TESTS OF THE UNCOVERED INTEREST PARITY

A Thesis by

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The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Arts with a major in Economics.

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ABSTRACT

This paper carries out empirical testing of the Uncovered Interest Parity for US-Mexico, US-Brazil and US-Japan using general OLS and GARCH from monthly data. Similar to numerous other studies UIP failed to hold empirically. I also test if deviations from UIP are in any way effected by business cycles but did not find any supporting evidence. In contrast to a number of other studies my slope coefficient was significantly different from unity. The coefficient also showed a negative sign for one of the economies. Additionally, there were presence of ARCH and GARCH effects in UIP deviations. Finally, no evidence was found for UIP to hold better for developed nations like Japan and not for emerging markets like Mexico and Brazil.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
ARCH	Auto Regressive Conditional Heteroskedasticity
CIP	Covered Interest Parity
GARCH	General AutoRegressive Conditional Heteroskedasticity
HAC	Heteroskedasticity and Autocorrelation Consistent
OLS	Ordinary Least Squares
UIRP	Uncovered Interest Rate Parity
VAR	Vector Auto Regression

Chapter One

Introduction

Uncovered Interest Rate Parity is an important cornerstone for different models of exchange rate determination. It states that the interest rate differential between two economies is an unbiased predictor of the changes in spot exchange rate. As a result, investors would be indifferent towards domestic and foreign assets denominated in the same currency hence, eliminating any gains from arbitrage opportunities. It is so because; a high yield currency would be expected to depreciate by the amount of the interest rate differential. Numerous empirical investigations have been carried out for UIRP, mostly failing to hold the expected relationship, indicating that capital markets are not efficient and arbitrage opportunities exist. Taylor (1995), Chinn (2006) and most other studies find the coefficient for interest rate differential to be smaller than unity and also display a negative sign. The violation of this relationship also violates the Efficient Market Hypothesis, which states that prices reflect all information, because exchange rates aren't adjusting to changes in interest rates, as they should. If these assumptions of rational expectations and risk neutrality hold, the UIP holds and the expected return of holding one currency over the other is offset by the opportunity costs of holding funds in that currency over other (Foy 2005).

Most empirical studies for UIRP are done for industrialized nations. However, with the increasing trend of liberalization and globalization capital can freely flow to many emerging markets as well. Emerging markets tend to have weaker fundamental and institutional variables that may cause such markets to deviate from the efficiency hypothesis. This paper examines UIRP conditions US-Mexico, US-Brazil and US-Japan using conventional regressions and a simple GARCH. The purpose of this paper is to see if UIRP conditions are less likely to hold for emerging markets like Mexico and Brazil than for a developed economy like Japan. In addition, I also check if business cycles have any influence in deviations from UIRP. Theoretical framework is presented in Section II followed by methodology, results and conclusion in the subsequent sections.

Chapter Two

Literature Review

Interest rate parity has been one of the most widespread approaches to examine the efficiency of exchange rate markets. Numerous studies have been carried out in the subject and results have been mixed. With the advent of globalization and improvement in transportation and communication technology better capital mobility has been obtained. This would lead us to expect the rate of returns on similar assets to be the same in different countries, if not opportunity of arbitrage exists. Thus, for capital markets to be in equilibrium foreign interest rate must equal the domestic rate and any expected appreciation or depreciation of the domestic currency; which is called Uncovered Interest Parity. The existence of forward markets provides a measure of expected appreciation or depreciation of the currency. Covered Interest Parity states that foreign interest rates equal the domestic rates and the forward premium on domestic currency. The forward premium is the amount by which investors expect the domestic currency to appreciate. In other words, for CIP to hold the interest rate differential equals the forward premium.

One common method to test for UIP is by running regression on a CIP model and testing the hypothesis for the constant to be zero and the coefficient on the interest differential to be 1. Majority of studies done on UIP find that it does not hold. The expected value as well as the sign of the coefficient has been wrong. Foy (2005) uses a rational expectations OLS model to examine the pound, the yen and the Canadian Dollar and rejects the UIP hypothesis on all three. On the other hand, Chinn and Meredith (1998) show that UIP holds better in the long run than in the short run. Rejection of the UIP is mainly attributed to non-rational expectations and risk aversion of investors. Bui (2010) applies a GMM model to test for UIP between Australia and New Zealand and finds the interest rate differential coefficient to be negative for short horizon while being closer to zero in the long horizon regressions. He also argues that low R-squared suggests UIP still not able to explain exchange rates variation.

On the other hand, Bekaert and others (2002) use VAR to examine UIP and the expectation hypothesis of term structure simultaneously at long and short horizons for US, UK and Germany. They find that a random walk model fitted the data better than the UIP-EHTS model. Another paper by Hnatkovska, Lahiri and Vegh (2008) finds, using six developing countries and four developed countries, that the relationship between exchange rates and interest rates are non monotonic: some effects depreciate the currency whereas some appreciate. Eichenbaum and Evans (1995) using a structural VAR find 24-39 months lagged effect of monetary policy shock in real exchange rate.

Dreger (2010) notes that UIRP deviations in emerging markets are an indicator of lack of financial market integration. Investors demand a higher risk premium to invest in emerging markets due to the poor level of macroeconomic stability and development. However, with improved financial liberalization and capital mobility in the last two decades, increases the possibility for UIRP to hold in emerging markets. Numerous studies have shown that financial liberalization of capital markets significantly effects deviations from UIRP. Francis, Hasan and Hunter (2002) find that deviations in UIRP are characterized by a time varying component as compensation for non-diversifiable risk and that the deviations from UIRP are significantly affected by liberalization in capital markets. In addition, they also find that the effect of liberalization for Latin American countries has been the opposite to that of Asian economies. Additionally, Jones (2009) finds evidence of large deviations from CIP during periods of significant turbulence. These controversies in the UIRP literature and little empirical research for emerging markets motivates further research in the field.

