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Keywords

asymmetric, interest, real, rate, parity, adjustment

Disciplines

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IS THE ADJUSTMENT TO REAL INTEREST RATE PARITY ASYMMETRIC?

Arusha Cooray*

Abstract: Threshold cointegration is employed in this study to test the real interest parity condition between the UK and the US. Evidence supports the asymmetric adjustment of real interest rates. The threshold error correction models indicate that negative deviations from long run real interest parity are eliminated faster than positive deviations.

JEL Classification: E 43, F36, F41

Keywords: real interest parity, threshold cointegration, threshold error correction, asymmetric adjustment, non-linear adjustment.

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1 Introduction

This paper employs threshold cointegration to investigate the real interest parity condition between the UK and the US. Real interest parity is chosen as a basis for this study because there is both a policy and theoretical dimension underpinning the real interest parity condition. The real interest rate is an important variable in the transmission mechanism of monetary policy. If the real interest parity condition holds, then capital market integration also holds and international capital is perfectly mobile. In relation to policy, Feldstein (1983) argues that if real interest parity holds then there is no basis for country specific monetary policy strategies designed to stabilise national incomes. In a theoretical context, real interest parity holds only if three other international equilibria hold, namely, uncovered interest, purchasing power parity and the Fisher equation in the domestic and foreign countries. Real interest parity does not hold if one of these conditions fail. A number of statistical reasons have also been put forward for the failure of real interest parity, among them, non stationarity (Mishkin 1984), structural breaks (Wu and Fountas 2000). More recently, it has been shown that real interest parity can hold during some periods and not in others due to the asymmetric adjustment in real interest rates.

Pippenger and Goering (1993), Balke and Fomby (1997), Enders and Granger (1998), Enders and Siklos (2001), Hansen and Seo (2002) show that conventional unit root and cointegration tests exhibit low power in the presence of non-linear adjustment towards long run equilibrium. A solution to this would be to specify a non-linear adjustment mechanism to test for the null hypothesis of a unit-root against the alternative of the specific adjustment mechanism. Hence, the main purpose of this study is to see if the adjustment of the real interest rate towards long run equilibrium is asymmetric. Siklos and Granger (1997) show that an equilibrium relationship can change if one country that has adopted an inflation targeting regime has close ties with another that does not follow an inflation targeting policy. The UK and the US are selected as a basis for this study because, while the UK has adopted a policy of inflation targeting, the US has not introduced an explicit policy of inflation targeting. Moreover, these two countries have very close relations with the US being Britain's largest export market and primary destination for British overseas investment (Foreign and Commonwealth Office UK 2008). The studies of Sekioua (2008), Chung and Crowder (2004), Wu and Fountas (2000) examine the real interest parity condition for several countries including the UK and the US. Sekioua, constructing confidence intervals for the half lives of deviations from real interest parity finds support for the real interest parity condition between the UK and the US. When non-linearities are taken into account the evidence is stronger. Chung and Crowder (2004) using multivariate unit root tests and Eurocurrency deposit rates for five countries that include the UK and the US over the 1960-1996 period, find that the real interest parity condition is rejected. Wu and Fountas find evidence in favour of short term real interest rate convergence between the UK and the US and evidence of one structural break. Hence support for the real interest parity condition appears to be stronger when structural breaks or non linearities are taken into account.

A number of factors can lead to non linear adjustment towards real interest parity. Interest rate differentials maybe non linear due to transaction costs (Obstfeld and Taylor 1997), Central Bank intervention (Mark and Moh 2003, Mc Millan 2004), asymmetric adjustment in real exchange rates (Paya, Venetis and Peel 2003), the downward rigidity of prices (Rhee and Rich 1995), differences in shoe leather costs and differences in productivity trends. In such cases the threshold cointegration methodology is particularly relevant. Support for asymmetric adjustment has been found for the purchasing power parity condition (Obstfeld and Taylor 1997, Enders and Chumrusphonlert 2004), uncovered interest parity (Siklos and Granger 1997), real interest parity (Holmes and Maghrebi 2004). Holmes and Maghrebi examine the real interest parity condition between South East Asia and Japan and South East Asia and the US using a Smooth Transition Autoregresstive Model. They find evidence in favour of non-linearities in real interest rates. The asymmetric adjustment of real interest rates suggests that a cointegrating relationship exists between real rates during certain periods and not during others. The use of conventional cointegration tests can be limiting in such instances.

