Empirical Exchange Rate Models of Thailand after 1997

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Abstract

This paper mainly aims to assess the exchange rate prediction of Thailand after the financial crisis in 1997. Using Thai and other relevant country data from 1999 to 2013 quarterly, the paper performs six country pair empirical tests, including the US, UK, EU, China, Japan and Korea currencies against the Thai baht. Following Messe and Rogoff (1983a), it compares the several models of exchange rates on the basis of their out-of-sample forecasting accuracy. The RMSE statistics are calculated and used to measure the out-of-sample accuracy. The three structural models are the Dornbusch-Frankel sticky price monetary model, the Frenkel-Bilson flexible price model and the Hooper-Morton sticky price with current account model. The two univariate time series techniques include the long AR model and the Akaike Information Criterion. The alternative models presented in this paper are the random walk and the forward rate models. The paper finds that the random walk model dominates the other models for out-of-sample forecasting of the Thai baht.

Keywords: Exchange Rate Models, Forecasting, Thai Baht

1. Introduction

The exchange rate is one of the vital macroeconomic variables that determine the economic performance. Exchange rates are very critical as they determine the level of imports and exports which are important to every country in the world including Thailand particularly. Over a decade Thai economic growth has been mainly driven by the export. Its economy has heavily been export-dependent, with exports accounting for more than 70 percent of its gross domestic product since 2004. Exchange rate movements can have a significant impact to Thailand multinational company's profitability. Local companies can even be affected, as changing exchange rates may substantially alter their material costs, or affect their ability to sell their products abroad. The exchange rate volatility may result in lost of Thailand's competitiveness.

The fixed exchange rate regime had been operated in Thailand since 1984 but it was abandoned in the mid of 1997. Since then the managed float exchange rate regime has been characterized of the behavior of Thai currency. The Thai baht has been determined mainly by the underlying balance of supply and demand for the currencies involved. Under the managed float, the Bank of Thailand intervenes on occasion by buying and selling the foreign exchange to moderate the fluctuation of the exchange rate and to achieve its policy targets.

To some extent, the increased importance of exchange rate is a result of the internationalization of business, the continuing growth in world trade and the trend towards economic integration. Therefore, exchange rates are among the most analyzed and manipulated economic measures. One of the purposes of studying the behavior of exchange rates is to be able to predict exchange rates. Exchange rate forecasts are necessary to evaluate the benefits and risks attached to the international economics. The original work of Messe and Rogoff on exchange rate predictability concludes that structural economic models cannot reliably out-predict the naive alternative of a random walk for short forecast horizon in out of sample forecast performance. Messe and Rogoff (1983a) show that the fundamental dictated by monetary models such as Frenkel (1976), Dornbusch (1976) and Bilson (1978) fail to provide

a satisfactory explanation of the exchange rate movement on the basis of the root mean squared error (RMSE). However, Woo (1985) finds that a reformulated monetary approach with a partial adjustment mechanism in a money demand function can outperform the random walk model in an out of sample forecast framework. Somanath (1986) argues that with a lagged endogenous variable a monetary model forecasts better than the random walk model. Mark (1995) argues that long horizon changes in the logarithm of exchange rates could be explained using more powerful statistical tests. Engel and West (2004) find that if monetary fundamentals are non-stationary and the discount factor is close to unity, the exchange rate could follow a near-random-walk process. Nonetheless, many others such as Killian (1999), Berkowitz and Giorgianni (2001), and Faust, Rogers and Write (2003) remain skeptical. After that influential research by Messe and Rogoff (1983), the exchange rate forecast has been receiving increasing attention in empirical international finance and nearly over the past three decades inspired the large number of papers. Despite the large amount of work in this area, we still know substantially little about the exchange rate prediction of Thailand. The research on the exchange rate predictability for Thai currency has not been largely explored.

This paper main purpose is to reassess the exchange rate models for Thai Baht against other six major currencies including US dollar, UK pound, EU Euro, China yuan, Japan yen and Korea won, after the operation of the managed float exchange rate regime in 1997 using the set of models including the structural, time series and alternative models with the quarterly data basis during 1999 to 2013. The three structural models are the Dornbusch-Frankel sticky price monetary model, the Frenkel-Bilson flexible price model and the Hooper-Morton sticky price with current account model. The two time series models include the long AR model and the Akaike Information Criterion. The alternative models presented in this paper are the random walk and the forward rate model. The focus of the research is to examine and compare the forecasting ability of several exchange rate models in term of out-of-sample forecasting performance using Thai Baht against the six other major currencies after 1997. The paper is structured in the following way. We proceed in section 2 by describing the theoretical models. Section 2 also discusses the

construction of the data. Section 3 then briefly outlines the methodology for comparing models out-of-sample. Section 4 provides the main results and data description. Section 5 concludes.

2. The Models

Under a floating exchange rate regime, most of the observed fluctuation in exchange rates cannot be satisfactorily explained by one simple model of exchange rate determination. The classes of monetary models of exchange rate determination have emerged as the dominant exchange rate models since early 1970s. It is useful to review the univariate time series models that are available as the candidates for forecasting the exchange rate. Among all theories of exchange rate determination, the alternative models are also highly potential competing models.

2.1 The Structure Models

From the early 1970s at the beginning of the floating exchange rate regime, the monetary approach to exchange rate determination was created by several well known economists such as Frenkel (1976), and Bilson (1978) as the dominant exchange rate models. This section describes the main features of the monetary approach to exchange rate determination. Because the monetary models are derived from a system of equations that identify the equilibrium in monetary markets, they are normally known as structural models. The assumption of the monetary models is initially based on the assumption of perfect capital mobility. Therefore, the real interest rate is exogenous and determined by the world markets.

The demand for real money balance may be written as,

$$m_t = p_t + \alpha y_t - \beta i_t \tag{1}$$

$$m_t^* = p_t^* + \alpha^* y_l^* - \beta^* i_t^* \tag{2}$$

where m_t , p_t , y_t and i_t are the logarithm of the money supply, the logarithm level of price, the logarithm level of real income, and the logarithm of nominal interest rate respectively. α and β are positive constant. Thai variables

are identified without the Asterisks (*) where as Asterisks denotes foreign country variables. Another assumption is that the monetary model uses the purchasing power parity (PPP) is to define the equilibrium condition. The model assumes PPP holds continuously,

$$s_t = p_t - p_t^* \tag{3}$$

where s_t is the logarithm level of nominal exchange rate defined as the domestic currency per unit of foreign currency or Baht price per foreign currency. Using equation (1), (2) and (3), we obtains the general specification,

$$s_t = (m_t - m_t^*) - (\alpha y_t - \alpha^* y_t^*) + (\beta i_t - \beta^* i_t^*) \tag{4}$$

with the simplication of the income elasticities and interest rate elasticities of money demand are the same for both countries, then $\alpha_t = \alpha_t^*$ and $\beta_t = \beta_t^*$. We have the basic prediction equation as follow,

$$s_t (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*) \tag{5}$$

Equation 5 represents the Frenkel-Bilson model as in Messe and Rogoff (1983a, 1983b)[2]. Frenkel (1976) develops the concepts of the monetary approach to examine the determinants of the exchange rate. The monetary approach to exchange rates, which assumes that the prices of goods are perfectly flexible, implies that a country's currency depreciates when the domestic money supply relative to the foreign money supply is increased. Messe and Rogoff (1983a, 1983b) also suggest that the exchange rate performs

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[2] The Frenkel-Bilson model may be derived from the quantity theory of money as well. The theory suggests that money supply equal to money demand, $M^S = M^D$. The real money demand depends on real income. Therefore $M^S = kPY$ where Y is real income, P is the price level and k is the desire to hold money as a fraction of national income. With the purchasing power parity holds or $S = \dfrac{P}{P^*}$ where is the nominal exchange rate. We can write $S = \dfrac{M^S k^* Y^*}{M^{S^*} kY}$ and in the logarithm form $s = (m - m^*) - (y - y^*) - (\ln k - \ln k^*)$. Given the fact that k is vary negatively with the interest rate, the consequence is that $s = (m - m^*) - (y - y^*) - (i - i^*)$ where i is nominal interest rate.

the first degree of homogeneity in the relative money or the coefficient restriction of $(m - m^*) = 1$[3]. On the other hand, an increase in domestic real income creates an excess demand for the domestic money stock. Since the price is perfectly adjusted to find the equilibrium in money market, the price falls to increase the real money balance, leading to the appreciation in the domestic currency based on PPP. The important assumption is that domestic and foreign capital are perfect substitutes and the Fisher equation holds in both countries[4]. Since the model assumes that a nominal interest rate rises because of a higher expected future inflation, the domestic currency depreciates. The model posits the coefficient restriction of $(m - m^*) = 1$, the coefficient of $(y - y^*) < 0$ and the coefficient of $(i - i^*) > 0$.

