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Forecasting Spot Exchange Rates Using Different Forecasting Techniques

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FORECASTING SPOT EXCHANGE RATES USING DIFFERENT FORECASTING TECHNIQUES

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ABSTRACT

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Forecasting of exchange rates has always been a popular research topic among scholars. The thesis tried to forecast the future change in spot rate using the difference between forward rate and the current spot rate. Forward rates of three time horizons were used as the time horizon's included 1 month, 3 month and 6 months. The study employed two exchange rates and both the exchange rates were forecasted using three forecasting methodologies to determine the best forecasting tool.

Several prior studies have produced different results and the thesis explores possible to improve the forecast of structural exchange rate models, by explicitly accounting for the time variability of the parameters when estimating these models. The study was not able to show the impact of time varying parameter characteristic on forecasting as the results indicated that both the exchange rate series did not possess any time-varying characteristics.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AR	Auto Regressive
CND	Canadian Dollar
Forw	Forward Exchange Rate
GBP	Sterling Pound
OLS	Ordinary Least Square
RMSE	Root Mean Squared Error
Spot	Spot Exchange Rate
TVP	Time Varying Parameter
USD	United States Dollar
US	United States
VAR	Vector Auto Regression

CHAPTER 1: Introduction

Time series analysis is carried out frequently on many fronts across many sectors. Time series data can be used mainly for two different purposes. The time series data can be used to analyze the past patterns or behaviors to reach a conclusion. Further, time series data are utilized to make data predictions. According to Harvey (1993) movements of time series are explained in terms of its own past and forecasts can be made using extrapolation. Several researches have conducted various methods that have been used to make forecasts.

Economy of a specific country is influenced by the development of exchange rates between domestic and foreign currencies. Exchange rates and their role in trade has always been widely studied research area by scholars. Since, Bretton-Woods agreement collapsed in 1968, a floating exchange rates system replaced the Bretton-Woods' scheme. The Bretton Woods systems' mechanism was to have fixed exchange rates between the U.S. dollar and the other currencies. Since the crossover to the floating exchange rate system, trade sector encountered scenario of exchange rate volatility.

From the inception of the floating exchange rate, the relationship between exchange rate volatility became a major area of study for economists. Many a number of models emerged regarding the impact on trade due to exchange rate volatility. The studies have progressed mainly on two different paths. Several scholars have conducted research on identifying the direct impact of exchange rate volatility on the trade or with the inclusion of different variable. Many scholars like Krugman, Obstfeld, Hooper and many more have looked into this area of research. The main concept which underpins the trade theory is that the relationship between exchange rate and trade is the stability of the exchange rate. Volatility will introduce an extra aspect of risk which would negatively impact traders. In the case of an exporter or an importer, who is risk averse, would like have stability in the exchange rate. For an example if an exporter and an importer make a trade deal at point of time for a specific value, the exporter selling the goods will be paid in the currency of the importer once the transaction is executed. Once the payment is made, the importer would have to utilize the current / spot exchange rate for the conversion to its home currency. Assuming that there are no forward or future contracts made between two trading parties, neither party have the option of having a fixed exchange rate for the transaction. The exchange rate volatility effect could spur up these following scenarios. Exchange rate volatility, in other words, the fluctuation of the currencies would determine whether the exporter or the importer will gain or lose. If the currency of the importers country strengthens against the exporters currency, the exporter will be at a loss and the importer will benefit. Bailey et al. (1987) assessed the effect of exchange rate volatility on export growth for eleven OECD countries This is a point where Bailey et al. (1987) has explained as one of the parties incurring a risk at the moment of the conversion.

The results obtained from research on the effect of exchange rate volatility are varying. Koray and Lastrapes (1989) studied the relationships between real exchange rate volatility and U.S. imports using a VAR model and found a very weak effect.

Evidently, information on future exchange rates became imperative in the world of trade. Forecasting spot exchange rates became widely popular among scholars as it showed a strong impact especially on the financial markets. Forward exchange rates been used as proxies for expected future spot rates in several studies. Numerous studies investigated whether the forward rates are reliable forecasters of the future spot rates. The research during the course of the period have produced conflicting results.

The reminder of the thesis organized as follows. Section 2 provides a review of the literature on exchange rate modeling and forecasting. Section 3 provides a theoretical background for the modelling. The empirical results are reported and analyzed in section 4. Section 5 discuss the results and conclusion is provided.

