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EXCHANGE RATE VOLATILITY AND UNCERTAINTY IN INDIA – A STUDY OF INR VS MYR

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ABSTRACT

The exchange rate volatility and its modelling has gained importance since the breakdown of Bretton Woods System in 1973 and subsequent movement of many countries shifting from fixed exchange rate system to floating exchange rate system. India shifted from fixed exchange rate to the Liberalized Exchange Rate Management System (LERMS) in 1992 and market determinant exchange rate regime in 1993 which is a major structural changes in Indian foreign exchange market. This has lead to huge volatility in exchange rate. Exchange rate volatility induces uncertainty in international transactions. This uncertainty reduces international trade and the growth of the economy. The present study is an attempt to analyse the volatility and uncertainty of exchange rate with specific reference to INR vs MYR (Malaysian Ringgit) based on the past 14 years daily exchange rate while the time series properties of the data was examined using the ADF and PP approach, the stationary process, and order of the incorporated series. The ARCH and GARCH models were used to examine the degree or severity of volatility based on the first difference estimated volatility. AR GARCH results showed that lagged (last year) exchange rate is significantly responsible for the dynamics of INR vs MYR exchange rate in India. Further, the Granger causality test conducted shows that the direction of causality is more powerful and significant from actual exchange rate to exchange rate uncertainty in India.

Keywords: *Exchange Rate, Volatility, Uncertainty, AR GARCH Model, Granger Causality*

INTRODUCTION

Exchange rate plays a crucial role in the international business. Currency conversion is essential in the cross border transactions such as imports, exports, ECBs, FDI flows and FPI flows. One of the major risk involved in these transactions is exchange rate risk. Exchange rate risk arises on conversion of one currency into another currency due to floating exchange rates. Exchange rates are volatile in this floating exchange rate regime. Since the breakdown of Bretton Woods System in 1973 and subsequent movement of many countries shifting from fixed exchange rate system to floating exchange rate system. India moved away from fixed exchange rate to the Liberalized Exchange Rate Management System (LERMS) in 1992 and market determinant exchange rate regime in 1993 which is a major structural changes in Indian foreign exchange market. Since then exchange rate is determined by market forces. Managed float exchange rate is prevailing in India. Exchange rate is not administratively determined, however, the RBI intervenes on need basis under the managed float system. This lead to volatile exchange rates in Indian Forex Market. RBI is trading actively in the market, to check undesirable appreciation and depreciation of INR against major currencies of the world.

Foreign exchange rate change is an inevitable factor and it is having impact on all the participants of foreign exchange market such as exporters, importers, investors, bankers, financial institutions, business concerns, foreign employees, NRIs, tourists, other service providers, and policy makers. The timely and accurate forecasting and other characteristics and trends of foreign exchange rate movements will give valuable information to these participants in decision making and managing the foreign exchange exposure. The exchange rate volatility and its modelling has gained importance in this floating exchange rate system. The present study aims to capture the volatility of exchange rate and uncertainty with specific reference to INR and MYR based on the 14 years data (1999-2013).

REVIEW OF LITERATURE

Brief review of literature on exchange rate volatility is done in this section. Augustine, et al., (2000)[1] The impact of exchange rate volatility on the export flows of 13 Less Developed Countries results in to that increase

[1] Augustine C. Arize, Thomas Osang, Daniel J. Slottje (2000), Exchange Rate Volatility and Foreign Trade: Evidence from 13 LDC's, Journal of Business and Economic Statistics, 18(1) pp. 10-17.

in the volatility of the real effective exchange rate uncertainty has a significant negative effect on export demand in both the short- run and long- run in each of 13 LDC's.

Ruiz (2005)[2] examines the effects of inflation and exchange rate uncertainty on real economic activity in Columbia, by using a generalized autoregressive conditional variance (GARCH) model of inflation and exchange rates, the conditional variances of the model's forecast errors were extracted as measures of uncertainty. The results suggest that higher levels of inflation Granger cause more uncertainty and vice versa for the Colombian economy.

Alok Kumar Mishra, Niranjan Swain, and D.K. Malhotra (2007)[3] explore the volatility spill over between the Indian stock and foreign exchange markets. The results indicate that there exists a bi-directional volatility spill over between the Indian stock market and the foreign exchange market with the exception of S&P CNX NIFTY and S&P CNX 500. The results of significant bi-directional volatility spill over suggest that there is an information flow (transmission) between these two markets and both these markets are integrated with each other.