The Dornbusch-Frankel model is also called the sticky price monetary model, due originally to Dornbusch (1976). The model allows for slow domestic price adjustment and as a result the model deviates from the PPP. The price is rigid and cannot be the crucial variable to clear the money balance. A fall in the nominal domestic money supply relative to domestic money demand implies a fall in real money supply and a rise in interest rates. The domestic interest rate will rise with regard to foreign interest rate creating an inflow of foreign capital and an appreciation of the nominal exchange rate. Under this model, the real interest rate has a negative relationship with the exchange rate. Thus, PPP would be true in the long run. output and price in the long run will adjust to respond to an increase in demand. In the short run, the nominal exchange rate is overshooting to compensate for the stickiness of the price level. Messe and Rogoff (1983a, 1983b) extend equation 5 by adding expectation inflation differential in an attempt to capture the deviation from PPP. The equation of The Dornbusch-Frankel model is as below,

$$s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*) + \theta(E[\pi] - E[\pi^*]) \qquad (6)$$

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[3] The rational is that as the money supply in Thailand goes up the price will go up by the same proportion. Since PPP continuously holds, the Thai Baht depreciates by the same amount. The coefficient of the logarithm of the ratio of the Thai money supply to foreign money supply is one.

[4] Fisher equation says that $i = r + \pi$ where r represents the real interest rate.

where $E[\pi]$ and $E[\pi^*]$ are the expected inflation rates of Thailand and foreign inflation respectively[5]. The model imposes the coefficient restriction of $(m - m^*) = 1$, the coefficient of $(y - y^*) < 0$ and the coefficient of $(i - i^*) > 0$ and the coefficient of $(E[\pi] - E[\pi^*]) > 0$.

The Hooper-Morton model extends the Dornbusch-Frankel model to allow for change in the long-run real exchange rate. Hooper and Morton (1982) argue that the long run real exchange rate changes are assumed to be correlated with unanticipated shocks to the trade balance. The model can be written as,

$$s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(i_t - i_t^*) + \theta(E[\pi] - E[\pi^*]) + \lambda tb_t + \kappa tb_t^* \qquad (7)$$

where tb_t and tb_t^* are the trade balance of Thailand and foreign respectively. A rise in the cumulated current account of domestic country signals an appreciation of home currency or $\lambda < 0$. Conversely, a rise in the cumulated current account of foreign country causes a depreciation of home currency or $k > 0$.

2.2 The Time Series Models

This section has the objective to present the univariate time series models which are employed in this study. The autoregressive (AR) model is well known of among a time series models and it has been applied in many area of economics. A univariate autoregression is estimated for the log of each spot rate corresponding to the six country pairs. This study examines two univariate time series models which are the long AR method and the Akaike Information Criterion. It is necessary to determine the appropriate lag length for both models.

The Long AR method is an unconstrained autoregression (AR) where the longest lag considered (M) is a function of sample size (N),

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[5] The variables such as long term interest rate differentials are typically used to proxy for the expected inflation differentials, the preceding twelve months period CPI or inflation rates as seen in Frankel (1981) and Hooper and Morton (1982). This study employs the preceding four quarter inflation as the expected inflation.

$$M = \frac{N}{\log N} \qquad (7)$$

The Akaike Information Criterion (AIC) is the one of the most widely used criteria to select the models. Ideally, the AIC will be as small as possible. The objective is to estimates p minimizing an information criterion,

$$AIC(p) = \ln\left(\frac{SSR(p)}{T}\right) + (p + 1)\frac{2}{T} \qquad (8)$$

Where SSR is the sum of squared residuals of the estimated AR(p) and T denotes the number of observations. The AIC penalizes for the addition of parameters, and thus selects a model that fits well but has a minimum number of parameters. Selecting the order p of an autoregression requires balancing the benefit of including more lags against the cost of additional estimation uncertainty. When we add lags, the first term on the right hand side could be the same or higher. However, the second term will increase. The AIC trades off these two forces so that the number of lags that minimizes the AIC is a consistent estimator of the true lag length[6].

2.3 The Alternative Models

This section purposes an alternative procedure for modeling exchange rate behavior. Two alternative models are described one is the random walk and another is the forward rate model.

Even though we are interested in stationary time series, we often encounter non-stationary time series such as the random walk model (RWM). The random walk model uses the current spot rate as a predictor of all future spot rates. The random walk model can be written as,

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[6] Stock and Watson (2003) document another criterion. It is the Bayes Information Criterion (BIC) also called the Schwarz Information Criterion (SIC) which $BIC(p)$ $= \ln\left(\frac{SSR(p)}{T}\right) + (p + 1)\frac{2}{\ln T}$. The difference between BIC and AIC is that the number 2 in the AIC is replaced by ln T in the BIC. The second term in BIC is larger. The AIC is commonly used even though the second term is not large enough to ensure that the correct lag length is chosen.

$$E_t[S_{t+1}] = S_t \qquad (9)$$

where S_t is the current spot exchange rate in Baht against foreign currency. The value of exchange rate S at time t is equal to its value of that exchange rate in the preceding period plus a random shock or $S_t = S_{t-1} + \varepsilon_t$. In regression analysis, we can explain the previous equation as the regression of S_t on S_{t-1}. However, this study uses the random walk with drift model. This is the situation where the value of the exchange rate in period t equals the value of that exchange rate lagged one period, plus a drift term δ and the random error term ε_t. Following the random walk with drift model, the exchange rate in period t can be shown that $S_t = \delta + S_{t-1} + \varepsilon_t{}^7$.

The forward rate model uses the forward rate as a predictor of all future spot rates. The expectation hypothesis of exchange rates states that the expected spot rate 1 period from now is equal to today's forward rate for delivery 1 period from now. It can be written as

$$E_t[S_{t+1}] = F_{t,t+1} \qquad (9)$$

where $F_{t,t+1}$ is a contract at date t to either buy or sell Baht against foreign currencies at $t + 1$ a rate specified at date t . This study uses 3 month forward rate to this empirical practice. Equation 9 has a strong intuitive appeal. If markets are perfect, speculators will trade forward contracts at prices equal to the expected future rate.