Another study conducted by Mark and Wu (1998) attempts to interpret the forward premium bias with the examination of an asset-pricing model and a noise trader model. They use a Vector Error Correction Model to estimate the expected excess returns and compare it with the risk premium generated from an economic model of risk. The estimates produced were not statistically significant and the standard model was unable to predict risk premium with the correct sign. However, they provide further support to the quasi-rational noise-trading model of De Long (1990) which takes into account to types of traders: fundamentalists who have rational expectations and noise traders whose believes regarding returns from investments are distorted due to excessive optimism or pessimism. Noise traders may cause assets prices to deviate far from their fundamental values, which would cause short-term rational investors to bear the risk of liquidating their positions. According to the model, noise traders induce excess currency movements, volume of transactions and currency risks. The model is also able to generate a negative slope coefficient. Additionally, the noise trader model is also supported by a number of other literature survey expectations: Froot and Frankel (1989), Frankel and Chinn (1993) and Cavaglia *et. al.* (1994).

Deviations from interest rate parity both covered and uncovered has long been used by economists as a measure of capital mobility. CIP deviations suggest the existence of risk free arbitrage opportunities whereas UIP deviations, which can occur even if CIP holds, suggest any kind of exchange risk premium. . Existence of perfect capital mobility would imply UIP to hold better. Frankel (1991) points out that while UIP holding, suggests a well integrated capital market with the international economy, it's deviations need not imply lack of capital mobility. On the other hand some other studies like Faruqee (1992) present an argument of dynamic capital mobility which links narrowing uncovered interest differentials over time to improved capital mobility. A similar study Kuen and Song (1996) on Singapore finds that CIP differentials which captures country specific risks become rather negligible after Singapore effectively eliminated all its capital and exchange controls in the 70s. Even with such policies they still found large deviations in UIP indicating barriers to capital movement due to currency related risks.

Chapter Three

Data and Methodology

The data set used consists of monthly data from January 1995 to October 2013. However, due to limitations in data availability, the data set for Mexico starts from April and that of Brazil from November of 1995. The interest rate and exchange rate data have been obtained from the Federal Reserve Economic Data and the Futures data have been obtained from the Chicago Mercantile Exchange. Dummy variables for business cycles were created based on the reference dates published by the National Bureau of Economic Research. Government Treasury Bills rates were used as interest rates for all economies.

Following the Latin American debt crisis in the 1980s and the collapse of the Peso, the Bank of Mexico issued new peso for old ones at the rate of 1:1000. Additionally, with trade and foreign investment resulting from the implementation of NAFTA, the Peso consistently performed well against the dollar. The new Brazilian Real was introduced on July 1994. After its introduction Brazil saw large capital inflows, which caused the currency to appreciate against the dollar. During the period of 1996 to 1998, the real depreciated steadily as it was tightly controlled by the central bank, however, in January of 1999, it decided to float the currency. This caused a huge devaluation and in the following years until 2002 crisis, it still depreciated against the dollar. After a new election in 2002 and improved macroeconomic policies, the real has performed well against the dollar since.

Following the Plaza Accord, the Japanese Yen's value was rose relative to the dollar and reached a peak of 80 yen per dollar in April 1995. Following the asset price bubble and crash and the zero interest rate policy of the Bank of Japan the yen declined again. Decreased yen investments and increased carry trade of investors borrowing in yen and investing in other currencies further helped keep the yen undervalued. However, since the 2008 financial crisis as major countries lowered their interest rates, the yen steadily appreciated against the dollar as well as other currencies. Following 2011 the Bank of Japan decided to increase its asset purchase program that helped devalue its currency.

Covered Interest Parity, assuming rational expectations and risk neutrality, implies that, at a time *t*, the interest rate differential between two countries is equal to the difference between the forward rate and spot rate. Algebraically,

$$F_t - S_t = i_t - i_t^* \qquad (1)$$

where, F_t and S_t are the log of forward and spot rates, respectively; i_t is nominal domestic interest rate and i_t^* is nominal foreign interest rate. On the other hand, Uncovered Interest Rate Parity holds if,

$$S_{t+k} - S_t = i_t - i_t^* + R_p \qquad (2)$$

where, k represents time to maturity and R_p the risk premium of investing abroad rather than in domestic market.

Based on *(1)* and *(2)*, two different regressions can be obtained:

$$S_{t+k} - S_t = \alpha + \beta(F_t - S_t) + e_t \text{ or,} \qquad (3)$$

$\Delta S_{t+k} = \alpha + \beta(i_t - i_t^*) + e_t$ (4)

The UIP condition can be tested through the joint hypothesis that $\alpha = 0$ and $\beta = 1$.

Other empirical studies show that test with (3) receives strong support as the slope coefficient is unity but is rejected by other studies based on (4). I run OLS based on (4), for Peso-Dollar, Yen-Dollar and Real-Dollar with monthly data ranging from Jan 1995 to Oct 2013. I use the Wald test to test the joint hypothesis for UIP to hold. Due to the unavailability of data on forward markets I use futures as the proxy for expected future spot rate at time *k* in (4).

I then run another regression to test if the deviations in UIP are effected by business cycle. The residuals from (4) were regressed with the independent variable as a dummy to account for recessionary periods. Larger deviations from the UIP are expected during periods of higher turbulence in the economy. The model is given as:

$e_t^e = \alpha + \beta D + \upsilon_t$ (5)

where,

D=1 (periods of recession) and D=0 (otherwise)

Finally, for volatility analysis I use a GARCH (1,1) model, which is given by:

$\Delta S_{t+k} = \alpha + \beta(i_t - i_t^*) + e_t$ *(Mean Equation), where,* $e_t \sim N(0, \sigma_t^2)$

$\sigma_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \beta\sigma_{t-1}^2$ (6) *(Variance Equation)*

However, before performing all the regressions, I first perform some diagnostic tests for the spot rate, the futures rate and the interest rate differential.