Chong Lee-Lee and Tan Hui-Boon (2007)[4] examine the factors of exchange rate volatility from the macroeconomic perspective for four neighbouring ASEAN economies in both the short and the long run by applying econometrics techniques. The results indicate that, a set of common factors seems to influence the exchange rate volatility, whereby the stock market is a great influence commonly found across countries. The Indonesian rupiah seems to be the most sensitive to the innovations in macroeconomic factors, while the Singapore dollar is the least.

Koi Nyen Wong and Tuck Cheong Tang (2007)[5] examines the effects of exchange rate variability on export demand for semiconductors, which is the largest sub-sector of electronics industry in Malaysia as reported

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2 Ruiz, I.C, Empirical analysis on the real effects of inflation and exchange rate uncertainty: The case of Colombia, Ecos de Economia, No. 20, Medellin, April 2005, pp. 7- 28.

3 Alok Kumar Mishra, Niranjan Swain, and D.K. Malhotra, Volatility spill over between Stock and Foreign Exchange Markets: Indian Evidence, International Journal of Business, Vol.12, No.3, 2007, pp. 1083–4346.

4 Chong Lee-Lee and Tan Hui-Boon, Macroeconomic factors of exchange rate volatility Evidence from four neighbouring ASEAN economies, Studies in Economics and Finance Vol. 24, No. 4, 2007, pp. 266-285.

5 Koi Nyen Wong and Tuck Cheong Tang, Exchange Rate Variability and the Export Demand for Malaysia's Semiconductors: An Empirical Study, Discussion Paper, 2007, ISSN 1441- 5429.

by MIDA (Malaysian Industrial Development Authority, 2004). The results shown were estimated based on the Johansen's multivariate co-integration tests and error correction model; suggest that there is a unique long-run relationship among quantities of export, relative price, real foreign income, and real exchange rate variability. The major finding was the variability of real exchange rate has some effect on semiconductor exports in both the long-run and the short-run.

Duc Khuong Nguyen (2008)[6] empirically examined the dynamic changes in emerging market volatility around stock market liberalization. A bivariate GARCH-M model which counts for partial market integration is developed for modelling stock market volatility in emerging market countries. Also the Bai and Perron stability test in a linear framework and a pooled time-series cross-section model were employed to examine the empirical relationship between stock market liberalization and volatility. Structural breaks detected in emerging market volatility series did not take place at the time of official liberalization dates, but they rather coincide with alternative events of liberalization process. The effects of official liberalization on return volatility are on average insignificant. The stock return volatility is however lowered when the participation of the US investors becomes effective and important on emerging markets when there is an increase in the size of emerging markets.

Ahmad Jafari Samimi, Mehdi Adibpour and Negin Heydarizadeh (2012)[7] analysed the exchange rate uncertainty and imports in the context of Iran. ARCH model has been used to calculate the real exchange rate uncertainty and the real exchange rate uncertainty variable along with other variables such as GDP were put into imports regression mode by performing co-integration test among existing variables in import model and certainty of existence of minimum one long-term relation among them, the vector error correction model was assessed by imposing a long-term vector auto-regression model. The results shown that, the real exchange rate uncertainty during the concerned period had negative impact on imports. In addition, the variable of real exchange rate was affected from the negative impact on imports. Furthermore, the GDP experienced positive impacts on the imports of the country.

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[6] Duc Khuong Nguyen, Stock market liberalization, structural breaks and dynamic changes in emerging market volatility, Review of Accounting and Finance, Vol. 7 No. 4, 2008, pp. 396-411.

[7] Ahmad Jafari Samimi, Mehdi Adibpour and Negin Heydarizadeh, Exchange Rate Uncertainty and Imports: Evidence from Iran, Middle-East Journal of Scientific Research, Vol.11, No.2, 2012, pp.167-172, ISSN 1990-9233.

Khalafalla Ahmed Mohamed Arabi (2012)[8] studies analysed to estimate volatility of exchange rate with respect to Sudanese pound. The consequences for exchange rate volatility were mutual influence of high inflation rate, deterioration of the productive sectors, continuous internal and external deficits and depreciation of the exchange rate. EGARCH (1,1) was used to estimate the exchange rate volatility. The results indicated that, the leverage effect term is negative and statistically different from zero, indicating the existence of the leverage effect (negative correlation between past returns and future volatility).