3. Model Selection Criterior

In any estimation problem, several competing methods for forecasting are tested. Given that the objective of this study is to compare the models for forecasting ability, this section discusses the criteria used to choose among the candidate models. To find the way to choose which one is most suitable, we distinguish between in sample forecasting and out of sample forecasting. The in-sample-forecasting explains generally chosen model fits the data in a given

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[7] The random walk model is also known as a unit root process. Given the initial condition S_0, the general solution for S_t is t given $S_t = S_0 + \delta t + \sum_{i=1}^{t} \varepsilon_i$ and $E[S_t] = S_0 + \delta t$ and $Var(S_t) = t\sigma^2$.

sample. It does not attempt to forecast the future path of the exchange rate. It uses today's information to predict what today's spot rate should be. Two criteria used for this purpose are R-square and adjusted R-square. However, as in fact forecasting is an out-of- sample problem, it is more appropriate for forecasting to use out-of-sample criteria. White (2000b) argues that the evidence based on in-sample-forecast performance is usually considered less reliable than evidence base on out-of-sample forecast performance. Diebold and Rudebush (1991) also suggest that the out-of-sample forecasts provide better information available to forecaster. Stock and Watson (2003) claim that the out-of-sample forecasting, or the forecasting performance in real time after the model has been estimated, is the ultimate test of a forecasting model. Out-of-sample forecasting experiments are essentially used to determine how fit the model forecasts future values of the dependent variable given values of the independent variable. The model can be estimated over only a portion of data set. We use the first portion of the observations to estimate the parameters and keep the rest of the observations for forecasting. The idea is to choose a date near the end of the sample, estimate the forecasting model using data up to that date, then use the estimated model to make a forecast. The out-of-sample forecasting attempts to use today's information to predict the future behavior of exchange rates. That is we forecast the path of exchange rates outside of our sample. Therefore, the out of sample forecasting is achieved without benefit of knowing the future variables of time series and gives a forecaster a sense of how well the model has been forecasting.

It is necessary to measure a report of the uncertainty of forecasting. Root mean square forecast error (RMSE) is one measure of the uncertainty of a forecast and it is also the main method used by Messe and Rogoff (1983a) to comparing forecasts. In general, the forecast errors composes of parts, one the uncertainty involving the estimation of regression coefficients, and another the uncertainty arising from the future unknown value of the error time, ε_t. Wooldridge (2009) documents that an expression of RMSE reflects these two source of uncertainties.

Given that we have we have $i + j$ observations and we use i the first observations to estimate the parameter of the model and use the last j observation for forecasting. Let $\hat{S}_{i+k}$ be the one step-ahead forecast of the exchange rate

S_{i+k+1} for $k = 0,1, 2,...., j-1$. The j forecast errors are $\hat{\varepsilon}^2_{i+k+1} = S_{i+k+1} - \hat{S}_{i+k}$. Thus the mean square error (MSE) is given by

$$MSE = E_t[(S_{i+k+1} - \hat{S}_{i+k})^2] = [j^{-1} \sum_{k=0}^{j-1}(S_{i+k+1} - \hat{S}_{i+k})] \qquad (10)$$

The root mean square error (RMSE) is the square root of the MSE. The MSE is essentially the sample variance of the forecast errors while the RMSE is the sample standard deviation of the forecast errors[8]. To compare the forecasting performance, we prefer the method with the smallest out-of-sample RMSE.

4. Data and The Results

After struggling to defend the peg, the Thai government abandoned its defense and announced that the Baht would float freely against the dollar during the mid of 1997. It was beginning of the floating exchange rate period in Thailand. Therefore, all the candidate models are forecasted over a quarterly data, starting from the fourth quarter 1999 and extend through the second quarter of 2013. There are two reasons why we start collecting data from 1999 quarter four. Because of the limitation of the data for the short term government bond of Thailand, the data for the rate of return of 3 month Thai government bond was available on the fourth quarter of 1999 onward. Another supportive reason is because Thai economy started to recover from the 1997 finance crisis, it is better to collect the data about two years after the crisis to test the competing models.

The analysis uses quarterly data for the Thailand, the United States, UK, EU, China, Japan and Korea over 1999 quarter four to 2013 quarter two.

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[8] There are two more measures of the forecast errors. A second common measure is the mean absolute error (MAE). The MAE is the average of the absolute forecast errors which $MAE = j^{-1} \sum_{k=0}^{j-1}|\hat{\varepsilon}_{i+k+1}|$. A third measure is the mean error (ME) which $ME = j^{-1} \sum_{k=0}^{j-1}\varepsilon_{i+k+1}$. The smaller values of the MAE and the ME are prefer. Even though the RMSE is the principal criterion for comparing forecasters by Messe and Rogoff (1983), the RMSE is concerned as an inappropriate criterion if exchange rates are occupied by a non-normal stable Paretian process with infinite variance and when exchange rate distribution has fat tails, even if the variance is finite.

All data are taken from the public available source and seasonally adjusted. The exchange rates are drawn from the Bank of Thailand. The money supplies are obtained from Federal Reserve Bank of St. Louis. Income variables are proxy by the industrial productions which the same as those used in Messe and Rogoff (1983). The industrial productions are collected from OECD, Main Economic Indicators with 2010 as the base year (2010=100). The consumer price indexes also use 2010 as base year and are taken from the OECD, Main Economic Indicators. Trade balances are obtained from IMF International Financial Statistics. The interest rates are the return from the short term or three month government bonds unless otherwise stated. The treasury bills for United States and United Kingdom are available from Federal Reserve Bank of St. Louis. The interest rate of Thailand is the three month government bond return and taken from the Bank of Thailand. The returns of the short term government bond are unavailable for Korea and EU, the one year and two year government bond are used for these two foreign countries respectively. One year government bond yield of Korea is obtained from the Bank of Korea while two year government bond yield of EU is drawn from European Central Bank. To assess the model performance to exchange rate determination, it is necessary to use one and two year government bond as the interest rates to determine the Thai baht/Korea won and the Thai baht/Euro. The data of the one and two year government bond yield of Thailand is available from the Thai Bond Market Association. Because the forward exchange rates are not readily available for China and Korea, the analysis for the forward rate model to forecast the exchange rate for the Thai baht/ China yuan and the Thai baht/Korea won are omitted. Since the forward rates are available from 2005 quarter two for UK, Japan and EU, the study of the forward rate model would have shorter information than other competing models for these three exchange rates. The data for forward rates are obtained from Kasikorn Thai Bank, Thailand. The forward rates for the United States are available in the observation period from 1999 quarter four to 2013 quarter two and are taken from the Bangkok Bank, Thailand.

This study investigates the forecasting performance of the exchange rate of 6 country pairs which are Thai Baht against the US Dollar, UK Pound, EU Euro, China Yuan, Japan Yen and Korea Won. Each model is initially

estimated for each exchange rate using data up through the first forecasting period, the third quarter of 2008. Forecasts are generated at horizons of one quarter. These forecast horizons correspond to the available forward rate data. Using rolling regressions, the data for the third quarter of 2008 are added to the sample, and the parameters of each model, including the seasonal adjustments parameters, are re-estimated. New forecasts are generated at one quarter horizon.

4.1 The in Sample Forecasting

The in-sample forecasting uses the whole data set to assess the model performance. The data starting from the fourth quarter 1999 to the second quarter of 2013 used to evaluate the potential models. Next subsection turns to the empirical evidence on the performance of the monetary model in forecasting exchange rates.

4.1.1 The Fundamental Models

The flexible price model or the Frankel-Bilson model is used to explain the behavior of Thai Baht against several foreign currencies as show in table 1. Under this model, higher growth of money creates a high inflationary expectations resulting in a reduction in the demand for real balances. This leads to an increase in spending and a rise in domestic price level and depreciation in the domestic currency. Given percentage increase in the Thai money supply to foreign money supply, the model implies that the exactly equivalent depreciation of the Thai Baht. As income in Thailand increases, the demand for money will go up. In an attempt to increase their real money balance, Thai people reduce their expenditure, resulting in a fall in the demand for goods and services and the prices fall. Thai Baht is appreciated afterward. Similarity, a higher Thai interest rate leads to a fall in demand for money, implying an increase in demand for goods and services. The price level of Thailand rises accordingly and this in turn depreciates of Thai currency.[9]

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[9] However, a higher interest rate could also attract the foreign inflow of capital from other countries, making the domestic currency appreciate. The results literary are ambiguous and depend on which force is dominated in particular period of time.