The rest of this paper is structured as follows. Section 2 includes a discussion of the approach applied, Section 3 examines the properties of the data set, the results of the analysis are presented in Section 4 and conclusions drawn in Section 5 with policy implications.

2 Real Interest Parity and Threshold Cointegration

Mishkin (1984, a,b) argues that the appropriate generic basis for testing capital market integration is the real interest parity (RIP) condition. A test of real interest parity constitutes estimating the following equation:

$$r_t = \alpha + \beta r_t^* + \varepsilon_t \qquad (1)$$

where r_t is the real interest rate in the reference country; r_t^* is the real interest rate in the foreign country and ε_t is the stochastic error term. The existence of real interest parity implies that the ε_t series is a stationary process. The conventional Engle and Granger (1987) cointegration test involves estimation of the following:

$$\Delta\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \nu_t \qquad (2)$$

where $\hat{\varepsilon}_t$ are the estimated residuals from Equation (1) and ν_t is a random error term with zero mean. Rejection of the null hypothesis that $\rho = 0$ suggests that the ε_t series is stationary and the existence of a long run relationship between the real interest rates. A shortcoming of this approach is that the standard cointegration tests assume that a change in $\hat{\varepsilon}_t$ is $\rho\hat{\varepsilon}_{t-1}$ irrespective of whether $\hat{\varepsilon}_{t-1}$ takes on a positive or negative value. Enders and Granger (1998) and Enders and Siklos (2001) put forward a test for a non stationary series against an alternative of asymmetric adjustment where the process is a two regime Threshold Autoregressive (TAR) or Momentum TAR (M-TAR) model. Therefore, following the approach of Enders and Granger and Enders and Siklos, the regression residuals from equation (1) are estimated in the following manner:

$$\Delta\hat{\varepsilon}_t = I_t\rho_1\hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2\hat{\varepsilon}_{t-1} + \nu_t \qquad (3)$$

where

$$I_t = \begin{cases} 1 & if \quad \hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if \quad \hat{\varepsilon}_{t-1} < \tau \end{cases} \qquad (4)$$

The value of the threshold is denoted by τ. What this implies is that if $\hat{\varepsilon}_{t-1} \geq \tau$, I_t takes on a value of one and the speed of adjustment in equation (3) is ρ_1. If on the other hand $\hat{\varepsilon}_{t-1} < \tau$, I_t takes on a value of zero and the speed of adjustment is ρ_2. If $|\rho_1| > |\rho_2|$, the adjustment process is faster for $\hat{\varepsilon}_{t-1} \geq \tau$ than $\hat{\varepsilon}_{t-1} < \tau$. Enders and Granger have computed critical values for the null of a unit root, that is, $\rho_1 = \rho_2 = 0$, against the TAR alternatives. The F statistic for the null hypothesis that $\rho_1 = \rho_2 = 0$

using the TAR model is denoted by Φ_u. A sufficient condition for the $\{\hat{\varepsilon}_t\}$ series to be stationary is -2 < ($\rho_{1,}\rho_2$) < 0. If $\rho_1 = \rho_2$, then equation (3) is equivalent to the Dickey Fuller test.

If the speed of adjustment depends upon the change in ε_{t-1} rather than the level of ε_{t-1}, equation (4) is represented by

$$I_t = \begin{cases} 1 & if \quad \Delta\hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if \quad \Delta\hat{\varepsilon}_{t-1} < \tau \end{cases} \qquad (5)$$

This is a M-TAR model and the F statistic for the null hypothesis that $\rho_1 = \rho_2 = 0$ is denoted by Φ_u^*. Enders and Granger have also computed critical values for Φ_u^*. This paper employs only the TAR model as both the AIC and SBC show that the TAR model is a better specification. The TAR models are estimated in Section 4 using both a threshold of zero and a estimated value for τ. A τ value is estimated using Chan's (1993) method. This procedure is explained in Section 4.