CHAPTER 2: Literature Review

Empirical results of exchange rate volatility impact on trade research, found to be inconclusive. Studies have come up with mixed results, where, some have had positive relationships with exchange rate and trade and some have found negative relationships. Arize (1995), Arize et al. (2000) and de Vita and Abbot (2004) obtained evidence that, exchange rate volatility has an adverse effect on trade due to risk-averse traders. That is, higher exchange rate volatility leads to higher costs for risk-averse traders and thus to less volume of trade. In contrast, Asseery and Peel (1991and Bredin et al. (2003) are among those who found that exchange rate volatility affects trade positively. Aristotelous (2001) found no evidence to suggest that exchange rate volatility has any significant impact on trade.

Looking in to the approach followed by scholars on assessing the impact of different measurements schemes of exchange rate volatility, McKenzie (1999) provides some in depth insights. McKenzie (1999) gives a thorough review of the literature and discusses several empirical issues that may be important when determining the impact of exchange rate volatility on trade. These issues are mainly related to which exchange rate volatility measure to use, which sample period to consider, which countries to study, which data frequency and aggregation level to employ and which estimation method to apply in each specific study at hand (McKenzie, 1999). As pointed out by McKenzie (1999), each of these issues and how they are handled may be part of the explanations for the inconclusive findings in the literature.

Several proxy measurements and measurement varieties have been used by some scholars. One of the most frequently used measures is the moving average standard deviation of the growth of the exchange rate. Fountas and Aristotelous (1999) and de Vita and Abbott (2004) used moving average standard deviation of the growth of the exchange rate measurement in their studies.

However, Pagan and Ullah (1988) have forwarded concerns on measurement error problem due to the lack of a parametric model in the approach of moving average standard deviation. Alternative efforts were taken by using models like autoregressive conditional heteroscedasticity (ARCH). Kroner and Lastrapes (1993) by including ARCH based measures of volatility. The ARCH based models were utilized to provide more produce consistent estimates of parameters. The ARCH models exchange rate volatility drew criticism on wrong statistical inference where parameter adjustments were required. Koray and Lastrapes (1989) studied the relationships between real exchange rate volatility and U.S. imports using a VAR model where macro variables were included and found a very weak effect on trade by the exchange rate volatility.

Fama (1984), conducted a research on joint measurement of variation in the premium and expected spot exchange rates of the forward rate components. Fama (1984) paper regressed future change in spot exchange on current change in forward and spot exchange rates. Fama (1984) concluded from the empirical results that forward exchange rate observed at time t has information on the spot exchange rate observed at t+1. However, Fama (1984) paper was based on the "unbiased hypothesis", which is forward exchange rate is considered to be the unbiased predictor for the future spot exchange rate provided rational expectations and risk neutrality. However, Hansen and Hodrick (1983) revealed statistically that forward exchange rate consisted of a risk premium which make it less of an optimal predictor. McCallum (1994) stated that forward exchange rate would fail as an unbiased predictor due to the influence of monetary policy changes effecting the rational expectation.

Taylor and Sarno (2003) explains that due to changes in the monetary policy or any other scenario change in policy regarding financial markets, foreign exchange markets continuously adjust their expectations. According to Taylor and Sarno (2003), continuous adjustment of expectations due to the changes in the monetary policy can create forecasting errors. The errors can be serially correlated as markets change their expectations through adaptive expectations by continuous expectation adjustments. For example, the future spot rate expectations will increase if the forward rates were under estimated (Taylor and Sarno, 2003). Taylor and Sarno (2003) suggested that Kalman filter method would be a suitable method to counter the changing expectation scenario as Kalman filter employs a recursive procedure for computing estimators.

The forecasting of exchange rates took a different direction when Wolff (1987) used recursive applications of the Kalman filter to predict exchange rates. Wolff (1987) compared the structural model and random walk model for predicting several exchange rates like U.S. Dollar-German Mark, U.S. Dollar-Japanese Yen and a few other. Wolff (1987) found mix results as for the U.S. Dollar-Mark exchange rate, structural model outperformed the random walk model at a number of horizons. Further, forecasts for the U.S. Dollar-Yen and U.S. Dollar-Pound exchange forecasted poorly rates at longer horizons compared to the random walk model (Wolf ,1987).

Wesso (1999) conducted a study on South African Rand-dollar exchange rate market efficiency, where the hypothesis was rejected. Wesso (1990) suggested the theoretical basis of constant coefficients used on the paper could be of fault. Wesso (1990) further suggested a time-variant coefficients approach to considering monetary policy changes happened during the data period used in the paper.

