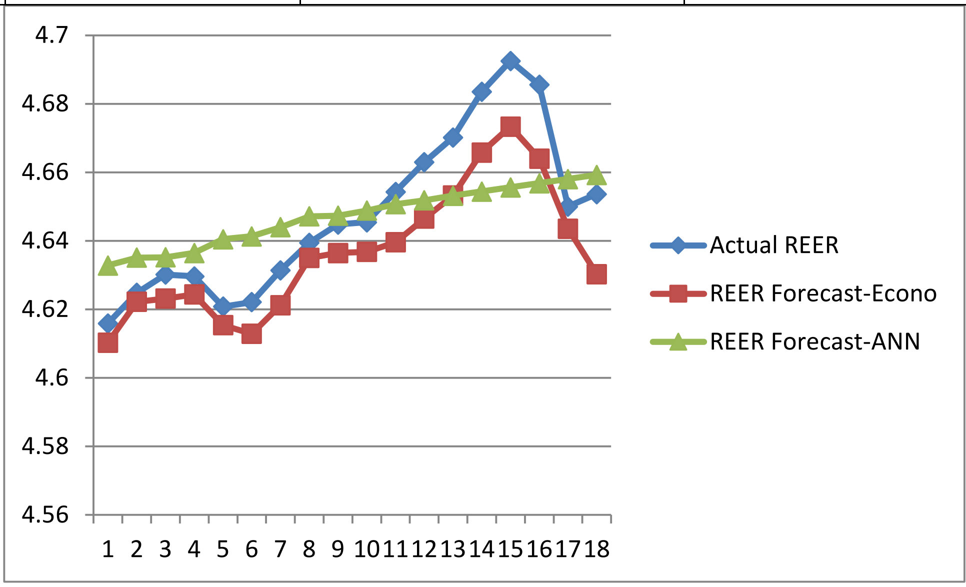

Figure 8 Forecasting Results of the compared methods

Source: Computer Result

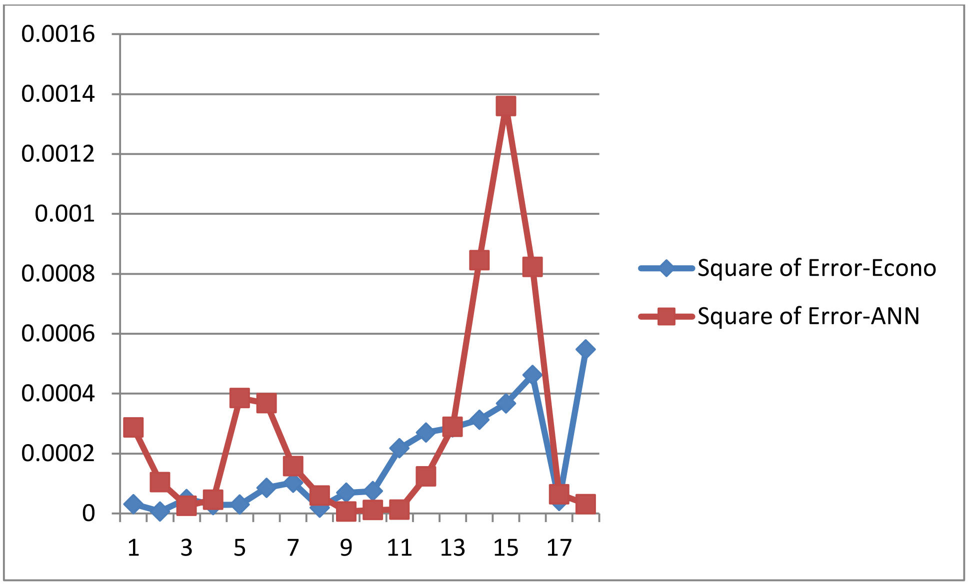

Figure 9 Square of Error of the compared methods

Source: Computer Result

Table 4 Root Mean Squared Error (RMSE) for the compared methods

Method	Econometric	ANN
Root Mean Square Error (RMSE)	0.0129170	0.0166759

Conclusion and Recommendation

There are two purposes of this study. For the first one, our research aims to employ the traditional econometric approach and the recently innovated ANN technique for predicting the value of the dependent (output) variable, namely Thai Baht Real Effective Exchange Rate (REER), given the set of six independent (input) variables.

For the second purpose, this study also seeks to compare the predicting performance between these two methods. The data obtained from outside sources are divided into two groups. The first group is used to make the predicting models "learn" or construct the relationship between variables. The second group is employed as a touchstone to compare the forecasting accuracy between the two contesting models.

The result indicates that Linear Regression Model (econometric) transcends ANN in forecasting performance. This is contrary to the results of many comparative studies concerning these two predictive methods. One reason could be that ANN was a "learning model". The higher number of training samples, the better forecasting results. In many cases of other researches, the amount of training samples is thousands, or even ten thousands, while the number of training samples in this study is only 198 due to the limitation in historical financial data in Thailand. Thus, the small size of input data restricts ANN from performing at its highest potential.

For the limitation of this study, as from RID model, one of four important factors that affect currency exchange rate is GDP (national income). But we can't include this variable in our analysis because the GDP data in Thailand is quarterly while other data are monthly. We can't use quarterly data for our analysis because Thai Baht was just switched to floating exchange system 19 years ago and then the amount of data would not be large enough to run ANN. Therefore, we use industrial production as a substitute for national income which definitely can't be a perfect substitution. If there is monthly data for national income and it is included in this study, the forecasting performance should be much better for both competing approaches.

There are two recommendations for further study in this area. The first one is to conduct the study by separate between normal time and the time of economic crisis, such as "Tom-Yum-Kung" crisis, sub-prime crisis and Chinese financial crisis, because during a crisis, relationships between variables tend to be quite different from those during normal time. The second one is to do the same as this study in a country where national income data is monthly reported, if there is any, and include this variable in an analysis. This should yield better results.

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