3 Data

The data used are three month Euro Dollar Deposit Rates for the US and the UK. All data are obtained from *Global Financial Data.* This ensures that the assets are comparable in terms of risk and tax treatment (see Siklos and Granger 1997). The data covers the period 1980.7 to 2005.02. Real interest rates are calculated as the nominal interest rate (i), less the rate of inflation (π), i-π.

Table 1 presents the Augmented Dickey Fuller (ADF -1979), Phillips-Perron (PP – 1988), and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS - 1992) test statistics for unit roots. The results suggest that both interest rate series are non stationary in levels and stationary in the first differences.

Table 1: Unit Root Tests

	ADF	PP	KPSS
r_{US}	-3.14**	-1.47	1.53***
r_{UK}	-2.01	-2.24	1.44***
$\Delta\, r_{US}$	-15.40***	-15.37***	0.04
$\Delta\, r_{UK}$	-4.32***	-21.21***	0.06

Critical values at 1%, 5% and 10% levels ADF and PP: -3.45, -2.87, -2.57
KPSS 1%, 5% and 10% levels: 0.739, 0.463, 0.347 (H_o = stationarity)

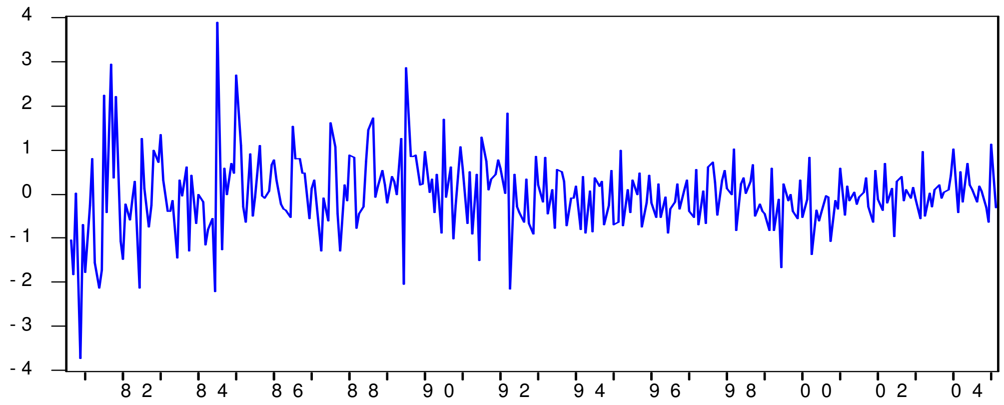
Figure 1 exhibits the time path of the TAR process:

$$\Delta\hat{\varepsilon}_t = -0.0052\ I_t\hat{\varepsilon}_{t-1} \ - 0.2289\ (1 - I_t)\hat{\varepsilon}_{t-1} \ + \ \nu_t$$

where $I_t = 1$ if $\varepsilon_{t-1} \geq 0$ and $I_t = 0$ if $\varepsilon_{t-1} < 0$.

The positive deviations from the mean appear to be more persistent than the negative deviations.

Figure 1: TAR Process



4 Empirical Results

Standard cointegration tests are carried out prior to threshold cointegration tests in order to see if there is any justification for the use of threshold cointegration.

4.1 Estimation Using Standard Cointegration Tests:

Equation (1) is estimated and the residuals ε_t are saved employing the UK as the base country. The US rate is assumed to be the world rate. A cointegration test is carried out on the residuals by estimating an equation of the form expressed by equation (2).