Clarida et al (2002) took a slightly different approach by introducing non-linear model for exchange rate forecast. Clarida et al (2002) employed a Markov-Switching vector error correction model and found out that the non-linear model outperformed the linear model and the random model in forecasting future dollar-yen exchange rate. However, many scholars argue that due to the sensitivity of the outliers and estimation error would result in higher erroneous forecasts by non-linear models. Clements and Hendry (2006) also added to the argument of employing non-linear models for forecasting by pointing out the parameter instability as the cause for erroneous forecasting.

CHAPTER 3-Theoretical Frameworks & Data

The general idea of using a filter on a data set is to cleanse the data further in order to distinguish between data and noise. There are several reasons for data to be noisy or unobserved, like measurement errors or frequency of measurement. The modeling method used in dynamic systems is generally called 'State Space Method' and the optimal solution of a linear dynamic system under a gaussian environment is given by the Kalman Filter (Hamilton J, 1994)

The thesis will employ three methods of forecasting. Random walk model or AR(1) model, Vector Auto Regression model (VAR) model and Time varying parameter model using the Kalman filter method to forecast the future spot exchange rate. The results will be compared to assess the accuracy of the models in forecasting spot exchange rate.

<u>Model for the OLS method</u>

$Spot_{t+1} - Spot_{t} = \alpha_{k,t} + \beta_{k,t}(Forw_{k,t} - Spot_{t}) + \Omega_{k,t+1}$

<u>Model for Kalman filter method</u>

$Spot_{t+1} - Spot_{t} = \alpha_{k,t} + \beta_{k,t}(Forw_{k,t} - Spot_{t}) + \mu_{k,t+1}$

$\beta_{k,t+1} = \beta_{k,t} + \upsilon_{k,t+1}$

$k = 1,3, 6$

$Forw_{k,t}$ = Forward exchange rate at time t for horizon k

$Spot_{,t+k}$=Spot exchange rate at time t+k

Where α is a fixed coefficient and $\beta_{k,t}$ is a vector of time-varying coefficient. $\mu_{k,t+1}$ is a scalar disturbance term and the error of the signal state. The error term of the transition state $\upsilon_{k,t+1}$ is a vector of disturbance term and. The following properties are assumed for the error terms:

$E(\mu_{k,t+1}) = 0$, $var(\mu_{k,t+1}) = Q$ (Q is a scalar)

$E(\upsilon_{k,t+1}) = 0$, $var(\upsilon_{k,t+1}) = R$ (R is a k X k matrix)

Data

Exchange rates of USD vs CND and GBP vs USD from period from January 2001 to December 2010 is used. The data has 120 monthly observations for each exchange rate series for a total of 480 observations for each exchange rate series as a series includes forward rates of three horizons and the spot exchange rate. Empirical analysis uses monthly data on both USD vs CND and GBP vs USD spot rates (Spot) and the 1-month (Forw1), 3-month (Forw3) and 6-month (Forw6) rates. Each sample will be performing out of sample forecasts to be compared with the actual data to assess the suitability and appropriateness of the model.

CHAPTER 4-Results & Analysis

The OLS model

The OLS method to predict the difference of future spot exchange rate and current spot exchange rate by regressing the difference on spot exchange rate forward exchange rate. Three different time horizon for the FWD is used for each exchange rate series. Time horizons for forward exchange rate are 1 month, 3 months and 6 months. The unit root tests are conducted to establish whether the data series are stationary to avoid spurious regression. The results of the Augmented Dickey-Fuller (ADF) unit root tests on the spot and forward rates difference series for each exchange rate series are presented in Table 3.1 and Table 3.2.

Table 3.1: Unit root test of different series at the level- USD vs CND

Variables	ADF (Adjusted t-statistics)
$Spot_{t+1}$- $Spot_t$	-4.1001**
$Forw_{1,t}$- $Spot_t$	-4.5389**
$Forw_{3,t}$- $Spot_t$	-4.2444**
$Forw_{6,t}$- $Spot_t$	-4.2536**

Note: ADF is Augmented Dickey-Fuller test where the null hypothesis is of a unit root in the series. ** and * indicate the rejection of the null hypothesis at the 90% and 95% level of confidence, respectively.