Yamini Karmarkar, Muskan Karamchandanic and Ashima Mantri (2012)[9] investigated the relationship between macroeconomic variables and exchange rate. A significant causal relation found between exchange rates and foreign exchange reserves, Sensex and reserve money. Bi-directional causality between exchange rates and other three macro-economic variables i.e. foreign exchange reserves, Sensex and RBI open market operations (net) were observed. India being a developing country has its exchange rates still being affected mostly by the fundamental variables of the external sector, financial market and financial sector. But as found out there is weak evidence in favour of Indian exchange rates being affected by the real sector.

Anita Mirchandani (2013)[10] carried out research in order to investigate various macroeconomic variables leading to acute variations in the exchange rate of a currency. An attempt has been made to review the probable reasons for the depreciation of the Rupee and analyse different macroeconomic determinants that have impact on the volatility of exchange rate and their extent of correlation with the same. Indian Rupee has shown high volatility over the years. There are various probable reasons associated with it. India was receiving capital inflows even amidst continued global uncertainty in2009-11 as its domestic outlook was positive. With domestic outlook also turning negative, Rupee depreciation was a natural outcome. Apart from lower capital inflows uncertainty over domestic economy has also made investors nervous over Indian economy which has further exaggerated depreciation pressures.

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8 Khalafalla Ahmed Mohamed Arabi, Estimation of Exchange Rate Volatility via GARCH Model Case Study Sudan (1978 – 2009), International Journal of Economics and Finance, Vol. 4, No. 11, 2012 ISSN 1916-971X, E-ISSN 1916-9728.

9 Yamini Karmarkar, Muskan Karamchandanic and Ashima Mantri, Exchange Rate and Macro-economic indicators: A Causal Study for India of the Past Decade, Pacific Business Review International, Volume 5 Issue 3, September 2012, pp. 97-113.

10 Anita Mirchandani, Analysis of Macroeconomic Determinants of Exchange Rate Volatility in India, International Journal of Economics and Financial Issues, Vol. 3, No. 1, 2013, pp.172-179.

Kelechinnamdi and EbeleIfionu (2013)[11] examined exchange rate volatility over time (1970-2012) using the Generalized Autoregressive Conditional Heteroscedasticity (AR GARCH) model of the Maximum Likelihood techniques. AR GARCH result showed that lagged (last year) exchange rate is significantly responsible for the dynamics of Naira/ Dollar exchange rate in Nigeria. ARCH and GARCH parameters indicate that exchange rate volatility shocks are rather persistent in Nigeria. It is found that exchange rate uncertainty has a direct relationship with current exchange rate in Nigeria. Further, the Granger causality test conducted revealed the direction of causality is more powerful and significant from exchange rate uncertainty to actual exchange rate in Nigeria.

Vandana Kotai (2013)[12] studied the intraday effects of a representative group of scheduled economic releases on five exchange rates: INR/USD, JPY/USD, EURO/USD, GBP/USD, and CNY/USD. It is found that the Indian currency market is more sensitive due to the external factors. Due to external and internal factors Indian currency market is more volatile and sensitive market compare to other countries.

Zukarnain Zakaria (2013)[13] empirically examined the relationship between exchange rate volatility and trade by using regression analysis of standard export demand models. The exchange rate volatilities were measured by GARCH (1,1) models. The results from regression analysis show that Malaysian exports to the US and Japan are significantly related with exchange rate volatility. The impact of exchange rate volatility on Malaysia export to US was found negative; while for Japan, it's positive. Malaysia's export to the UK and Singapore was found not significantly related to the volatility in the exchange rates. The findings from this study clearly indicate that the relationship between export performance and exchange rates volatility is ambiguous.

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11 Kelechi Nnamdi and EbeleIfionu, Exchange Rate Volatility and Exchange Rate Uncertainty in Nigeria: A Financial Econometric Analysis (1970- 2012), University of Port Harcourt, Nigeria, 2013, MPRA Paper No. 48316.

12 Vandana Kotai, An Empirical Study on Currency volatility in Foreign Exchange Market, Global Journal of Management and Business Studies. ISSN 2248-9878 Volume 3, Number 8 (2013), pp. 897-904.

13 Zukarnain Zakaria, The Relationship between Export and Exchange Rate Volatility: Empirical Evidence Based on the Trade between Malaysia and Its Major Trading Partners, Journal of Emerging Issues in Economics, Finance and Banking (JEIEFB) *An Online International Monthly Journal, Vol. 2, No.2, August 2013*, ISSN: 2306-367X.