The Estimated Equations Using Standard Cointegration Tests:

The Real Interest Parity Condition between the UK and the US: $r_{UK} - r_{US}$

$$\Delta\hat{\varepsilon}_t = \underset{(-3.89)}{-0.087}\,\hat{\varepsilon}_{t-1} + \nu_t \qquad (6)$$

t statistics reported in parenthesis
1%, 5% and 10% levels of significance respectively: -4.29, -3.74, -3.45

If the null hypothesis that $\rho = 0$ can be rejected it can be concluded that the series is stationary and that a long run relationship exists between r_{UK} and r_{US}. The null hypothesis that ρ =0 is rejected at the 5% level providing some support for the non-linear adjustment in real interest rates.

4.2 The Case for Threshold Cointegration

If there is very slow mean reversion equation (2) is incorrectly specified. Therefore, it is useful to test for non-linearity in the models. A Regression Error Specification Test (RESET) is carried out to test for non linearity. The RESET tests for the null hypothesis of linearity against the alternative of non linearity. If the residuals from a linear model are independent they should not be correlated with the regressors in the equation or the fitted values. Hence if the model is linear a regression of the residuals on these variables should yield an F statistic or a Log Likelihood ratio statistic that is not statistically significant. The RESET is calculated as:

$$\varepsilon_t = \varphi z_t + \sum_{i=1}^{N} \alpha_j \hat{y}_t^i \qquad for \quad N \geq 2$$

where ε_t denotes a vector of residuals from the model, y_t represents a vector of fitted values of r on r^*, $\hat{y}_t = [\hat{y}^1, \hat{y}^2..]$

The null hypothesis tests for $\alpha_1 = \alpha_2 = ... = \alpha_N$. If the calculated statistics exceed the critical values it is possible to conclude that the model is non linear.

Regression Error Specification Test (RESET)

$r_{UK} - r_{US}$ calculated F statistic 23.567 (7)

Equation (7) reports the RESET results. The F statistic exceeds the 5% critical value leading to the rejection of the null hypothesis that $\alpha_1 = \alpha_2 = .. = \alpha_N$. This provides evidence in support of non linearity in the model. The RESET results confirm the need for an alternative specification. Therefore, the models are estimated using the TAR procedure.

4.3 Threshold Cointegration

With Zero Threshold:

The model is estimated using a τ value of zero and an estimated τ value. Equation (8) reports threshold cointegration estimates for real interest parity with a zero threshold.

Threshold cointegration with zero threshold

$\underline{r_{UK} - r_{US}}$

$$\Delta\hat{\varepsilon}_t = \underset{(-0.137)}{-0.0052}\ I_t\hat{\varepsilon}_{t-1} \quad \underset{(-3.937)}{-\ 0.2289}\ (1 - I_t)\hat{\varepsilon}_{t-1} \quad + \ \nu_t \qquad (8)$$

Φ_U = 6.986** $\qquad \rho_1 = \rho_2$: 0.008 $\qquad \tau = 0$

AIC: 446 SBC: 441

Notes: t statistics reported in parenthesis

critical values for threshold unit roots: 10%, 5% and 1% levels respectively: -5.11, -6.03, 8.04

$\rho_1 = \rho_2$ denote symmetric adjustment and the values expressed are the p values of symmetric adjustment.

The null hypothesis of symmetric adjustment, $\rho_1 = \rho_2$, is rejected at the 5% level yielding an F statistic of 6.986. The estimated values for ρ_1 and ρ_2 are –0.0052 and –0.2289 respectively. The estimates suggest that the speed of adjustment is faster for negative rather than for positive deviations. The real rate adjusts to its long run equilibrium at a speed of 0.52% for positive deviations from equilibrium and at a rate of 22.89% for negative deviations. The evidence appears to support non linear adjustment in the RIP condition between the UK and the US.