Table 1: The Frankel-Bilson model

	THB/USD	THB/GBP	THB/EUR	THB/CNY	THB/JPY	THB/KRW
			Exchange rate			
m-m*	0.018	-0.761***	-0.017	0.105**	0.297***	-0.259**
	[0.1865]	[0.162]	[0.1510]	[0.0448]	[0.1027]	[0.1261]
y-y*	-0.708***	-0.176**	-1.014***	-0.093*	-0.239***	0.605***
	[0.0718]	[0.0785]	[0.0601]	[0.0527]	[0.0835]	[0.1043]
r-r*	-0.045***	-0.034***	0.026***	0.003	-0.040***	0.018***
	[0.0100]	[0.0110]	[0.0086]	[0.0055]	[0.0116]	[0.0066]
cons	3.445***	6.565***	4.099***	1.637***	-2.085***	4.625***
	[0.2440]	[0.5300]	[0.2148]	[0.0273]	[0.3824]	[0.3890]
R^2	0.873	0.776	0.855	0.127	0.238	0.578
Adj R^2	0.865	0.763	0.847	0.076	0.193	0.553
RMSE	0.088	0.076	0.093	0.046	0.076	0.067

The figure in [ ] denotes the stand error, significant at 1% (***), significant at 5% (**) and significant at 10%, significant at 10% (*)

Table 1 suggests that the flexible price monetary model is able to forecast in sample better for the exchange rate of the Thai baht against the US dollar, UK pound and the Euro than the exchange rate of Thai Baht against the main currency of Asia. The R2 for Thai baht per the US dollar, UK pound and the Euro are 87.3, 77.6, and 85.5 percent respectively while the R2 for Thai Baht per China yuan and Japan yen and Korean won are significantly low. However the coefficients of the logarithm of the ratio of the Thai money supply to the foreign money supply are significantly different from one. The sign of the coefficient of (m-m*) is even negative for the Thai baht per the UK pound, Euro the Korea won. The model predict correctly the sign of the coefficient of (y-y*) except for the Korea won. The model predicts the negative relationship between interest rate and the exchange rate, but the empirical study shows mix signs among the six exchange rate pairs.

For the Dornbusch-Frankel model, as Thai money supply decreases relative to Thai money demand, the price is sticky in the short run and it will not adjust. To clear the market, this implies an initial fall in the real money

supply and a consequent rise in interest rate. This creates an inflow of foreign capital and an appreciation of Thai Baht[10]. Table 2 summarizes the results of the Dornbusch-Frankel sticky price model on the full sample.

Table 2: The Dornbusch-Frankel model

	Exchange rate					
	THB/USD	THB/GBP	THB/EUR	THB/CNY	THB/JPY	THB/KRW
m-m*	0.137	-0.945***	0.209	0.105**	0.460**	-0.206
	[0.2265]	[0.1963]	[0.2066]	[0.0496]	[0.1127]	[0.1316]
y-y*	-0.711***	-0.945***	-0.982***	-0.091***	-0.323***	0.546***
	[0.0747]	[0.0856]	[0.0643]	[0.0628]	[0.0810]	[0.1082]
r-r*	-0.044***	-0.030***	0.033***	0.003	-0.044***	0.021***
	[0.0106]	[0.0111]	[0.0096]	[0.0059]	[0.0104]	[0.0074]
inf-inf*	-0.011	0.012	-0.004	0.001	0.004	0.013
	[0.0224]	[0.0122]	[0.0160]	[0.0044]	[0.0104]	[0.0104]
cons	3.292***	7.155***	3.779***	1.636***	-2.683***	4.471***
	[0.2962]	[0.6378]	[0.2930]	[0.0322]	[0.4178]	[0.4039]
R^2	0.867	0.751	0.854	0.131	0.369	0.580
Adj R^2	0.855	0.729	0.841	0.056	0.314	0.543
RMSE	0.090	0.076	0.094	0.048	0.068	0.067

The figure in [ ] denotes the stand error, significant at 1% (***), significant at 5% (**) and significant at 10%, significant at 10% (*), inf represent the expected inflation

As shown in table 2, the sticky price model could determine the exchange rate of the Thai baht against the US dollar, UK pound and the Euro, not the exchange rate of Thai Baht against the main Asia currencies. The sign of the Thai baht against the US dollar are correct except for the expectation long run inflation differential. Across all the exchange rates, it is striking that the expectation long run inflation differentials are not statistically significant.

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[10] Dornbush (1976) states that a sticky price model would mean that PPP would hold in the long run. There will be a short run overshooting of exchange rate compensating for stickiness in goods prices.

The sign of the coefficients are not entirely consistent with the model prediction.

The sticky price model which incorporate current account or the Hooper-Morton model also fails to explain the exchange rate of the Thai baht against China yuan, Japan yen and Korea won as shown in table 3 with low value of the R^2. The table also indicates that adding the trade balance of Thai and other countries to the model has no influence on the exchange rate determination. The income differential and the nominal interest rate differential are significant even at 1 percent. The expectation long run inflation differentials are not significant for all six pairs of exchange rate. The signs of the coefficients are not consistent to the model's estimation.

Table 3: The Hooper-Morton model

	Exchange rate					
	THB/USD	THB/GBP	THB/EUR	THB/CNY	THB/JPY	THB/KRW
m-m*	0.056	-0.933***	0.363*	0.073***	0.220**	-0.270
	[0.2242]	[0.1833]	[0.2083]	[0.0656]	[0.1396]	[.1349624]
y-y*	-0.577***	-0.378**	-0.999***	-0.074***	-0.220*	0.620***
	[0.1021]	[0.1128]	[0.0634]	[0.0566]	[0.0833]	[.121991]
r-r*	-0.047***	-0.030***	0.030***	0.005	-0.050***	0.016***
	[0.0115]	[0.01033]	[0.0093]	[0.0063]	[0.0099]	[.0079541]
inf-inf*	-0.010	0.011	0.001	0.001	-0.003	0.007
	[0.0215]	[0.0116]	[0.0155]	[0.0045]	[0.0101]	[.0118834]
tb	0.000	0.000**	0.000	0.000	0.000	0.000*
	[6.16e-06]	[4.24e-06]	[5.54e-06]	[2.98e-06]	[4.25e-06]	[4.85e-06]
tb*	0.000**	0.000*	0.000**	0.000	0.000	0.000*
	[4.36e-07]	[2.21e-06]	[9.16e-07]	[3.40e-07]	[1.13e-06]	[2.64e-06]
cons	3.605***	6.951***	3.570***	1.636***	-1.742	4.661***
	[0.3291]	[0.6225]	[0.2959]	[0.0332]	[0.5287]	[0.4141]
R2	0.880	0.802	0.873	0.160	0.473	0.608
Adj R2	0.870	0.775	0.855	0.045	0.401	0.555
RMSE	0.086	0.069	0.090	0.048	0.063	0.066

The figure in [ ] denotes the stand error, significant at 1% (***), significant at 5% (**) and significant at 10%, significant at 10% (*), inf represent the expected inflation

      The coefficients on the interest rate and the expected inflation could be examined using the fundamental models. According to the PPP, the percentage change in the Thai baht/US dollar exchange rate over the next year for instance will equal the difference between the inflation rates of the Thailand and the United States over that year. If people expect relative PPP to hold, the difference between the interest rate offered by Thailand and the United States will equal the difference between the inflation rates expected over the relevant horizon, in Thailand and in the United States. To see the condition of interest parity (UIP) which must hold in the long run as well as in the short run fits with the PPP, we test the equalization of the coefficient of both the interest rate and the expected inflation. In the case of the flexible price model, the expected inflation does not appear in the model. Therefore, the hypothesis is that the coefficient of the interest rate differential is zero. Under the sticky price models which allow a deviation from PPP, we expected that the coefficient of interest rate differentials should not equal to the coefficient of the expected inflation. For the sticky price models