Diagnostic Tests

a. Stationarity

The Augmented Dickey Fuller test is used on the variables of (4) to test for stationarity. The ADF is used on the expected change in spot rate and the interest rate differential. The expected change in spot rate is given as the log futures rate less the log spot rate at time $t+k$ and the interest rate differential is given as the log of US interest rate less foreign interest rate. In level form, the spot rate differential for all three countries are stationary at 5% whereas the interest differential for all have unit roots. Both variables turn stationary when first difference is taken. The results of the ADF tests are presented in the Appendix.

b. Autocorrelation

The Breusch-Godfrey Serial Correlation LM Test was used to check for autocorrelation between residuals. Results (also in the Appendix) show presence of auto correlation problem for Mexico and Brazil but not for Japan. The autocorrelation problem can be eliminated using an AR(1) model. I have used the HAC consistent estimates for the regressions to address the problem.

c. Heteroscedasticity

White's test for heteroscedasticity revealed the presence of homoscedasticity for Japan and Mexico but not Brazil. The results of the test are presented in the Appendix. Due to the presence of heteroscedasticity as well as autocorrelation in some of the regressions, I used the Heterosccedasticity and Autocorrelation Consistent Newey-West estimation for the regressions.

d. Causality

Pairwise Granger causality shows that the expected change in spot rate does not Granger cause the interest rate differential and vice versa, for all three economies.

Chapter Four

Results and Findings

From preliminary regressions I find the interest differential to be insignificant in the expected change in the spot rate for Mexico and Japan but significant, at 5%, for Brazil. However, to control for unit roots first difference was used which made the coefficient insignificant even for Brazil. Additionally, the sign on the slope coefficient for Japan was negative compared to positive for the other two. Wald test was used to test the joint hypothesis that the constant equals zero and the slope coefficient equals one. The null hypothesis was rejected for all three economies meaning that the constant and the slope coefficient were significantly different from their expected values. Hence, indicating that the UIP doesn't hold for both the emerging markets as well as the developed one. Additionally, there was no evidence that it should hold better for developed economies than for developing ones because the R-squared for Brazil was the highest among the three where as Mexico and Japan had identical R squared. The differences in sign of the slope coefficient between the two emerging markets show that other variables account for the appreciation or depreciation of a currency than just the interest rate differential. My results confirm with that of Chinn (2006) and Lucio (2005) that reject the unity restriction of the slope coefficient and find few coefficients to be positive. The adjusted R-squared are also very low and sometimes even negative.

Next, I try to see if deviations from the UIP, given by the residuals, are effected by the business cycle. I use general OLS to model the residuals as the dependent variable on dummy variables for business cycle. At 5% significance level, the business cycle variable doesn't seem to effect the deviations from UIP for all three economies. This was in contrast to our expectations as well as inconsistent with Jones (2009) results on CIP. Additionally, I found a negative slope coefficient for Brazil, which was contradictory. For the same purpose, I also added the business cycle dummy to equation *(4)* giving,

$$\Delta S_{t+k} = \alpha + \beta_1(i_t - i_t^*) + \beta_2 D + e_t \qquad (7)$$

There was no change in the significance of business cycle at 5% level.

Finally, I also use a GARCH (1,1) model, given by (6), to consider the effects of volatility in UIP deviation. I also included the dummy for business cycles in the variance equation to see if it affects the volatility. The results presented in the Appendix show GARCH and ARCH effect for both Mexico and Brazil but only ARCH effect for Japan.

Chapter Five

Conclusion

My results indicate no evidence of UIP holding for Mexico, Brazil or Japan, supporting the vast literature that it fails empirically. The slope coefficients were significantly different from one and even had a negative sign for Japan. Additionally, business cycles seem to have no effect on the deviations from UIP for the given economies. However, I did find some significant GARCH and ARCH effects. Very low R-squared in all regressions suggest that UIP can only explain a small variation in exchange rate movements. The reasons for UIP not holding could be the violation of the rational expectations and risk neutrality assumptions. One problem with the study is the use of futures rate as the expected spot rate, which may have caused erroneous results. Other empirical studies suggest rational learning, self-fulfilling bias, incomplete information, etc. to be other causes of UIP deviation.