With a Consistent Estimate of the Threshold:

The equations are re-estimated with a consistent estimate of a threshold in order to see if an estimate of the threshold yields a better fit. Chan's (1993) procedure is used to calculate an estimate for the threshold. According to Chan, in order to obtain a consistent estimate of τ, the estimate of τ must lie between the maximum and minimum values of the series. The estimate of τ is computed as follows. The series is ranked. Next, the highest 15% and lowest 15% of the series, is removed. Of the remaining 70% of the data points, each one has the potential to be the threshold. The estimates for the threshold parameters for each model is selected so that the sum of squared residuals is minimized for each equation. Having followed this procedure, the selected τ value for r_{UK-US} is 0.42849. Equation (9) reports cointegration test results for the equation with a consistent estimator of the threshold.

Threshold cointegration with estimate of threshold

$r_{UK} - r_{US}$

$$\Delta\hat{\varepsilon}_t = \underset{(2.885)}{0.0078}\; I_t\hat{\varepsilon}_{t-1} + \underset{(3.698)}{0.0122}\; (1 - I_t)\hat{\varepsilon}_{t-1} + v_t \qquad (9)$$

Φ_U = 59.25*** $\rho_1 = \rho_2$: 0.00 $\tau = 0.42849$

AIC: 251 SBC: 255

Notes: t statistics reported in parenthesis

critical values for threshold unit roots: 10%, 5% and 1% levels respectively: -5.11, -6.03, 8.04

$\rho_1 = \rho_2$ denote symmetric adjustment and the values expressed are the p values of symmetric adjustment.

Observe that symmetric adjustment, that is $\rho_1 = \rho_2$, is rejected at the 1% level for equation (9). Real interest parity therefore appears to hold given the non-linear adjustment in interest rates. The estimates for ρ_1 and ρ_2 are 0.0078 and 0.0122 respectively, suggesting that negative deviations from equilibrium adjust faster to long run equilibrium, at a rate of 1.2%, compared to positive deviations from real interest parity which adjust at a rate of 0.7%. An examination of the AIC and SBC statistics indicate that the model with the estimated threshold is better specified than the model with the zero threshold.

4.4 Threshold Error Correction

If real interest parity holds in an asymmetric model, an error correction model can be used to check the short run dynamics of the time series. The general asymmetric error correction model for the real interest parity condition given by equation (1) can be represented as:

$$\Delta r_t = \vartheta + \delta_{11}\ ec^{+}_{t-1} \ + \ \delta_{12}\ ec^{-}_{t-1} \ + \ \alpha_{11}(L)\Delta r^{*}_{t-1} \ + \ \alpha_{12}(L)\Delta r_{t-1}$$

where ϑ is a constant and ec^{+}_{t-1} and ec^{-}_{t-1} are the error correction terms. The estimated coefficients on ec^{+}_{t-1} and ec^{-}_{t-1} determine the rate at which positive and negative deviations from real interest parity adjust to long run equilibrium.

Using the consistent estimate of the threshold, ec^{+}_{t-1} and ec^{-}_{t-1} are estimated based on the cointegrating relationship between the r_{UK} and $r_{US.}$ OLS is used to estimate the long run relation. This yielded: $r_t = -3.76 + 0.72 r*$. Using these estimates ec^{+}_{t-1} and ec^{-}_{t-1} have been calculated as follows: $ec^{+}_{t-1} = I(r_{t-1}$ - 0.72 r^{*}_{t-1} + 3.76); $ec^{-}_{t-1} = (1-I)\,(r_{t-1} - 0.72 r^{*}_{t-1} + 3.76)$; $\alpha_{ij}(L)$ is a 4th order polynomial in the lag operator *L*. The lag length is selected according to the AIC criteria. Equations (10) and (11) are based upon these estimates. The estimated coefficients for all variables are reported in Table 2. For purposes of evaluating the error correction terms, equations (10) –(11) report the coefficients on the error correction terms only.