Table 4: Test of coefficient on real interest rate and the expected inflation

The Fundamental Models

	The F-B model	The D-F model	The H-M model
THB/USD	21.10	1.61	2.14
THB/GBP	9.44	6.50	7.41
THB/EUR	9.35	4.12	2.69
THB/CNY	0.25	0.08	0.36
THB/JPY	11.95	10.97	12.21
THB/KRW	7.33	0.29	0.4

The numbers are the F-test

Table 4 shows that under the flexible price model, we reject the hypothesis that the coefficient of the interest rate differential equals to zero for all the exchange rate but not for the Thai baht/China yuan exchange rate. The flexible price model perform poor in explain the theory of UIP and PPP. In the case of the sticky price Dornbusch-Frankel model, the three out of six exchange rats are in line with the theory those are the Thai baht/UK pound, Thai baht/Euro and Thai baht/Japan yen. Regarding to the sticky price with trade balance the Thai baht/Euro and Thai baht/Japan yen are consistent with the theory.

4.1.2 The Time Series Models

This study focuses on the univariate autoregression time series models which are the long AR model and the Akaike information criterion model. It is a crucial econometrics task to estimate the lag length of the time series model. The lag length selection criteria in determining the autoregressive lag length is important. The lag length of the long AR model depend on the number of observations. Messe and Rogoff (1983a) argue that this fixed rule has long been used in spectral estimation. The optimal numbers of lags are the same for all exchange rates because each exchange rate has the same number of observations. Based on equation 7, the optimal lag length for the long AR models is 14 lags as indicating in table 5. The AIC model has a different optimal lag length for different exchange rate. The smallest AIC indicates the best fit of the model. As the fit model improves, the AIC will approach a minus infinity. The AIC is employed as the selection criterion since these two models choose too many parameters, which increase R2 with number of lag. Too many lags and regressors shorten the sample and increase the within fit. Liew and Sen (2004) conclude that the Akaike information criterion (AIC) and final prediction error (FPE) are superior than the other criteria for a small sample size, 60 observations and below, in the manners that they minimize the chance of under estimation while maximizing the chance of recovering the true lag length. Under this study, the optimal lag of AIC make the value of FPE smallest as reveal in table 6.

Table 5: The long AR model

	Exchange rate					
	THB/USD	THB/GBP	THB/EUR	THB/CNY	THB/JPY	THB/KRW
AIC	-2.910	-0.579	-2.910	-3.691	-1.957	-2.175
HQIC	-2.880	-0.548	-2.880	-3.660	-1.927	-2.145
SBIC	-2.827	-0.495	-2.827	-3.607	-1.873	-2.092
R^2	0.7682	0.0211	0.7682	0.0543	0.1229	0.1722
RMSE	0.0551	0.1770	0.0551	0.0373	0.0890	0.0796
lag	14	14	14	14	14	14

Table 6: The Akaike information criterion model

	Exchange rate					
	THB/USD	THB/GBP	THB/EUR	THB/CN	THB/JPY	THB/KRW
AIC	-2.178	-2.043	-2.178	-3.912	-2.159	-2.773
HQIC	-2.150	-2.012	-2.150	-3.882	-2.130	-2.744
SBIC	-2.104	-1.951	-2.104	-3.822	-2.083	-2.699
R^2	0.8765	0.7493	0.8765	0.3138	0.1566	0.6478
RMSE	0.0799	0.0845	0.0799	0.0332	0.0806	0.0594
lag	2	23	2	22	4	2
FPE	0.000541	0.000364	0.000541	0.000001	0.002456	0.001842

This study employs the AIC as the principle criterion for comparing the two time series models. The long AR model outperforms the AIC model for the Thai baht/US dollar and Thai baht/Euro exchange rate. In other words, the long AR model superior than the AIC model for forecasting in sample of the Thai baht/US dollar and Thai baht/Euro exchange rate. However, the AIC model fits the Thai baht/UK pound, Thai baht/China yuan, Thai baht/Japan yen and Thai baht/Korea won exchange rate better than the long AR does.

4.2 The Out-of-Sample Forecasting

All competing models is used to forecast the exchange rate for one quarter ahead over the period 2008 quarter 4 and ends in 2013 quarter 2. The RMSE statistics are calculated and used to measure the out-of-sample accuracy. Table 7 reveals the RMSE of the monetary models, the time series model and the alternative models. Obviously the random walk model outperforms the others. This means that fundamental variables for instance money supplies, income, interest rate, and expected inflation would not help to forecast the exchange rate one quarter ahead. All models except the random walk do not perform as good predictors.

Among the fundamental models, the flexible price Frenkel-Bilson model is superior for the Thai baht/US dollar, Thai baht/Euro, Thai baht/China yuan and Thai baht/Japan yen exchange rate. The sticky price Dornbusch-Frankel model outperforms the others for Thai baht/UK pound. The sticky price models dominate the flexible price model for Thai baht/Korea won exchange rate.

In case of time series models, the long AR model defeats the AIC model for Thai baht/US dollar, Thai baht/Euro, Thai baht/China yuan and Thai baht/Japan yen. The AIC model outranks the long AR model for Thai baht/UK pound and Thai baht/Korea won. Because the random walk model produces the lower value of RMSE than the forward rate model does, the random walk model is better than the forward rate model under the alternative approach.

Considering all models to exchange rate determination based on the out-of-sample performance, the random walk model has proven unbeatable for Thai baht against six foreign currency exchange rates.

Table 7: RMSE: Out of sample forecast

	Exchange rate					
	THB/USD	THB/GBP	THB/EUR	THB/CNY	THB/JPY	THB/KRW
The F-B model	0.1036153	0.0741477	0.101863	0.0597337	0.0636964	0.0644722
The D-F model	0.1065102	0.0736916	0.1043311	0.061283	0.0653506	0.0623818
The H-M model	0.1214132	0.0758753	0.1043311	0.0653732	0.0661207	0.0623818
The long AR model	0.0129429	0.0264798	0.0129429	0.0083657	0.0173817	0.0176778
The AIC model	0.031623	0.0169314	0.0316239	0.0137201	0.0261716	0.0123323
Random walk model	0.0115716	0.0046766	0.0115716	0.0049133	0.0057791	0.0061032
Forward rate model	0.0317932	4.042099	3.533004		1.059617	

The missing figures of the forward rate for THB/CNY and THB/KRW due to the lack of the information

This research also provides the fit impression from the figure 1 to figure 7 to compare all the potential models to exchange rate determination.

5. Conculsion

This paper has mainly examined the structural models of exchange rates, the time series, and the alternative on the basis of their out-of-sample forecasting accuracy for Thai Baht against another six major currencies. The three structural models are the Frenkel-Bilson flexible price monetary model, the Dornbusch-Frankel sticky price monetary model, and the Hooper- Morton sticky price with current account model. The two time series include the long AR model and the Akaike Information Criterion. The alternative models presented in this paper are the random walk and the forward rate model. There are two types of forecasts considered in this paper, one in-sample and another out-of-sample forecasting. In the case of in-sample forecasting, the fundamental models perform better for the Thai baht against US dollar, UK pound and Euro. They perform poorly for the Thai baht against China yuan, Japan yen and Korea won. One of the strong assumptions of the fundamental models is that monetary market is in the equilibrium. The monetary models are derived based on the equilibrium in monetary market. Nonetheless in the real world the monetary market is not in equilibrium most of the times. The fundamental models in general may not be perfectly accurate. The equilibrium

of monetary markets in developed countries is more stabilize than that of the developing countries. The fundamental models of the Thai baht against developed country currencies outperform that of the Thai baht against Asia country currencies. The long AR model outperforms the AIC model in sample forecasting of the Thai baht/US dollar and Thai baht/Euro exchange rate. Nonetheless, the AIC model fits the Thai baht/UK pound, Thai baht/China yuan, Thai baht/Japan yen and Thai baht/Korea won exchange rate better than the long AR does.