Table 3.2: Unit root test of different series at the level- GBP vs USD

Variables	ADF (Adjusted t-statistics)
$Spot_{t+1}$- $Spot_t$	-3.9533 **
$Forw_{1,t}$- $Spot_t$	-5.1941 **
$Forw_{3,t}$- $Spot_t$	-5.2008 **
$Forw_{6,t}$- $Spot_t$	-5.1995 **

Note: ADF is Augmented Dickey-Fuller test where the null hypothesis is of a unit root in the series. ** and * indicate the rejection of the null hypothesis at the 90% and 95% level of confidence, respectively.

The OLS estimation of the relationship between the spot exchange rate difference and each forward rate spot exchange rate difference in the two exchange rates are represented in Table 3.3 and 3.4.

Table 3.3: OLS estimation of the difference of future spot exchange rate and current spot exchange rate- USD vs CND
Dependent variable: $Spot_{t+1}$- $Spot_t$

	$Forw_{1,t}$-$Spot_t$	$Forw_{3,t}$-$Spot_t$	$Forw_{6,t}$-$Spot_t$
α	-0.002705	-0.002641	-0.002485
β	0.010966	0.012827	0.017260
R^2	0.002633	0.01337	0.01949
F-statistic	1.314	1.599	2.346
Probability (F-stat)	0.254	0.2086	0.1283

Note: *, ** and *** mean significant at 1%, 5% and 10%, respectively.

Table 3.4: OLS estimation of the difference of future spot exchange rate and current spot exchange rate- GBP vs USD
Dependent variable: $Spot_{t+1}$- $Spot_t$

	$Forw_{1,t}$-$Spot_t$	$Forw_{3,t}$-$Spot_t$	$Forw_{6,t}$ -$Spot_t$
α	0.0006095	0.001238	0.002160
β	0.1881157*	0.188295*	0.188154*
R^2	0.3227	0.3200	0.3148
F-statistic	56.23	55.54	54.21
Probability (F-stat)	0.0000	0.0000	0.00000

Note: *, ** and *** mean significant at 1%, 5% and 10%, respectively.

The results in Table 3.3 indicate that in the regression between the difference of the spot rates and the difference of forward rate and current spot rate of USD vs CND for all the time horizons are statistically insignificant at all levels. To further explore the case, granger causality test was performed on the USD vs CND using and table 3.5 presents the granger causality results for USD vs CND exchange rate.

Table 3.5: Statistics of the Granger Causality results- USD vs CND

Null hypothesis	P-Value
fwdspotcanchange1.subset do not Granger-cause spotchange.subset	0.1899
spotchangecan.subset do not Granger-cause fwdspotcanchange1.subset	0.0134**
Fwdspotcanchange3.subset do not Granger-cause spotchange.subset	0.3728
spotchangecan.subset do not Granger-cause fwdspotcanchange3.subset	1.533e-07 *
Fwdspotcanchange6.subset do not Granger-cause spotchange.subset	0.2818
spotchangecan.subset do not Granger-cause fwdspotcanchange6.subset	2.2e-16 *

Note: *, ** and *** mean significant at 1%, 5% and 10%, respectively

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The granger causality test suggests that for all time horizons difference of forward rate and current spot rate does not granger cause spot exchange rate difference in USD vs CND exchange rate. This finding indicates support for rejecting the unbiased forward rate hypothesis. According to Clarida et al (2002), although forward rate is found to not significant, forward rate still can contain important information to forecast the future spot rate. In order to probe more in to the matter, the data series will be used to forecast spot exchange rate difference using the Kalman filter method.

The results in Table 3.4 indicate that in GBP vs USD exchange rate series, the regression between the spot exchange rate difference and forward rate spot exchange rate difference for all time horizons are statistically significant. All the slope coefficients are similar but the intercept coefficients are not statistically significant for all time horizons. To further confirm the relationship granger causality test was performed for the GBP vs USD exchange rate series. Results are presented in Table 3.6

Table 3.6: Statistics of the Granger Causality results- GBP vs USD

Null hypothesis	P-Value
Fwdspotchange.subset do not Granger-cause spotchange.subset	2.2e-16*
spotchange.subset do not Granger-cause Fwdspotchange.subset	9.104e-15*
Fwd3spotchange.subset do not Granger-cause spotchange.subset	2.2e-16*
spotchange.subset do not Granger-cause fwd3spotchange.subset	5.107e-15*
Fwd6spotchange.subset do not Granger-cause spotchange.subset	2.2e-16*
spotchange.subset do not Granger-cause Fwd6spotchange.subset	2.941e-09*

Note: *, ** and *** mean significant at 1%, 5% and 10%, respectively.