Reported below are the estimated error correction models with t statistics reported in parenthesis.

$$\Delta r_{t_{UK}} = \vartheta_3 - 0.0079\ ec^{+}_{t-1} \ - \ 0.1559\ ec^{-}_{t-1} \ + \ \alpha_{11}(L)\Delta r^{*}_{t-1\ US} \ + \ \alpha_{12}(L)\Delta r_{t-1\ UK} \quad (10)$$

(-0.23) (-2.86)

$$\Delta r_{US} = \vartheta_4 - 0.0061\ ec^{+}_{t-1} \quad - \ 0.1055\ ec^{-}_{t-1} \ + \ \alpha_{11}(L)\Delta r^{*}_{t-1\ UK} \ + \ \alpha_{12}(L)\Delta r_{t-1\ US} \qquad (11)$$

(-0.25) (-2.72)

Equations (10) and (11) which are based upon the regression of $r_{UK} - r_{US}$, indicate that negative deviations from real interest parity are eliminated faster than positive deviations. The point estimates for equation (10) suggest that if there is a unit positive deviation from interest parity, it is corrected at a rate of 0.79% in one month while a unit point negative deviation from interest parity is corrected at a rate of 15% in a month. The estimates in equation (11) indicate that 0.61% of the discrepancy of a positive deviation from real interest parity is eliminated in one period while a negative deviation from interest parity is corrected at a faster rate of 10.55%. The negative deviations are significant in both equations.

Diagnostic tests have been performed for serial correlation, normality of residuals and heteroscedasticity. The LM statistics for 12^{th} order serial correlation in the residuals are to be compared with the 5% critical value of 21.03. In each case, the data support the assumption of serial independence. The Jarque-Bera (1980) test for the normality of residuals indicate a normal distribution for the disturbance terms in all equations. All equations, support the assumption of homoscedasticity on the basis of a LM test.

Table 2: Error Correction Models

$\Delta r_{t_{UK}} = \vartheta_3 - 0.0079\ ec^{+}_{t-1}$ - $0.1559\ ec^{-}_{t-1}$ + $\alpha_{11}(L)\Delta r^{*}_{t-1\ US}$ + $\alpha_{12}(L)\Delta r_{t-1\ UK}$		
Variable	Coefficient	t-Statistic
ec^{+}_{t-1}	-0.007931	-0.231895
ec^{-}_{t-1}	-0.155894	-2.864021
$\Delta r_{UK(t-1)}$	-0.146601	-2.510685
$\Delta r_{UK(t-2)}$	0.086769	1.472798
$\Delta r_{UK(t-3)}$	-0.177547	-3.036343
$\Delta r_{UK(t-4)}$	-0.076785	-1.330569
$\Delta r_{US(t-1)}$	0.008046	0.101945
$\Delta r_{US(t-2)}$	0.070443	0.898343
$\Delta r_{US(t-3)}$	0.122532	1.576489
$\Delta r_{US(t-4)}$	-0.049507	-0.659832
ϑ_3	0.123482	1.487970
$\chi^2_{sc} = 4.52$	$\chi^2_{n} = 2.29$	$\chi^2_{hs} = 0.23$

$\Delta r_{US} = \vartheta_4 - 0.0061\ ec^{+}_{t-1}$ - $0.1055\ ec^{-}_{t-1}$ + $\alpha_{11}(L)\Delta r^{*}_{t-1\ UK}$ + $\alpha_{12}(L)\Delta r_{t-1\ US}$		
Variable	Coefficient	t-Statistic
ec^{+}_{t-1}	-0.006113	-0.247583
ec^{-}_{t-1}	-0.105487	-2.724134
$\Delta r_{US(t-1)}$	0.003632	0.063338
$\Delta r_{US(t-2)}$	-0.088773	-1.578194
$\Delta r_{US(t-3)}$	-0.013870	-0.248084
$\Delta r_{US(t-4)}$	-0.056810	-1.051342
$\Delta r_{UK(t-1)}$	0.084245	1.986384
$\Delta r_{UK(t-2)}$	-0.014009	-0.327430
$\Delta r_{UK(t-3)}$	-0.038802	-0.905432
$\Delta r_{UK(t-4)}$	0.023864	0.566266
ϑ_4	-0.139194	-2.373129
$\chi^2_{sc} = 6.52$	$\chi^2_{n} = 1.30$	$\chi^2_{hs} = 0.46$

4.5 Impulse Response Functions

Figures 2 and 3 plot the impulse response of the real Eurorate to a positive and negative shock respectively. In response to a positive shock, the real rate returns to steady state after about 7 periods. In response to a negative shock the real rate adjusts to long run equilibrium after approximately 3 periods.