The empirical results give a question on the ability of the fundamental model as a model of exchange rate determination. By comparing the RMSE of all models, the random walk produces the smallest value of the RMSE. Therefore, the random walk model outperforms the others for out-of-sample forecasting. The random walk model is a superior forecaster of short term exchange rates than models emphasizing economic fundamentals. Even though economic fundamentals have long been recognized influential determinants and commonly used in modeling of exchange rates, this study finds that they do not well explain the fluctuation of the Thai baht against the six foreign currencies from 1999 to 2013. Exchange rate of Thai baht follows a random walk in the sense that knowing the values of this variable today will not enable us to predict what this value will be tomorrow. Thus, it is hard to tell what the Thai baht exchange rate will be tomorrow, knowing its value today. The Thai baht is not predictable, especially in the short horizon.

This paper provides the evidence of forecasting the Thai baht against several main foreign currencies. It is a starting point to a further study. Therefore, other extensions or further research are indispensible for the Thai baht in term of forecasting ability. The forecasting horizon could be a longer. The asset pricing approach could be considered to find the longer horizon relationship between the fundamentals and the exchange rates. Dynamic features could also be incorporated in the models. Additionally, instead of using the mean absolute error or the root means square error, the alternative measures of forecasting accuracy proposed by Moosa and Burns (2014) such as the direction accuracy and proximity to a perfect forecast could be used to evaluate the forecasting ability of the models for Thai currency.

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Figure 1. Out-of-sample forecasting Frenkel-Bilson model (log of exchange rate)
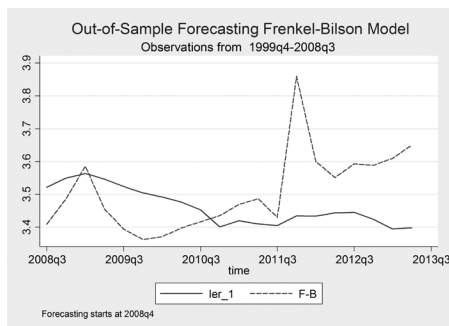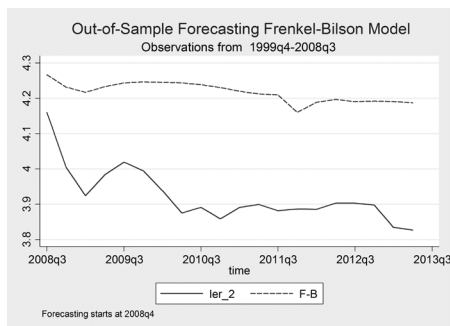
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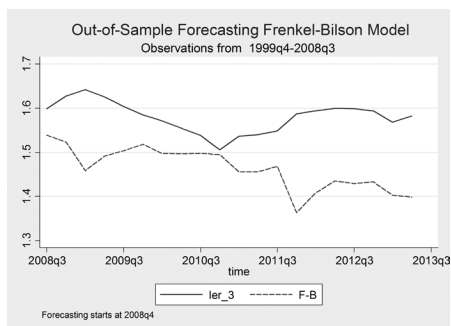
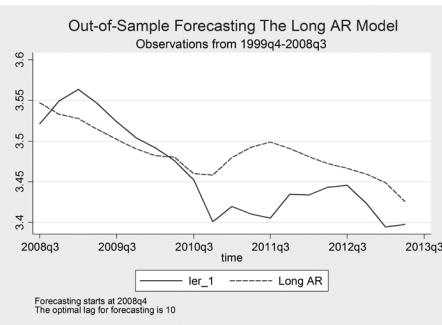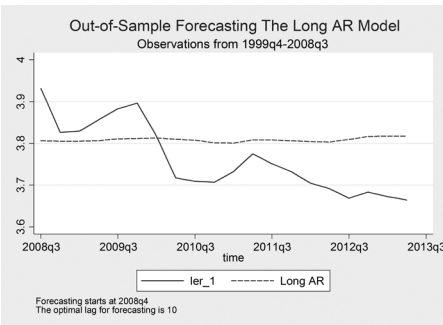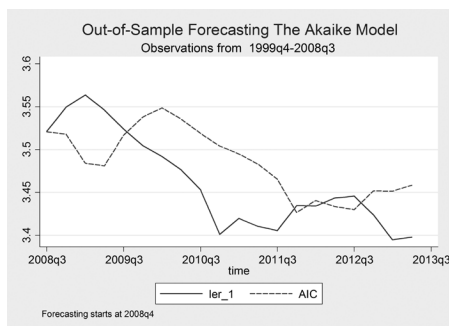
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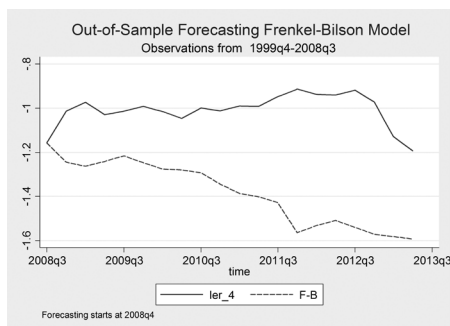
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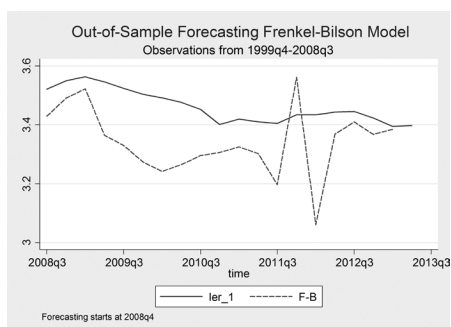
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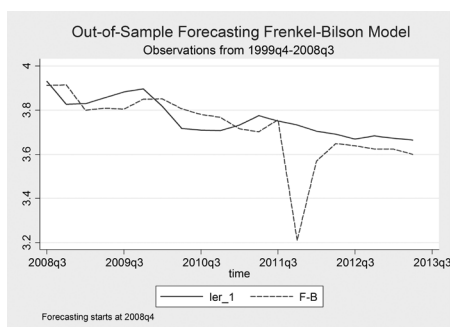
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Panel F THB/KRW