The granger causality results in table 3.6 confirms that at all levels and horizons the null hypothesis is rejected for GBP vs USD.

<u>Random walk model</u>

Because this paper compares the forecast ability of the AR(1), Kalman Filter and VAR model estimations this section presents the random Walk estimation results. The random walk model or the AR(1) model is taken as the base model.

$Spot_{t+1}$-$Spot_t$ = β_t ($Spot_t$-$Spot_{t-1}$) + e_t, (1) Where e_t is the error term.

The estimation results of the random walk model for the GBP vs USD presented in Table 3.7.

Table 3.7: Statistics of the AR(1)- GBP vs USD
Dependent Variable: $Spot_{t+1}$- $Spot_t$

Variable	Coefficient	Std. Error
$Spot_t$- $Spot_{t-1}$	0.3498	0.001382
Intercept	0.0005	0.0052
Adjust. R-squared	0.3495	
Sum Squared res	0.001382	
Akaike info.	-443.44	
Log likelihood	224.72	

The results in table 3.7 suggests that even though the coefficients are significant, the slope coefficient values are not close to unity. The result makes it difficult to confirm whether the $Spot_t$-$Spot_{t-1}$ of GBP VS USD follow a random walk.

<u>Comparison of the forecasting models</u>

Table 3.8: Out-of-sample statistics for GBP vs USD

Forecast Methods	RMSE
Kalman Filter	
1-month forward	0.05723
3-month forward	0.05715
6-month forward	0.05694
VAR	
1-month forward	0.00045
3-month forward	0.00118
6-month forward	0.00233
AR(1)	0.05500

Table 3.9: Out-of-sample statistics for USD vs CND

Forecast Methods	RMSE
Kalman Filter	
1-month forward	0.05320
3-month forward	0.05308
6-month forward	0.05288
VAR	
1-month forward	0.02414
3-month forward	0.02526
6-month forward	0.02531
AR(1)	0.02360