METHODOLOGY

The present study attempts to describe the exchange rate volatility and exchange rate uncertainty in India with specific reference to INR vs MYR. The study employs analytical research. The data has been collected from the website of Bank of Lithuania. Analysis is based on daily exchange rate of INR vs MYR for past fourteen years - January 1999 to December 2013. The exchange rate volatility and exchange rate uncertainty in India has been analysed by using financial econometric models. Unit Root Tests (Augmented Dickey Fuller Test and Phillips-Parren Test) applied to test the stationarity of the time- series data, Auto Regressive Conditional Heteroscedasticity (ARCH), and Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) models are applied to forecast and analyse the size of errors especially in case of volatility. Granger Causality test is used to forecast one time series data with another and to check the causal relationship between actual exchange rate and its uncertainty.

Equations developed to establish the relationship between actual exchange rate (σt) and exchange rate uncertainty (∂t) are applied[14].

$$\sigma_t = \sum_{i=1}^{n} \pi_0\, \partial_{t-1} + \sum_{j=1}^{n} \pi_1\, \sigma_{t-1} + \mu_{1t} \quad (1)$$

$$\partial_t = \sum_{i=1}^{n} \delta_0\, \partial_{t-1} + \sum_{j=1}^{n} \delta_1\, \sigma_{t-1} + \mu_{2t} \quad (2)$$

Where,

σt = Actual Exchange rate

∂t = Exchange rate uncertainty

μ_{1t} and μ_{2t} = Uncorrelated by assumption

RESULTS AND DISCUSSION

This section of the paper presents and analyses the empirical results. ARCH model suggests that heteroscedasticity or unequal variance may have an autoregressive structure such that heteroscedasticity observed over different periods are uncorrelated. Unit root test applied to check for stationarity of the time series data. The estimation of the volatility and uncertainty of the exchange rate has been done by using ARCH, GARCH

14 Source: Kelechi Nnamdi and EbeleIfionu, Exchange Rate Volatility and Exchange Rate Uncertainty in Nigeria: A Financial Econometric Analysis (1970- 2012), University of Port Harcourt, Nigeria, 2013, MPRA Paper No. 48316.

models and Granger Causality tests. The results of all the models used in the study to estimate the exchange rate volatility and exchange rate uncertainty in India are discussed under this section.

1. **Unit Root for Stationarity:** Results from Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests with the test level and with an intercept are shown in the Table 1. E-Views output is given in Appendix A to H.

Table 1

Unit Root Test of Stationarity Results

Table 1.1: The estimated τ statistic values from Unit root test				
Variables	**Level& Intercept**		**1st difference & Intercept+ Trend**	
	ADF	PP	ADF	PP
Actual Exchange rate(σt)	-1.57902	-1.5758	-74.02	-74.023
Exchange Rate Uncertainty(∂t)	-3.29659	-3.2994	-66.24	-66.2457

Notes: a. Critical values for unit root test (ADF & PP) are:
-3.431363* and -2.861873** (without trend) and;
-3.959713*, -3.410625** (with trend)
b. * and ** indicate stationarity respectively at 1% and 5% levels.

Application of Augmented Dickey- Fuller (ADF) and Phillips- Perron (PP) tests shown in Table 1 indicates that the Unit Root Test results of actual exchange rate and exchange rate uncertainty in the model with the level and intercept shown insignificant results, but the model is integrated of the order one, I (1), implying that are stationary at their first difference, and also with the trend and intercept.

2. **AR GARCH Estimation Results:** Estimation of volatility using AR GARCH model is given in the Table 2. E-Views output is given in Appendix J and K.

The results obtained as shown in the Table 2 can be interpreted as, the output from the ARCH and GARCH estimation has been divided in to two parts i.e., the upper part shows the Standard Output for the Mean Equation, while the lower part named as Variance Equation which contains the Coefficients, Standard Errors, t- Statistics and pp- values for the coefficients of the variance equation.

Table 2

AR GARCH Estimation of Exchange Rate in India (1999- 2013)

Independent Variable	**Dependent Variable**	
	σt **(with GARCH)**	σt **(without GARCH)**
	0.004547 (0.644092)	0.002755 (0.832547)
	0.999383 (1135.254)	0.999613 (2423.890)
Statistics		
R-squared	0.999322	0.999322
F-statistics	2016169.	2688643.
D-W statistics	2.000149	2.000554
Variance Equation		
ARCH (1)	-0.006621 (-14.70970)	
GARCH (1)	0.601320 (10.78288)	

Note: z values are shown in parentheses

AR GARCH estimation from the Table 2 can be interpreted as; the t-statistic show that lagged (last year) exchange rate is significantly responsible for the dynamics of Rupee/ MYR exchange rate in India. The overall summary statistics shows that, the R- squared of 0.999322 (99%) indicates that the model has a good fit for prediction and policy purposes. The F- statistic shows overall significance of the model, while the Durbin- Watson statistic indicates the absence of serial auto correlation in the model, whether positive or negative.