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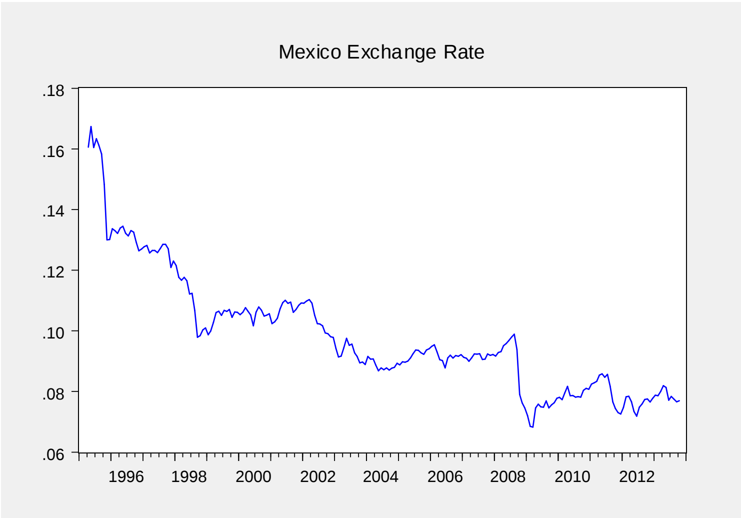
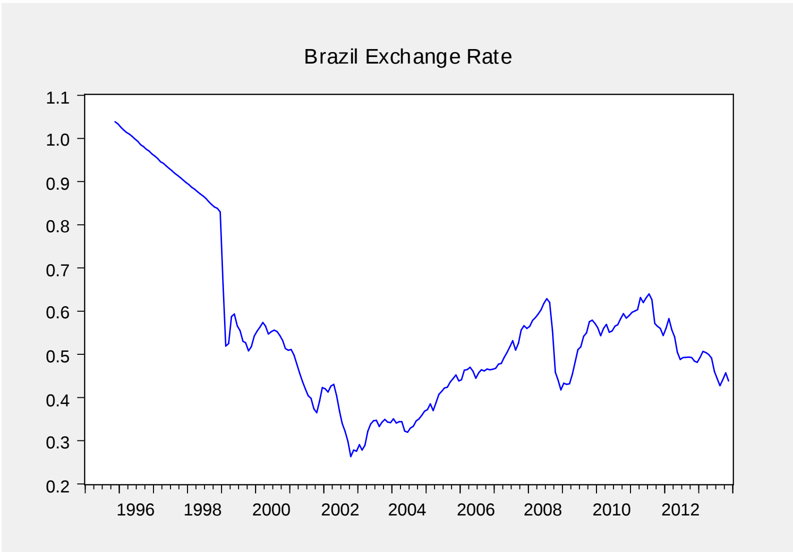
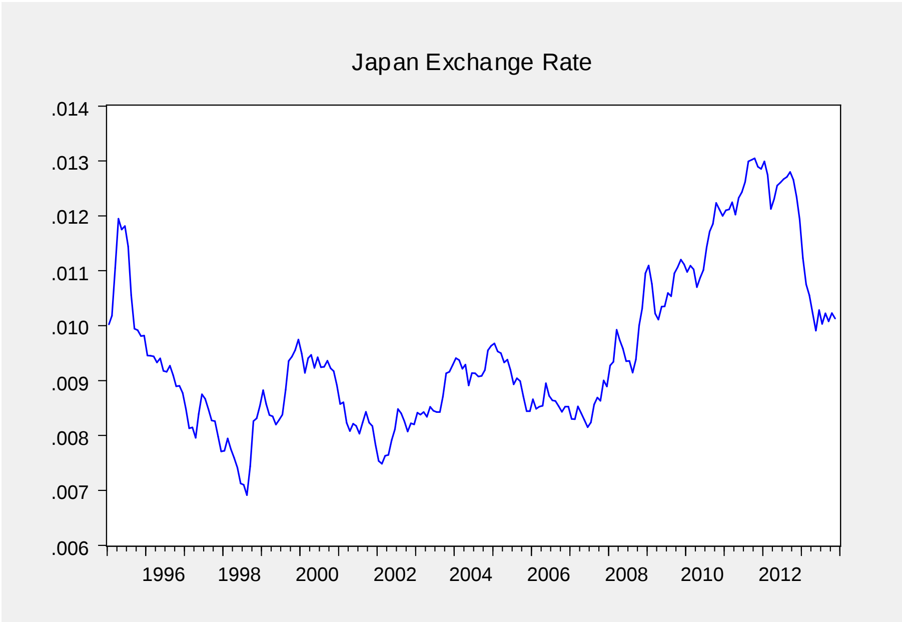
APPENDIX