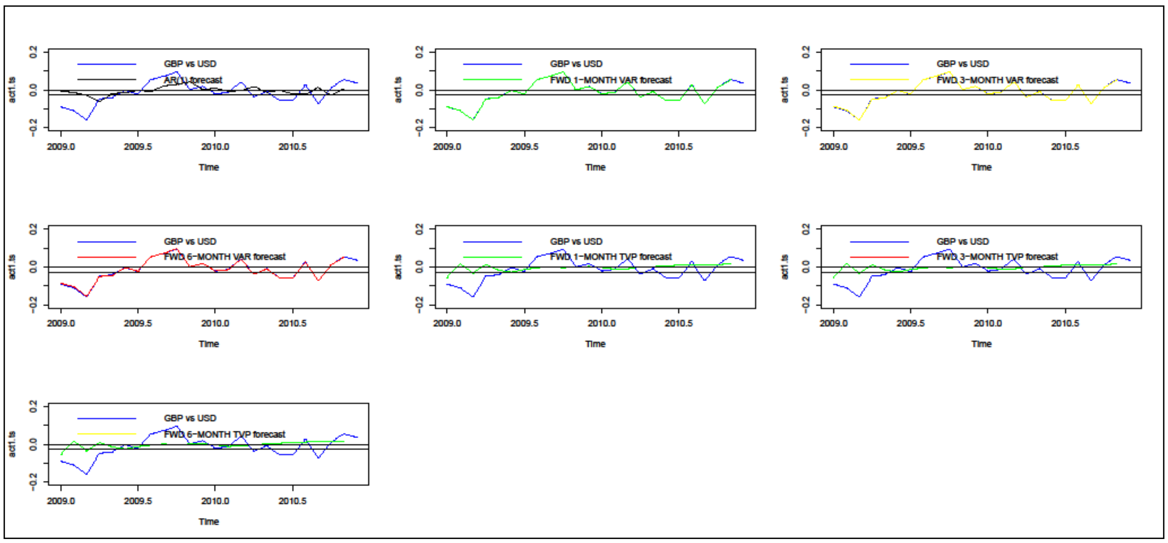

Figure 3.1 Out of sample forecast of GBP vs USD

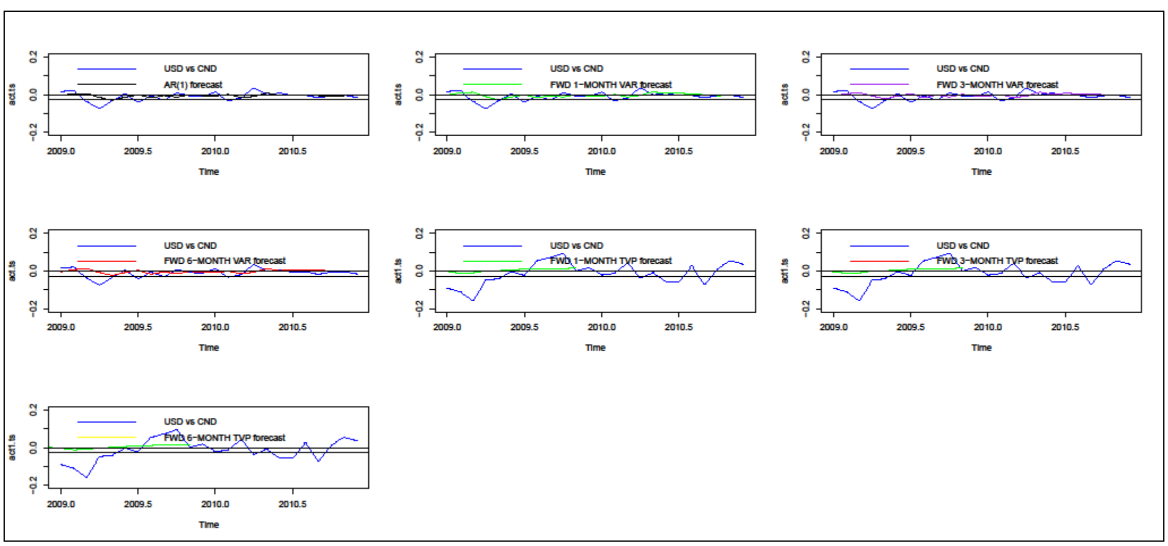

Figure 3.2 Out–of sample forecast of USD vs CND

Model comparison section discuss the forecasting method that best predicts the future spot exchange rate difference. The thesis is assessing the forecast accuracy of spot exchange rate of both the USD vs CND and GBP vs USD exchange rate series, through three different models, AR(1), Kalman Filter and VAR models . Root means square error (RMSE) will be the basis in assessing the forecast accuracy of for the one-month-ahead forecasts for the two exchange rate series used in the thesis. Table 3.8 show that the GBP vs USD exchange rate forecasts of the future spot exchange rate differences. According to table 3.8 VAR model with the FWD-1 month has the least RMSE of 0.0045 out of all the forecasting models. Figure 3.1 how each model forecast against the actual and predicted future spot exchange rate difference estimated with AR(1) and VAR model. According to figure 3.1, all the VAR models outperform the AR(1) and Kalman filter models.

Table 3.9 show that the USD vs CND dollar exchange rate forecasts of the future spot exchange rate differences shows a different story to the GBP vs USD exchange rate series. According to Table 3.9 AR model for with 1-month forward exchange rate has the least RMSE of 0.02360 out of all the forecasting models. AR(1) model is less than all the horizons of the Kalman filter approach and the VAR models. In the Kalman filter approach, once the horizon increases the forecasting error decreases. Figure 3.2 shows the performance of each forecast model against the actual data. According to figure 3.2, except the AR(1)model, VAR model and Kalman filter models are very weak in predicting USD vs CND dollar future spot exchange difference.

CHAPTER 5-Conclusion

The use of Kalman filter method in determining the time-varying coefficients characteristic of the data concluded that there is no time variance of the coefficients. Hence, Kalman filter method did not contribute in improving the predictability of the of both the exchange rate series.

Furthermore, the out-of-sample forecast accuracy of the AR (1) method outperformed both Kalman filter and VAR models in predicting the USD vs CND exchange rate future spot rates. The result aligns with previous studies as random walk model was found to be the most effective model. Therefore, in predicting for USD vs CND spot exchange rate difference, the time horizon effect of the forward rates can be concluded as ineffective.

However, predicting GBP vs USD spot exchange rate difference, VAR model outperforms both AR(1) model and the Kalman filter approach for GBP vs USD. Since, GBP vs USD showed greater granger causality, the result can be deemed accurate.

This indicates that even though the structural models are used in time-varying coefficients it does not guarantee that it will outperform the fixed coefficient approach. This may be due to the fact that; data does not have strong time-varying coefficients for both exchange rate series. The characteristic of the data is evidently highly influential in forecasting.

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