In this study, the sum of ARCH and the GARCH coefficients is used to capture the nature of volatility shocks over time. From the results shown in the Table 2, the sum of the ARCH and GARCH coefficients is not close to unity; this indicates that exchange rate volatility shocks are not quite consistent in India.

3. **Estimated relationship between the actual exchange rate and exchange rate uncertainty:** Estimated relationship between the actual exchange rate and exchange rate uncertainty as proposed in equations (1) and (2) is shown as under:

$$\sigma_t = 0.005004 + 0.999450\ \sigma_{t-1} + -0.570696\ \partial t \qquad (3)$$

(0.713827) (2820.983) (-0.136282)

$R^{2}=0.999322$

F- Statistics= 4033888.

Durbin-Watson Statistics= 2.000204

$$\partial t = 0.000678 + 0.550996\, \partial_{t-1} + 0.00000466\, \sigma_t \qquad (4)$$
(36.28286) (49.36776) (4.937174)

$R^{2}=0.318051$

F- Statistics= 1276.499

Durbin-Watson Statistics= 1.980794

Note: E-Views output used for equation 3 and 4 given in Appendix L and M.

In comparing between equations (3) and (4) above, it is shown that actual exchange rate has a direct relationship with the exchange rate uncertainty in India. This is evidence, that consciousness of lack of knowledge about present exchange rate or future possibilities of changes in the exchange rate by economic agents will definitely influence the current exchange rate, than the previous exchange rate. The overall summary statistics (R^2, F- Statistics and D.W Statistics) are supportive and shown the significant results.

3. **The Granger Causality Test:** A test of causality conducted is shown in Table 3. E-Views output is given in Appendix N.

Table 3

Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
∂t does not Granger Cause	5476	0.01149	0.9886
σ_t does not Granger Cause		16.0307	0.0000001

Significance at 5%

The results show that the direction of causality is more powerful and significant from actual exchange rate to exchange rate uncertainty in India. This finding supports the results of equation (3) and (4).

CONCLUSION

The present study describes and analyses the exchange rate volatility and its uncertainty in India with specific reference to exchange rate between INR vs MYR for fourteen years - January 1999- December 2013. Lagged exchange rate is significantly responsible for dynamics in current exchange rate in India. It indicates that the prior information leads to ascertain the current exchange rate. Unit root test results shown the model is integrated of the order one, I (1), implying that are stationary at their first difference with intercept and trend. The estimation of volatility has been done by using the financial econometric models such as ARCH and GARCH. Granger Causality test results have shown that the direction of causality is more powerful and significant from actual exchange rate to exchange rate uncertainty in India. The financial econometric test results have indicated that volatility in the exchange rate was not only significant but also persistent in India over the study period.

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APPENDIX – E-VIEWS OUTPUT

A. AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE

(Test for unit root in level and equation test with intercept)

Null Hypothesis: D(σ) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic based on SIC, MAXLAG=32)				
			t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic			-1.579024	0.4933
Test critical values:	1% level		-3.431363	
	5% level		-2.861873	
	10% level		-2.566989	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(σ_t, 2)				
Method: Least Squares				
Date: 04/27/14 Time: 20:01				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-0.000556	0.000352	-1.579024	0.1144
C	0.004140	0.002991	1.384008	0.1664
R-squared	0.000455	Mean dependent var		-0.000529
Adjusted R-squared	0.000273	S.D. dependent var		0.033379
S.E. of regression	0.033374	Akaike info criterion		-3.961713
Sum squared resid	6.099305	Schwarz criterion		-3.959301
Log likelihood	10853.13	Hannan-Quinn criter.		-3.960872
F-statistic	2.493318	Durbin-Watson stat		2.000302
Prob(F-statistic)	0.114388			

AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE

(Test for unit root in 1st difference and equation test with trend & intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic based on SIC, MAXLAG=32)				
			t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic			-74.01711	0.0001
Test critical values:	1% level		-3.959713	
	5% level		-3.410625	
	10% level		-3.127091	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(□□, 2)				
Method: Least Squares				
Date: 04/29/14 Time: 00:58				
Sample (adjusted): 3 5479				
Included observations: 5477 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-1.000414	0.013516	-74.01711	0.0000
C	-0.001267	0.000903	-1.403060	0.1607
@TREND(1)	2.69E-07	2.85E-07	0.942557	0.3459
R-squared	0.500207	Mean dependent var		-2.74E-19
Adjusted R-squared	0.500024	S.D. dependent var		0.047215
S.E. of regression	0.033385	Akaike info criterion		-3.960873
Sum squared resid	6.101091	Schwarz criterion		-3.957253
Log likelihood	10849.85	Hannan-Quinn criter.		-3.959610
F-statistic	2739.266	Durbin-Watson stat		2.000001
Prob(F-statistic)	0.000000			