Appendix

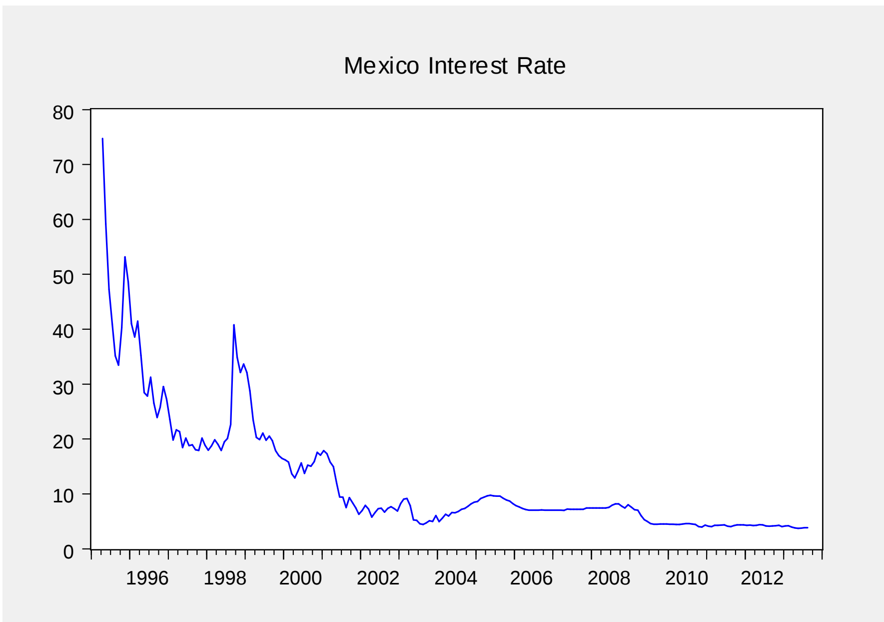
Exchange Rates

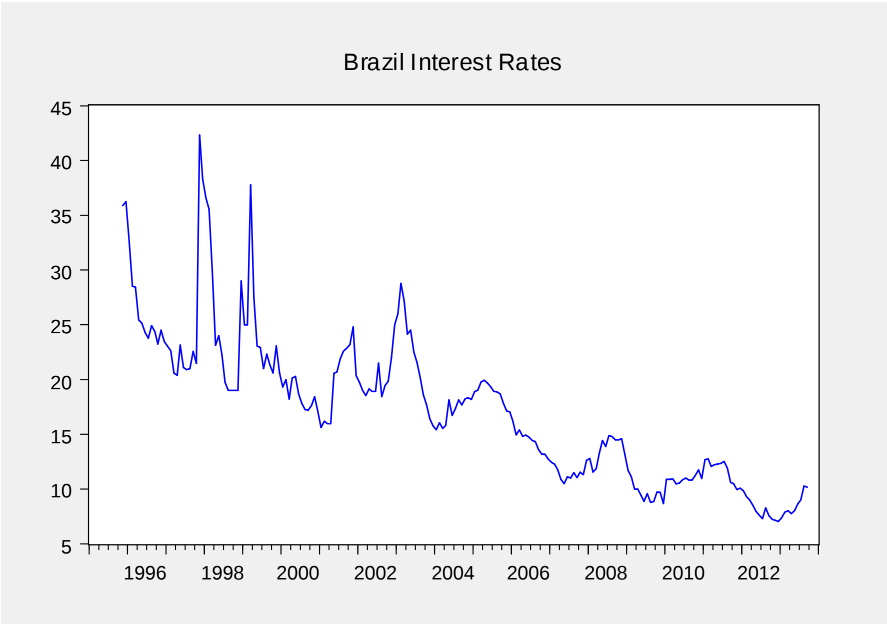




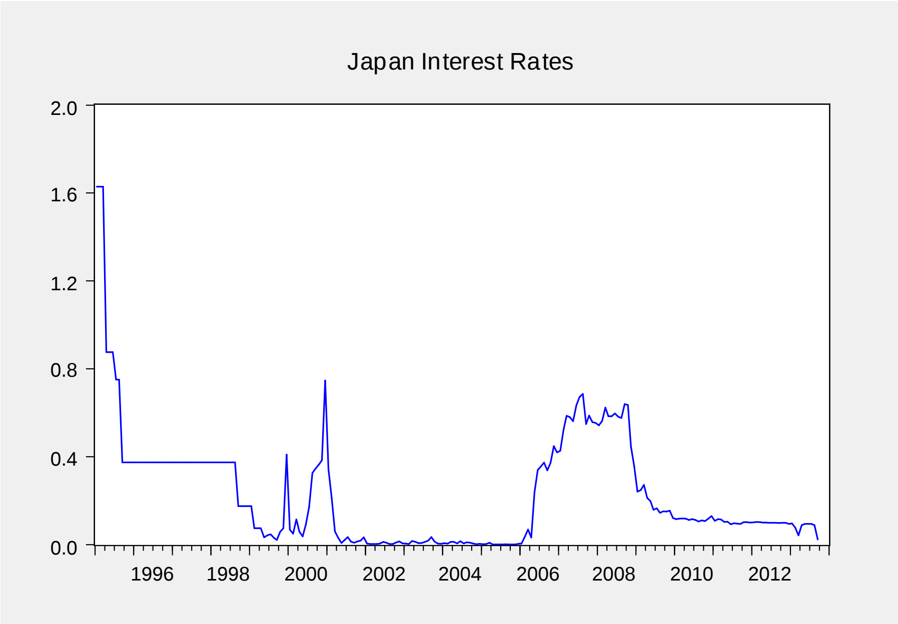


Interest Rates





Brazil Interest Rates
45
40
35
30
25
20
15
10
5
1996
1998
2000
2002
2004
2006
2008
2010
2012



Japan Interest Rates
2.0
1.6
1.2
0.8
0.4
0.0
1996
1998
2000
2002
2004
2006
2008
2010
2012

Augmented Dickey Fuller Tests

DER = Log(Futures) – Log(Spot Rate)

IDIFF = Log(USTB3MS) – Log(Foreign Interest Rate)

Mexico

Null Hypothesis: DER has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.410741	0.0004
Test critical values:	1% level	-3.460035	
	5% level	-2.874495	
	10% level	-2.573751	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DER(-1)	-0.330746	0.074986	-4.410741	0
D(DER(-1))	-0.557322	0.073038	-7.630577	0
D(DER(-2))	-0.442085	0.059206	-7.466915	0
C	-0.004215	0.001535	-2.746318	0.0065

R-squared	0.525399	Mean dependent var	0.000386
Adjusted R-squared	0.518807	S.D. dependent var	0.02321
S.E. of regression	0.0161	Akaike info criterion	-5.40192
Sum squared resid	0.055993	Schwarz criterion	-5.340218
Log likelihood	598.2112	Hannan-Quinn criter.	-5.377003
F-statistic	79.70622	Durbin-Watson stat	2.082927
Prob(F-statistic)	0		

Null Hypothesis: IDIFF has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.971633	0.7634
Test critical values:	1% level	-3.460313	
	5% level	-2.874617	
	10% level	-2.573817	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IDIFF(-1)	-0.014266	0.014682	-0.971633	0.3323
D(IDIFF(-1))	0.238978	0.066507	3.593270	0.0004
D(IDIFF(-2))	-0.237471	0.066874	-3.551026	0.0005
C	-0.039645	0.035282	-1.123664	0.2624

R-squared	0.097598	Mean dependent var	-0.011047
Adjusted R-squared	0.084947	S.D. dependent var	0.290789
S.E. of regression	0.278164	Akaike info criterion	0.296967
Sum squared resid	16.55830	Schwarz criterion	0.359068
Log likelihood	-28.36940	Hannan-Quinn criter.	0.322050
F-statistic	7.714930	Durbin-Watson stat	1.943046
Prob(F-statistic)	0.000064		

Brazil

Null Hypothesis: DER has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.787499	0.0001
Test critical values:	1% level	-3.460884	
	5% level	-2.874868	
	10% level	-2.573951	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DER(-1)	-0.252925	0.052830	-4.787499	0.0000
D(DER(-1))	-0.164694	0.067898	-2.425612	0.0161
C	0.001775	0.005132	0.345776	0.7299

R-squared	0.174466	Mean dependent var	7.09E-05
Adjusted R-squared	0.166641	S.D. dependent var	0.082044
S.E. of regression	0.074897	Akaike info criterion	-2.331483
Sum squared resid	1.183621	Schwarz criterion	-2.284296
Log likelihood	252.4687	Hannan-Quinn criter.	-2.312415
F-statistic	22.29603	Durbin-Watson stat	2.001156
Prob(F-statistic)	0.000000		

Null Hypothesis: IDIFF has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.446079	0.8975
Test critical values:	1% level	-3.461178	
	5% level	-2.874997	
	10% level	-2.574019	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IDIFF(-1)	-0.005939	0.013313	-0.446079	0.6560
D(IDIFF(-1))	0.237268	0.068990	3.439154	0.0007
D(IDIFF(-2))	-0.206351	0.069378	-2.974279	0.0033
C	-0.035616	0.039973	-0.890988	0.3740