Figure 2: Response of Euro rate UK to a Positive Shock

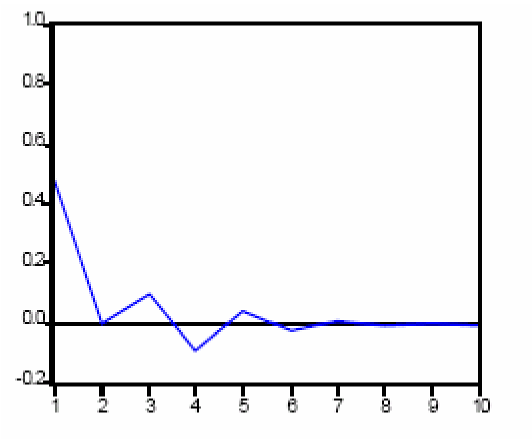
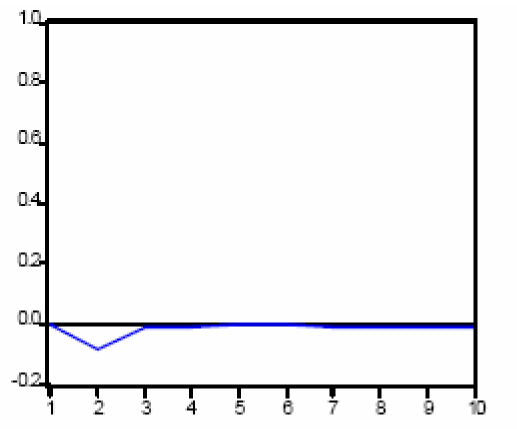


Figure 3: Response of Euro rate UK to a Negative Shock



5 Policy Implications and Conclusions

The results suggest that real interest parity holds between the Euro rates of the UK and the US when asymmetric adjustment is taken into account. Siklos and Granger (1997) show that an equilibrium relationship can change if one country that has adopted an inflation targeting regime has close ties with another that does not follow an inflation targeting policy. The UK introduced a policy of inflation targeting in

1992. The US has not yet adopted an explicit policy of inflation targeting. This perhaps is the reason for the asymmetric adjustment to long run real interest parity. The results are consistent with those of Sekioua (2008) who finds that support for the real interest parity condition is stronger when non-linearities are taken into account, and Wu and Fountas (2000) who find evidence in favour of short term real interest rate convergence between the UK and the US. The results are also consistent with those of Holmes and Maghrebi (2004) who find evidence in favour of non-linearities in real interest rate adjustment.

The estimates of the cointegrating error correction models indicate that negative deviations from interest parity are eliminated faster than positive deviations. It is possible that in the event of a negative shock that the Bank of England intervenes in order to restore the economy back to its long run equilibrium. It is also possible that a negative shock such as in increase in the rate of inflation leads to a change in the real rate rather than vice versa.

In recent times the UK and the US have both experienced low real rates, however, this has not led to stronger growth. How can this be explained in the context of these results? One explanation is that negative shocks in the UK have led to a widening of the negative output gap offsetting the stimulating effects of low real interest rates. Another possible explanation is that the asymmetric adjustment in interest rates has led to asymmetric information in credit and financial markets and as pointed out by Rajan (2005), in the presence of low real rates of interest, investors can underprice risk leading them to undertake increased speculative investment. Under such circumstances the Bank of England is more likely to intervene in order to correct a negative shock to restore the economy back to long run equilibrium. The real rate in the UK is also likely to be influenced by the US real rate. Therefore a change in the real rate in the UK should be examined in the light of changes in the US real rate.

In conclusion, the results suggest that real interest parity holds between the US and the UK during some periods and not in others. This implies that the two countries can pursue independent monetary policies during certain periods and not during others.

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