PHILLIPS- PERRON UNIT ROOTS TEST ON EXCHANGE RATE

(Test for unit root in level and equation test with intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant				
Bandwidth: 10 (Newey-West using Bartlett kernel)				
			Adj. t-Stat	**Prob.***
Phillips-Perron test statistic			-1.575754	0.4950
Test critical values:	1% level		-3.431363	
	5% level		-2.861873	
	10% level		-2.566989	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				0.001113
HAC corrected variance (Bartlett kernel)				0.001092
Phillips-Perron Test Equation				
Dependent Variable: D(□□, 2)				
Method: Least Squares				
Date: 04/27/14 Time: 20:03				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D (□(-1))	-0.000556	0.000352	-1.579024	0.1144
C	0.004140	0.002991	1.384008	0.1664
R-squared	0.000455	Mean dependent var		-0.000529
Adjusted R-squared	0.000273	S.D. dependent var		0.033379
S.E. of regression	0.033374	Akaike info criterion		-3.961713
Sum squared resid	6.099305	Schwarz criterion		-3.959301
Log likelihood	10853.13	Hannan-Quinn criter.		-3.960872
F-statistic	2.493318	Durbin-Watson stat		2.000302
Prob(F-statistic)	0.114388			

D. PHILLIPS- PERRON UNIT ROOTS TEST ON EXCHANGE RATE
(Test for unit root in 1st difference and equation test with trend & intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant, Linear Trend				
Bandwidth: 11 (Newey-West using Bartlett kernel)				
			Adj. t-Stat	**Prob.***
Phillips-Perron test statistic			-74.02282	0.0001
Test critical values:	1% level		-3.959713	
	5% level		-3.410625	
	10% level		-3.127091	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				0.001114
HAC corrected variance (Bartlett kernel)				0.001087
Phillips-Perron Test Equation				
Dependent Variable: D(□□,2)				
Method: Least Squares				
Date: 04/29/14 Time: 01:05				
Sample (adjusted): 3 5479				
Included observations: 5477 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D (□(-1))	-1.000414	0.013516	-74.01711	0.0000
C	-0.001267	0.000903	-1.403060	0.1607
@TREND(1)	2.69E-07	2.85E-07	0.942557	0.3459
R-squared	0.500207	Mean dependent var		-2.74E-19
Adjusted R-squared	0.500024	S.D. dependent var		0.047215
S.E. of regression	0.033385	Akaike info criterion		-3.960873
Sum squared resid	6.101091	Schwarz criterion		-3.957253
Log likelihood	10849.85	Hannan-Quinn criter.		-3.959610
F-statistic	2739.266	Durbin-Watson stat		2.000001
Prob(F-statistic)	0.000000			

E. AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE UNCERTAINTY

(Test for unit root in level and equation test with intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic based on SIC, MAXLAG=30)				
			t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic			-3.296589	0.0151
Test critical values:	1% level		-3.431659	
	5% level		-2.862003	
	10% level		-2.567060	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(□□, 2)				
Method: Least Squares				
Date: 04/27/14 Time: 20:08				
Sample: 1098 5479				
Included observations: 4382				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-0.002309	0.000700	-3.296589	0.0010
C	0.017517	0.005543	3.160160	0.0016
R-squared	0.002475	Mean dependent var		-0.000662
Adjusted R-squared	0.002247	S.D. dependent var		0.037300
S.E. of regression	0.037258	Akaike info criterion		-3.741466
Sum squared resid	6.079998	Schwarz criterion		-3.738552
Log likelihood	8199.552	Hannan-Quinn criter.		-3.740438
F-statistic	10.86750	Durbin-Watson stat		2.000969
Prob(F-statistic)	0.000986			