Figure 2. Out-of-sample forecasting Dornbush-Frankel model (log of exchange rate)
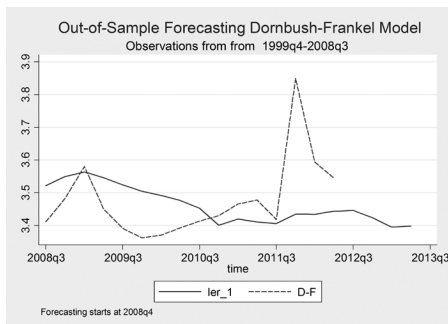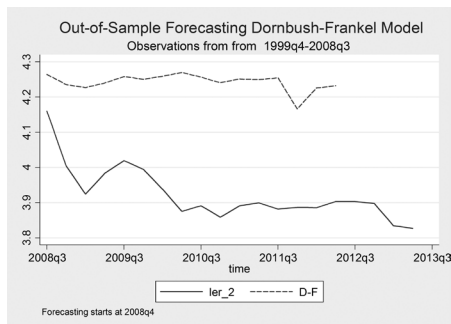
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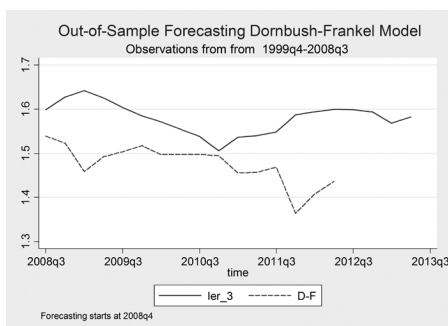
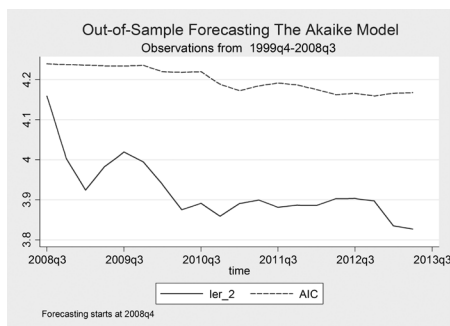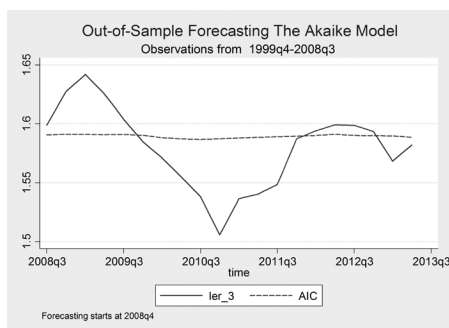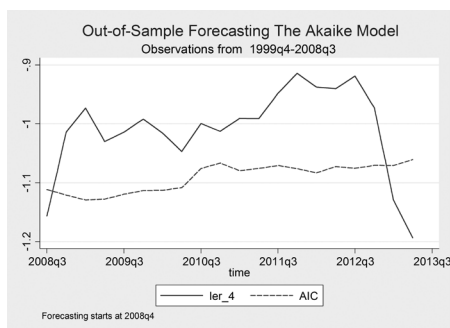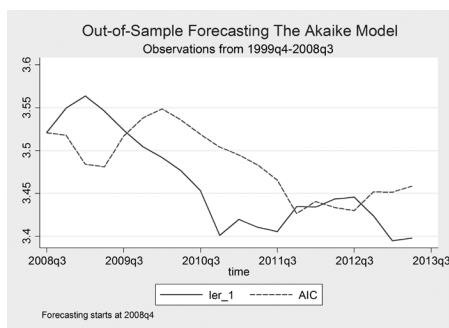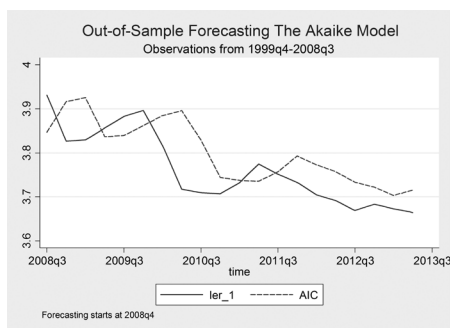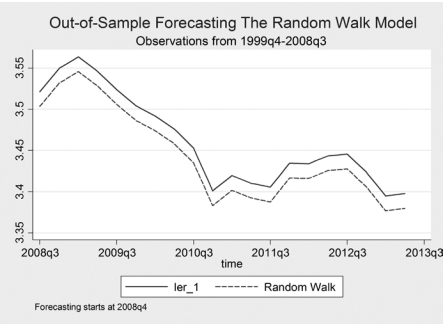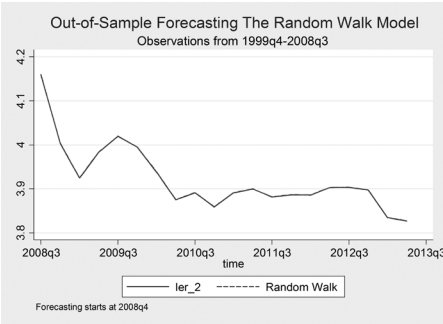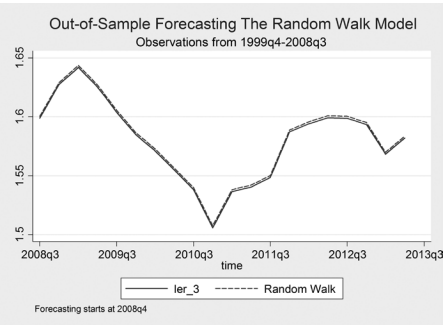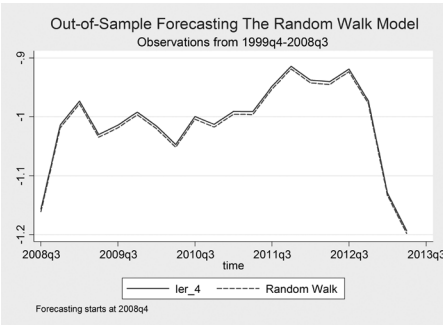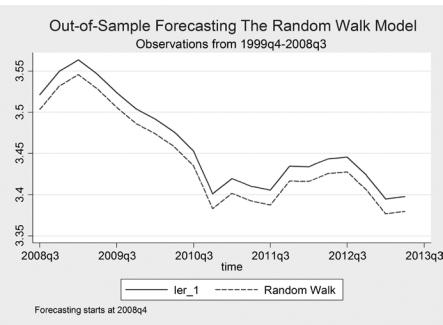Panel B THB /GBP
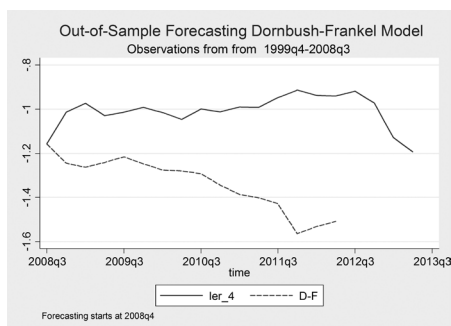
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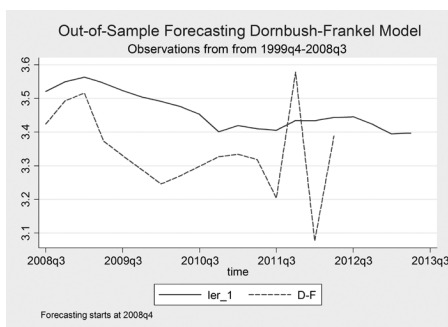
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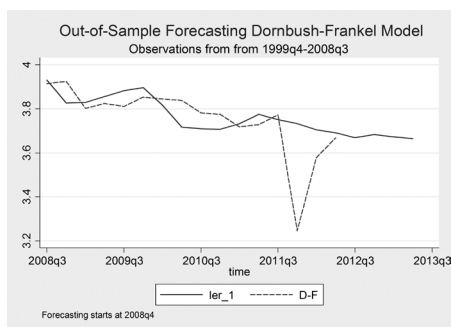
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Panel F THB/KRW