R-squared	0.079477	Mean dependent var	-0.020555
Adjusted R-squared	0.066200	S.D. dependent var	0.295286
S.E. of regression	0.285345	Akaike info criterion	0.348452
Sum squared resid	16.93572	Schwarz criterion	0.411783
Log likelihood	-32.93587	Hannan-Quinn criter.	0.374049
F-statistic	5.986161	Durbin-Watson stat	1.929739
Prob(F-statistic)	0.000623		

Japan

Null Hypothesis: DER has a unit root				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-14.51326	0.0000
Test critical values:	1% level		-3.459362	
	5% level		-2.874200	
	10% level		-2.573594	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DER(-1)	-0.971310	0.066926	-14.51326	0.0000
C	0.004394	0.000995	4.415560	0.0000

R-squared	0.485742	Mean dependent var	-1.79E-05
Adjusted R-squared	0.483436	S.D. dependent var	0.019773
S.E. of regression	0.014212	Akaike info criterion	-5.660663
Sum squared resid	0.045039	Schwarz criterion	-5.630298
Log likelihood	638.8246	Hannan-Quinn criter.	-5.648408
F-statistic	210.6346	Durbin-Watson stat	2.006571
Prob(F-statistic)	0.000000		

Null Hypothesis: IDIFF has a unit root				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2.402015	0.1423
Test critical values:	1% level		-3.459494	
	5% level		-2.874258	
	10% level		-2.573625	

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IDIFF)
Method: Least Squares
Date: 12/02/13 Time: 09:11
Sample (adjusted): 1995M02 2013M09
Included observations: 224 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IDIFF(-1)	-0.052321	0.021782	-2.402015	0.0171
C	0.143759	0.088730	1.620176	0.1066

R-squared	0.025331	Mean dependent var	-0.006223
Adjusted R-squared	0.020941	S.D. dependent var	0.953565
S.E. of regression	0.943528	Akaike info criterion	2.730506
Sum squared resid	197.6343	Schwarz criterion	2.760968
Log likelihood	-303.8167	Hannan-Quinn criter.	2.742802
F-statistic	5.769677	Durbin-Watson stat	2.249343
Prob(F-statistic)	0.017128		

Breusch-Godfrey Serial Correlation LM Test

Mexico

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	17.73522	Prob. F(2,217)		0.0000
Obs*R-squared	31.04905	Prob. Chi-Square(2)		0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000367	0.002307	-0.159157	0.8737
IDIFF	-0.000190	0.000945	-0.200776	0.8411
RESID(-1)	0.241187	0.066193	3.643684	0.0003
RESID(-2)	0.222449	0.066311	3.354658	0.0009

R-squared	0.140493	Mean dependent var	1.09E-17
Adjusted R-squared	0.128611	S.D. dependent var	0.019795
S.E. of regression	0.018478	Akaike info criterion	-5.126538
Sum squared resid	0.074092	Schwarz criterion	-5.065033
Log likelihood	570.4825	Hannan-Quinn criter.	-5.101704
F-statistic	11.82348	Durbin-Watson stat	2.186049
Prob(F-statistic)	0.000000		

Brazil

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	99.13226	Prob. F(2,211)		0.0000
Obs*R-squared	104.1548	Prob. Chi-Square(2)		0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001972	0.010274	-0.191935	0.8480
IDIFF	-0.000786	0.003369	-0.233239	0.8158
RESID(-1)	0.579129	0.067994	8.517390	0.0000
RESID(-2)	0.156885	0.068019	2.306491	0.0221

R-squared	0.484441	Mean dependent var	1.70E-17
Adjusted R-squared	0.477111	S.D. dependent var	0.103439
S.E. of regression	0.074798	Akaike info criterion	-2.329631
Sum squared resid	1.180480	Schwarz criterion	-2.266921
Log likelihood	254.4353	Hannan-Quinn criter.	-2.304293
F-statistic	66.08818	Durbin-Watson stat	1.999998
Prob(F-statistic)	0.000000		

Japan

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.738111	Prob. F(2,221)		0.1782
Obs*R-squared	3.484333	Prob. Chi-Square(2)		0.1751

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.83E-05	0.001327	-0.051495	0.9590
IDIFF	2.27E-05	0.000327	0.069442	0.9447
RESID(-1)	0.025070	0.066801	0.375297	0.7078
RESID(-2)	0.121490	0.066962	1.814327	0.0710

R-squared	0.015486	Mean dependent var	1.49E-18
Adjusted R-squared	0.002121	S.D. dependent var	0.014188
S.E. of regression	0.014173	Akaike info criterion	-5.657328
Sum squared resid	0.044394	Schwarz criterion	-5.596598
Log likelihood	640.4495	Hannan-Quinn criter.	-5.632817
F-statistic	1.158741	Durbin-Watson stat	2.008454
Prob(F-statistic)	0.326389		

White's Test of Heteroskedasticity

Mexico

Heteroskedasticity Test: White

F-statistic	1.102740	Prob. F(2,218)		0.3338
Obs*R-squared	2.213437	Prob. Chi-Square(2)		0.3306
Scaled explained SS	7.050729	Prob. Chi-Square(2)		0.0294

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.29E-05	0.000224	0.325889	0.7448
IDIFF	-0.000287	0.000200	-1.437633	0.1520
IDIFF^2	-4.58E-05	3.54E-05	-1.295378	0.1966

R-squared	0.010016	Mean dependent var	0.000390
Adjusted R-squared	0.000933	S.D. dependent var	0.000996
S.E. of regression	0.000995	Akaike info criterion	-10.97356
Sum squared resid	0.000216	Schwarz criterion	-10.92743
Log likelihood	1215.579	Hannan-Quinn criter.	-10.95494
F-statistic	1.102740	Durbin-Watson stat	1.763812
Prob(F-statistic)	0.333805		