F. AUGMENTED DICKEY- FULLER UNIT ROOT TEST ON EXCHANGE RATE UNCETAINTY

(Test for unit root in 1st difference and equation test with trend & intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic based on SIC, MAXLAG=30)				
			t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic			-66.23790	0.0000
Test critical values:	1% level		-3.960133	
	5% level		-3.410830	
	10% level		-3.127213	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D($□_{□}$, 2)				
Method: Least Squares				
Date: 04/29/14 Time: 01:15				
Sample: 1098 5479				
Included observations: 4382				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-1.000965	0.015112	-66.23790	0.0000
C	-0.002310	0.001127	-2.049343	0.0405
@TREND(1098)	7.52E-07	4.46E-07	1.688139	0.0915
R-squared	0.500483	Mean dependent var		-3.67E-19
Adjusted R-squared	0.500254	S.D. dependent var		0.052758
S.E. of regression	0.037296	Akaike info criterion		-3.739182
Sum squared resid	6.091119	Schwarz criterion		-3.734811
Log likelihood	8195.549	Hannan-Quinn criter.		-3.737640
F-statistic	2193.730	Durbin-Watson stat		2.000003
Prob(F-statistic)	0.000000			

G. PHILLIPS- PERRON UNIT ROOTS TEST ON EXCHANGE RATE UNCERTAINTY

(Test for unit root in level and equation test with intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant				
Bandwidth: 10 (Newey-West using Bartlett kernel)				
			Adj. t-Stat	**Prob.***
Phillips-Perron test statistic			-3.299362	0.0150
Test critical values:	1% level		-3.431659	
	5% level		-2.862003	
	10% level		-2.567060	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				0.001387
HAC corrected variance (Bartlett kernel)				0.001357
Phillips-Perron Test Equation				
Dependent Variable: D(□□, 2)				
Method: Least Squares				
Date: 04/27/14 Time: 20:08				
Sample: 1098 5479				
Included observations: 4382				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-0.002309	0.000700	-3.296589	0.0010
C	0.017517	0.005543	3.160160	0.0016
R-squared	0.002475	Mean dependent var		-0.000662
Adjusted R-squared	0.002247	S.D. dependent var		0.037300
S.E. of regression	0.037258	Akaike info criterion		-3.741466
Sum squared resid	6.079998	Schwarz criterion		-3.738552
Log likelihood	8199.552	Hannan-Quinn criter.		-3.740438
F-statistic	10.86750	Durbin-Watson stat		2.000969
Prob(F-statistic)	0.000986			

H. PHILLIPS- PERRON UNIT ROOTS TEST ON EXCHANGE RATE UNCERTAINTY

(Test for unit root in 1st difference and equation test with trend & intercept)

Null Hypothesis: D(□) has a unit root				
Exogenous: Constant, Linear Trend				
Bandwidth: 11 (Newey-West using Bartlett kernel)				
			Adj. t-Stat	**Prob.***
Phillips-Perron test statistic			-66.24572	0.0000
Test critical values:	1% level		-3.960133	
	5% level		-3.410830	
	10% level		-3.127213	
*MacKinnon (1996) one-sided p-values.				
Residual variance (no correction)				0.001390
HAC corrected variance (Bartlett kernel)				0.001350
Phillips-Perron Test Equation				
Dependent Variable: D(□□, 2)				
Method: Least Squares				
Date: 04/29/14 Time: 01:28				
Sample: 1098 5479				
Included observations: 4382				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(□(-1))	-1.000965	0.015112	-66.23790	0.0000
C	-0.002310	0.001127	-2.049343	0.0405
@TREND(1098)	7.52E-07	4.46E-07	1.688139	0.0915
R-squared	0.500483	Mean dependent var		-3.67E-19
Adjusted R-squared	0.500254	S.D. dependent var		0.052758
S.E. of regression	0.037296	Akaike info criterion		-3.739182
Sum squared resid	6.091119	Schwarz criterion		-3.734811
Log likelihood	8195.549	Hannan-Quinn criter.		-3.737640
F-statistic	2193.730	Durbin-Watson stat		2.000003
Prob(F-statistic)	0.000000			

I. AR RESULT

Dependent Variable: $\square_{\square}$				
Method: Least Squares				
Date: 04/27/14 Time: 20:10				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
$\square_0$	0.004140	0.002991	1.384008	0.1664
$\square_{\square\ -1}$	0.999444	0.000352	2840.638	0.0000
R-squared	0.999322	Mean dependent var		8.404132
Adjusted R-squared	0.999322	S.D. dependent var		1.281446
S.E. of regression	0.033374	Akaike info criterion		-3.961713
Sum squared resid	6.099305	Schwarz criterion		-3.959301
Log likelihood	10853.13	Hannan-Quinn criter.		-3.960872
F-statistic	8069223.	Durbin-Watson stat		2.000302
Prob(F-statistic)	0.000000			