Figure 3. Out-of-sample forecasting Hooper-Morton model (log of exchange rate)
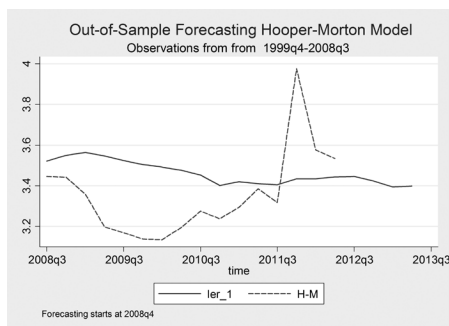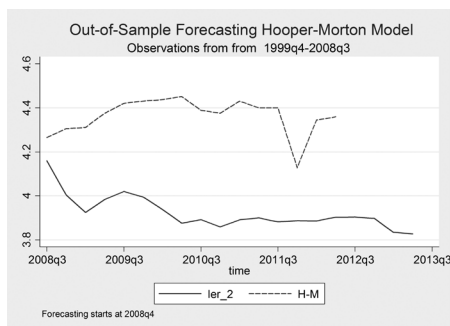
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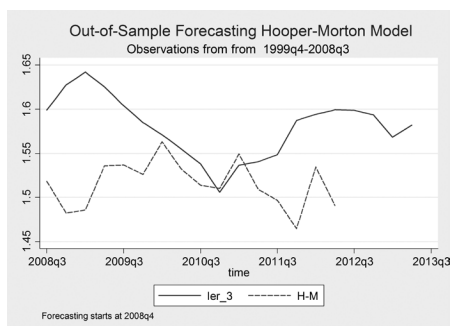
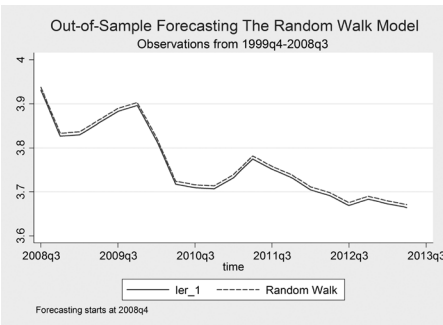Panel B THB /GBP
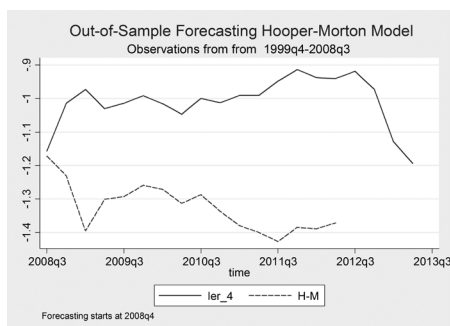
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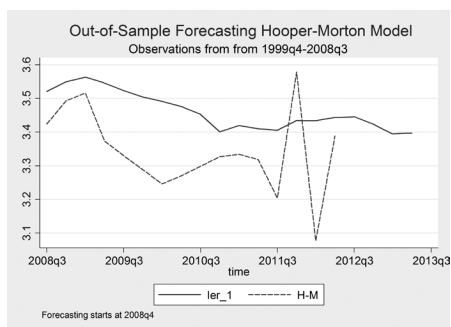
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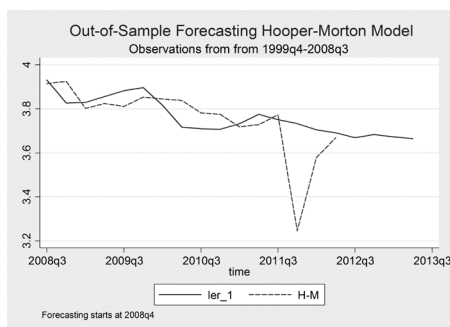
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Figure 4. Out-of-sample forecasting The Long AR model (log of exchange rate)
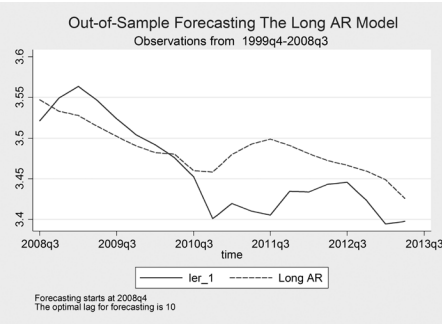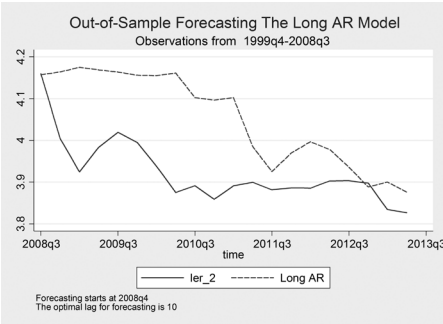
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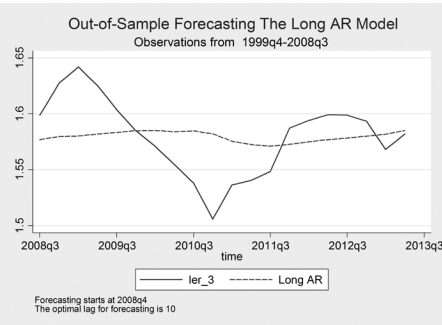
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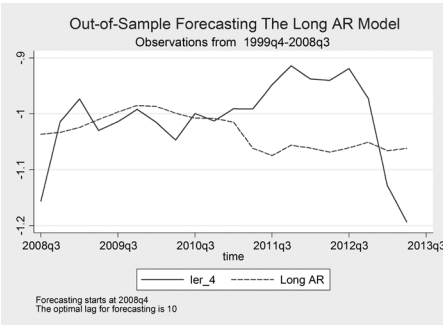
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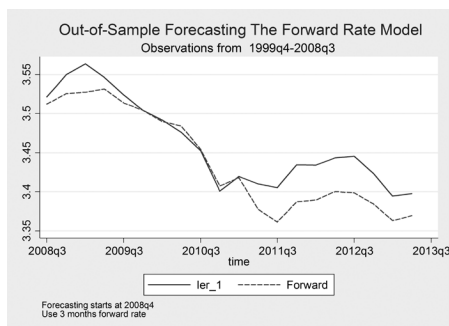

Panel D THB/JPY

Panel E THB/EUR

Panel F THB/KRW

Figure 5. Out-of-sample forecasting the AIC model (log of exchange rate)

Panel A THB/USD

Panel B THB /GBP

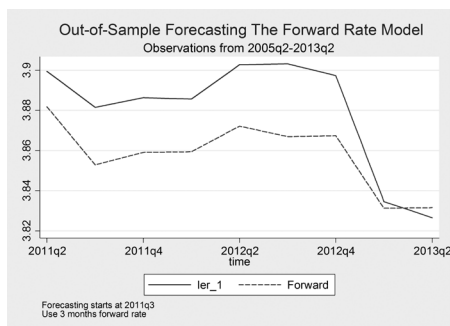Panel C THB/CNY

Panel D THB/JPY

Panel E THB/EUR

Panel F THB/KRW

Figure 6. Out-of-sample forecasting the random walk model (log of exchange
rate)

Panel A THB/USD

Panel B THB /GBP

Panel C THB/CNY

Panel D THB/JPY

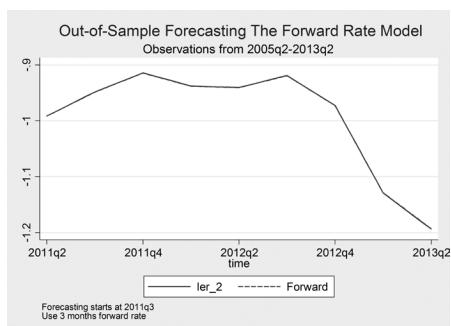Panel E THB/EUR

Panel F THB/KRW

Figure 7. Out-of-sample forecasting the random walk model (log of exchange
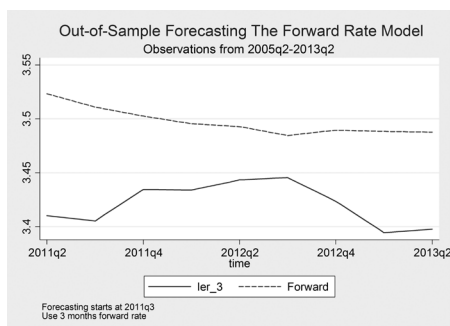rate)

Panel A THB/USD

Panel B THB /GBP

Panel C THB/JPY

Panel D THB/EUR

Figure 8. Comparing RMSE

Panel A THB/USD

Panel B THB /GBP

Panel C THB/CNY

Panel D THB/JPY

Panel E THB/EUR

Panel F THB/KRW