Brazil

Heteroskedasticity Test: White				
F-statistic	8.027531	Prob. F(2,212)		0.0004
Obs*R-squared	15.13599	Prob. Chi-Square(2)		0.0005
Scaled explained SS	145.5322	Prob. Chi-Square(2)		0.0000
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.057482	0.013180	4.361389	0.0000
IDIFF	0.030378	0.009461	3.210738	0.0015
IDIFF^2	0.003611	0.001383	2.611590	0.0097
R-squared	0.070400	Mean dependent var		0.010650
Adjusted R-squared	0.061630	S.D. dependent var		0.047250
S.E. of regression	0.045771	Akaike info criterion		-3.316482
Sum squared resid	0.444134	Schwarz criterion		-3.269450
Log likelihood	359.5218	Hannan-Quinn criter.		-3.297479
F-statistic	8.027531	Durbin-Watson stat		0.620186
Prob(F-statistic)	0.000436			

Japan

Heteroskedasticity Test: White				
F-statistic	0.551129	Prob. F(2,222)		0.5771
Obs*R-squared	1.111635	Prob. Chi-Square(2)		0.5736
Scaled explained SS	1.394775	Prob. Chi-Square(2)		0.4979
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000202	3.27E-05	6.172937	0.0000
IDIFF	7.00E-06	1.50E-05	0.466457	0.6413
IDIFF^2	-1.29E-06	1.49E-06	-0.869872	0.3853
R-squared	0.004941	Mean dependent var		0.000200
Adjusted R-squared	-0.004024	S.D. dependent var		0.000321
S.E. of regression	0.000322	Akaike info criterion		-13.23281
Sum squared resid	2.30E-05	Schwarz criterion		-13.18726
Log likelihood	1491.691	Hannan-Quinn criter.		-13.21443
F-statistic	0.551129	Durbin-Watson stat		1.995204
Prob(F-statistic)	0.577085			

Granger Causality Test

Mexico

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
IDIFF does not Granger Cause DER	219	0.97576	0.3786
DER does not Granger Cause IDIFF		0.42659	0.6533

Brazil

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
IDIFF does not Granger Cause DER	213	0.32751	0.7211
DER does not Granger Cause IDIFF		0.32253	0.7247

Japan

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
IDIFF does not Granger Cause DER	223	0.15054	0.8603
DER does not Granger Cause IDIFF		0.79462	0.4531

Regression Output

Mexico

Dependent Variable: D(DER)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000137	0.000721	0.189316	0.8500
D(IDIFF)	0.004399	0.008034	0.547552	0.5846

R-squared	0.003010	Mean dependent var	9.69E-05
Adjusted R-squared	-0.001563	S.D. dependent var	0.023273
S.E. of regression	0.023292	Akaike info criterion	-4.672394
Sum squared resid	0.118265	Schwarz criterion	-4.641543
Log likelihood	515.9633	Hannan-Quinn criter.	-4.659935
F-statistic	0.658202	Durbin-Watson stat	2.976261
Prob(F-statistic)	0.418080		

Brazil

Dependent Variable: D(DER)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.19E-05	0.003741	0.013883	0.9889
D(IDIFF)	0.004461	0.013507	0.330265	0.7415

R-squared	0.000255	Mean dependent var	-3.83E-05
Adjusted R-squared	-0.004460	S.D. dependent var	0.082048
S.E. of regression	0.082231	Akaike info criterion	-2.149273
Sum squared resid	1.433523	Schwarz criterion	-2.117815
Log likelihood	231.9722	Hannan-Quinn criter.	-2.136561
F-statistic	0.054175	Durbin-Watson stat	2.581047
Prob(F-statistic)	0.816175		

Japan

Dependent Variable: D(DER)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.59E-06	0.000637	0.004070	0.9968
D(IDIFF)	-0.000454	0.001550	-0.292920	0.7699

R-squared	0.000477	Mean dependent var	5.42E-06
Adjusted R-squared	-0.004025	S.D. dependent var	0.019815
S.E. of regression	0.019854	Akaike info criterion	-4.991888
Sum squared resid	0.087512	Schwarz criterion	-4.961427
Log likelihood	561.0915	Hannan-Quinn criter.	-4.979593
F-statistic	0.106002	Durbin-Watson stat	3.088814
Prob(F-statistic)	0.745050		

Wald's Test

Mexico

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	7721.905	(2, 218)	0.0000
Chi-square	15443.81	2	0.0000

Null Hypothesis: C(1)=0, C(2)=1

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.000137	0.000721
-1 + C(2)	-0.995601	0.008034

Restrictions are linear in coefficients.

Brazil

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	2716.336	(2, 212)	0.0000
Chi-square	5432.672	2	0.0000

Null Hypothesis: C(1)=0, C(2)=1

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	5.19E-05	0.003741
-1 + C(2)	-0.995539	0.013507

Restrictions are linear in coefficients.

Japan

Wald Test:

Test Statistic	Value	df	Probability
F-statistic	208815.7	(2, 222)	0.0000
Chi-square	417631.4	2	0.0000

Null Hypothesis: C(1)=0, C(2)=1

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	2.59E-06	0.000637
-1 + C(2)	-1.000454	0.001550

Restrictions are linear in coefficients.