J. Estimated ARCH Results

Dependent Variable: $\square_{\square}$				
Method: ML - ARCH (Marquardt) - Normal distribution				
Date: 04/27/14 Time: 20:10				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Convergence achieved after 10 iterations				
Presample variance: backcast (parameter = 0.7)				
GARCH = C(3) + C(4)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
$\square_0$	0.002755	0.003309	0.832547	0.4051
$\square_{\square\ -1}$	0.999613	0.000412	2423.890	0.0000
Variance Equation				
C	0.000763	2.68E-06	284.2064	0.0000
RESID(-1)^2	-0.006621	0.000450	-14.70970	0.0000
R-squared	0.999322	Mean dependent var		8.404132
Adjusted R-squared	0.999321	S.D. dependent var		1.281446

(continued)

S.E. of regression	0.033381	Akaike info criterion	-3.891980
Sum squared resid	6.099565	Schwarz criterion	-3.887155
Log likelihood	10664.13	Hannan-Quinn criter.	-3.890297
F-statistic	2688643.	Durbin-Watson stat	2.000554
Prob(F-statistic)	0.000000		

K. ESTIMATED AR GARCH RESULTS

Dependent Variable: □$_{□}$				
Method: ML - ARCH (Marquardt) - Normal distribution				
Date: 04/27/14 Time: 20:11				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Convergence achieved after 17 iterations				
Pre sample variance: back cast (parameter = 0.7)				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
□$_{0}$	0.004547	0.007059	0.644092	0.5195
□$_{□-1}$	0.999383	0.000880	1135.254	0.0000
Variance Equation				
C	0.000653	8.83E-05	7.394648	0.0000
RESID(-1)^2	-0.014795	0.000142	-104.0614	0.0000
GARCH(-1)	0.601320	0.055766	10.78288	0.0000
R-squared	0.999322	Mean dependent var		8.404132
Adjusted R-squared	0.999321	S.D. dependent var		1.281446
S.E. of regression	0.033383	Akaike info criterion		-3.921122
Sum squared resid	6.099400	Schwarz criterion		-3.915091
Log likelihood	10744.95	Hannan-Quinn criter.		-3.919018
F-statistic	2016169.	Durbin-Watson stat		2.000149
Prob(F-statistic)	0.000000			

L. EXHANGE RATE AND EXCHANGE RATE UNCERTAINTY

Dependent Variable: □□				
Method: Least Squares				
Date: 04/27/14 Time: 20:16				
Sample (adjusted): 2 5479				
Included observations: 5478 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.005004	0.007010	0.713827	0.4754
□□ -1	0.999450	0.000354	2820.983	0.0000
□□	-0.570696	4.187603	-0.136282	0.8916
R-squared	0.999322	Mean dependent var		8.404132
Adjusted R-squared	0.999322	S.D. dependent var		1.281446
S.E. of regression	0.033377	Akaike info criterion		-3.961352
Sum squared resid	6.099284	Schwarz criterion		-3.957733
Log likelihood	10853.14	Hannan-Quinn criter.		-3.960089
F-statistic	4033888.	Durbin-Watson stat		2.000204
Prob(F-statistic)	0.000000			

M. EXCHANGE RATE UNCERTAINTY AND EXCHANGE RATE

Dependent Variable: □□				
Method: Least Squares				
Date: 04/27/14 Time: 20:17				
Sample (adjusted): 3 5479				
Included observations: 5477 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.000678	1.87E-05	36.28286	0.0000
□□ -1	0.550996	0.011161	49.36776	0.0000
□□	4.66E-06	9.45E-07	4.937174	0.0000
R-squared	0.318051	Mean dependent var		0.001597
Adjusted R-squared	0.317802	S.D. dependent var		0.000108
S.E. of regression	8.90E-05	Akaike info criterion		-15.81631
Sum squared resid	4.33E-05	Schwarz criterion		-15.81269
Log likelihood	43315.98	Hannan-Quinn criter.		-15.81505
F-statistic	1276.499	Durbin-Watson stat		1.980794
Prob(F-statistic)	0.000000			

N. CAUSALITY TEST

Pairwise Granger Causality Tests			
Date: 04/27/14 Time: 20:18			
Sample: 1 5479			
Lags: 2			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
$\square_{\square}$ does not Granger Cause $\square_{\square}$	5476	0.01149	0.9886
$\square_{\square}$ does not Granger Cause $\square_{\square}$		16.0307	1.E-07