Additional Regressions for Business Cycle Effect

Mexico

Dependent Variable: ET

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000135	0.001681	-0.080560	0.9359
DUMMY	0.001064	0.004711	0.225814	0.8216

R-squared	0.000234	Mean dependent var	1.26E-19
Adjusted R-squared	-0.004352	S.D. dependent var	0.023238
S.E. of regression	0.023289	Akaike info criterion	-4.672628
Sum squared resid	0.118238	Schwarz criterion	-4.641777
Log likelihood	515.9891	Hannan-Quinn criter.	-4.660169
F-statistic	0.050992	Durbin-Watson stat	2.976832
Prob(F-statistic)	0.821557		

Dependent Variable: D(DER)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.81E-07	0.000754	0.000904	0.9993
D(IDIFF)	0.004537	0.008052	0.563441	0.5737
DUMMY	0.001077	0.002445	0.440552	0.6600

R-squared	0.003246	Mean dependent var	9.69E-05
Adjusted R-squared	-0.005940	S.D. dependent var	0.023273
S.E. of regression	0.023342	Akaike info criterion	-4.663540
Sum squared resid	0.118237	Schwarz criterion	-4.617263
Log likelihood	515.9894	Hannan-Quinn criter.	-4.644852
F-statistic	0.353365	Durbin-Watson stat	2.976485
Prob(F-statistic)	0.702724		

Brazil

Dependent Variable: ET

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000339	0.006029	-0.056229	0.9552
DUMMY	0.002591	0.016668	0.155450	0.8766

R-squared	0.000114	Mean dependent var	-1.34E-18
Adjusted R-squared	-0.004602	S.D. dependent var	0.082038
S.E. of regression	0.082226	Akaike info criterion	-2.149387
Sum squared resid	1.433359	Schwarz criterion	-2.117929
Log likelihood	231.9844	Hannan-Quinn criter.	-2.136675
F-statistic	0.024165	Durbin-Watson stat	2.581357
Prob(F-statistic)	0.876614		

Dependent Variable: D(DER)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000286	0.004278	-0.066926	0.9467
D(IDIFF)	0.004964	0.013893	0.357281	0.7212
DUMMY	0.002663	0.005337	0.498914	0.6184

R-squared	0.000373	Mean dependent var	-3.83E-05
Adjusted R-squared	-0.009103	S.D. dependent var	0.082048
S.E. of regression	0.082421	Akaike info criterion	-2.140044
Sum squared resid	1.433355	Schwarz criterion	-2.092857
Log likelihood	231.9847	Hannan-Quinn criter.	-2.120976
F-statistic	0.039322	Durbin-Watson stat	2.581213
Prob(F-statistic)	0.961448		

Japan

Dependent Variable: ET				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000179	0.001418	0.126552	0.8994
DUMMY	-0.001435	0.004010	-0.357944	0.7207
R-squared	0.000577	Mean dependent var		6.20E-19
Adjusted R-squared	-0.003925	S.D. dependent var		0.019810
S.E. of regression	0.019849	Akaike info criterion		-4.992465
Sum squared resid	0.087462	Schwarz criterion		-4.962004
Log likelihood	561.1561	Hannan-Quinn criter.		-4.980170
F-statistic	0.128124	Durbin-Watson stat		3.089856
Prob(F-statistic)	0.720726			

Dependent Variable: D(DER)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000182	0.000688	0.264705	0.7915
D(IDIFF)	-0.000454	0.001548	-0.293072	0.7697
DUMMY	-0.001435	0.002049	-0.700371	0.4844
R-squared	0.001054	Mean dependent var		5.42E-06
Adjusted R-squared	-0.007986	S.D. dependent var		0.019815
S.E. of regression	0.019894	Akaike info criterion		-4.983537
Sum squared resid	0.087462	Schwarz criterion		-4.937845
Log likelihood	561.1561	Hannan-Quinn criter.		-4.965093
F-statistic	0.116566	Durbin-Watson stat		3.089857
Prob(F-statistic)	0.890026			

GARCH (1,1)

Mexico

Dependent Variable: D(DER)				
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*DUMMY				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000450	0.001165	-0.386533	0.6991
D(IDIFF)	-0.001348	0.005726	-0.235363	0.8139
	Variance Equation			
C	9.98E-05	5.33E-05	1.871359	0.0613
RESID(-1)^2	0.457829	0.126824	3.609951	0.0003
GARCH(-1)	0.379843	0.154228	2.462864	0.0138
DUMMY	1.77E-05	4.32E-05	0.409306	0.6823

R-squared	-0.002658	Mean dependent var	9.69E-05
Adjusted R-squared	-0.007257	S.D. dependent var	0.023273
S.E. of regression	0.023358	Akaike info criterion	-4.852356
Sum squared resid	0.118938	Schwarz criterion	-4.759803
Log likelihood	539.7592	Hannan-Quinn criter.	-4.814981
Durbin-Watson stat	2.982674		

Brazil

Dependent Variable: D(DER)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*DUMMY

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.001967	0.001979	-0.993903	0.3203
D(IDIFF)	0.000810	0.005393	0.150204	0.8806
		Variance Equation		
C	-1.58E-05	2.31E-05	-0.686421	0.4924
RESID(-1)^2	0.511478	0.066260	7.719236	0.0000
GARCH(-1)	0.760506	0.013660	55.67445	0.0000
DUMMY	-4.05E-05	9.04E-05	-0.448036	0.6541

R-squared	-0.000480	Mean dependent var	-3.83E-05
Adjusted R-squared	-0.005199	S.D. dependent var	0.082048
S.E. of regression	0.082261	Akaike info criterion	-3.348538
Sum squared resid	1.434577	Schwarz criterion	-3.254164
Log likelihood	364.2935	Hannan-Quinn criter.	-3.310402
Durbin-Watson stat	2.580567		

Japan

Dependent Variable: D(DER)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*DUMMY

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000266	0.001120	0.237209	0.8125
D(IDIFF)	2.83E-05	0.001047	0.027011	0.9785
		Variance Equation		
C	0.000384	0.000110	3.476037	0.0005
RESID(-1)^2	0.319102	0.122785	2.598862	0.0094
GARCH(-1)	-0.315758	0.220686	-1.430800	0.1525
DUMMY	-3.18E-05	0.000106	-0.301062	0.7634

R-squared	-0.000234	Mean dependent var	5.42E-06
Adjusted R-squared	-0.004740	S.D. dependent var	0.019815
S.E. of regression	0.019862	Akaike info criterion	-5.044941
Sum squared resid	0.087575	Schwarz criterion	-4.953557
Log likelihood	571.0334	Hannan-Quinn criter.	-5.008054
Durbin-Watson stat	3.089864		