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AND TAYLOR RULE DEVIATIONS

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Abstract

This paper investigates the PPP and UIP conditions by taking into account possible nonlinearities as well as the role of Taylor rule deviations under alternative monetary policy frameworks. The analysis is conducted using monthly data from January 1993 to December 2020 for five inflation-targeting countries (the UK, Canada, Australia, New Zealand and Sweden) and three non-targeting ones (the US, the Euro-Area and Switzerland). Both a benchmark linear VECM and a nonlinear Threshold VECM are estimated; the latter includes Taylor rule deviations as the threshold variable. The results can be summarised as follows. First, the nonlinear specification provides much stronger evidence for the PPP and UIP conditions, the estimated adjustment speed towards equilibrium being twice as fast. Second, Taylor rule deviations play an important role: the adjustment speed is twice as fast when deviations are small and the credibility of the central bank is higher. Third, inflation targeting tends to generate a higher degree of credibility for the monetary authorities thereby reducing deviations of the exchange rate from the PPP- and UIP-implied equilibrium.

Keywords: PPP; UIP**;** nonlinearities; Taylor rules deviations; inflation targeting

JEL Classification: C32, F31, G15

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1. Introduction

Two well-known puzzles in international finance arise as a result of the apparent failure of many empirical models to find support for either the PPP (Purchasing Power Parity) or the UIP (Uncovered Interest Rate Parity) relations. Various possible explanations have been offered for these findings including: the low power of standard unit root tests (Murray and Papell, 2005); the presence of nonlinearities (Taylor et al., 2001; Kapetanios et al., 2003; Sarno et al., 2006); the failure to take into account the interaction between goods and asset markets (Johansen and Juselius, 1992; Juselius, 1995); non-tradability of goods (Sarno and Chowdhury, 2003) and real frictions (Ford and Horioka, 2017) in the case of PPP; the existence of a risk premium (Li et al., 2012; Biswas et al., 2020), the occurrence of rational bubbles (Obstfeld, 1987; Canterbery, 2000), or deviations from rationality of market participants (Gregory, 1987; Chinn and Quayyum, 2012) in the case of UIP.

Another interesting issue in this context is the possible role of monetary policy regimes. In particular, a few studies have analysed the impact of Taylor rules on PPP (Kim et al., 2014) or UIP (e.g., Backus et al., 2010) separately. By contrast, the present paper aims to assess jointly the empirical validity of PPP and UIP under different monetary policy setups. Specifically, the analysis is conducted over the period from January 1993 to December 2020 for two sets of countries, the first comprising five economies that have adopted inflation targeting (the UK, Canada, Australia, New Zealand and Sweden), the second including three countries (the US, the Euro-Area and Switzerland) that have chosen instead other monetary policy regimes (see Neumann and Von Hagen, 2002, for a similar sample selection). A linear Vector Error Correction Model (VECM) for testing jointly PPP and UIP is estimated in the first instance (Juselius, 1995). Given the evidence on possible nonlinearities in exchange rate behaviour (Taylor et al., 2001) a nonlinear Threshold VECM framework is then applied. Under inflation targeting the credibility of the central bank is particularly important for the successful implementation of monetary policy and may affect the adjustment to long-run PPP and UIP. Deviations from the Taylor rule can be interpreted as an indicator of such credibility (Wilde, 2012), therefore we use them as the threshold variable between regimes characterised by small and large deviations respectively and with different adjustment speeds.

The layout of the paper is as follows: Section 2 briefly reviews the relevant literature; Section 3 outlines the methodology; Section 4 presents the data and discusses the empirical results; Section 5 offers some concluding remarks.

2. Literature Review

Most of the literature on the PPP and UIP puzzles assesses them separately. In the case of PPP unit root tests of the real exchange rate have produced mixed results, with some studies rejecting the null (Cumby and Obstfeld, 1981; Diebold, Husted and Rush, 1991) and others finding instead evidence of nonstationarity (Hakkio, 1984; MacDonald, 1985). Cointegration tests of the PPP relation have been equally inconclusive (Taylor, 1988; McNown and Wallace, 1990; Kim, 1990; Taylor, 1992). As for UIP, most studies have reported that the interest rate differential is not an optimal predictor of exchange rate changes (Cumby and Obstfeld, 1981; Taylor, 1987; Mylonidis and Semertzidou, 2010; Londono and Zhou, 2017).

A possible reason for the lack of strong evidence for PPP and UIP is the need to investigate their joint validity in equilibrium models taking into account the linkages between goods and capital markets. For this purpose Johansen and Juselius (1992) estimated a five-dimensional multivariate cointegration model for the UK based on the framework developed by Johansen (1991) and concluded that more empirical support can be found for exchange rates parities when allowing for interactions between both types of markets. Since then, several other studies have used a similar approach to test for PPP and UIP. Hunter (1992) dropped the weak exogeneity assumption for oil prices and found two cointegration vectors representing the long-run PPP and UIP relations for the British pound. Camarero and Tamarit (1996) conducted the analysis for Spain and provided some more supportive evidence for PPP and UIP. Juselius (1995) examined the case of the Danish krone whilst Caporale et al. (2001) also used a FIML framework for the German mark and the Japanese yen, both studies confirming the importance of allowing for cross-market linkages. Jaramillo Franco and Serván Lozano (2012) found two stationary vectors in the case of the Peruvian sol, one representing the joint PPP and UIP equilibrium, the other being an interest rate equation with a risk premium.

More recent studies have provided evidence of nonlinear adjustment to long-run PPP and UIP (Kapetanios et al., 2003; Sarno et al., 2006). For instance, Holmes and Maghrebi (2004) and Kisswani and Nusair (2014) estimated a Logistic Smooth Transition Autoregressive (LSTAR) model for Real Interest Parity (RIP) for selected South-East Asian economies; their results support both PPP and UIP with a nonlinear adjustment. A drawback of the RIP approach to investigating exchange rate parities is that it does not shed light on whether a rejection of the joint null is due to a failure of PPP or UIP or both.

Finally, a few papers have found that Taylor rule deviations, measured as the difference between the actual and the target interest rate, can influence the path of the real exchange rate through their impact on central bank credibility (Wilde, 2012). Nikolsko-Rzhevskyy et al. (2014) also calculated several central bank loss functions and found that the costs of deviations from different types of Taylor rules are large; frequent deviations are seen by agents as a permanent shift in monetary policy and might lead to a loss of central bank credibility and affect the monetary policy transmission mechanism.

3. Empirical Framework

3.1. The Linear Vector Error Correction Model

As a first step, in order to test jointly for long-run PPP and UIP equilibrium relations and also examine the dynamic adjustment process the following linear Vector Error Correction Model (VECM) is estimated (see Johansen, 1991):

$$\Delta Y_t = \mu + \theta z_{t-1} + \sum_{i=1}^{p} \Phi_i \Delta Y_{t-1} + u_t \tag{1}$$

where Y_t is a vector including in our case the nominal exchange rate s_t (defined as domestic currency units per unit of foreign currency), the interest rate differential $\tilde{\imath}_t = i_t - i_t^*$, which is the difference between the domestic and foreign interest rate, and the inflation differential $\tilde{\pi}_t = \pi_t - \pi_t^*$, which is the difference between the domestic and foreign inflation rate; z_{t-1} is the error correction term representing the long-run equilibrium, Δ is the difference operator, the Φ_i stands for the parameters corresponding to the short-run dynamics, θ is the adjustment parameter measuring the speed at which the system returns to equilibrium after any deviations from it, and u_t stands for the innovations. Unit root tests, such as the Dickey Fuller Generalised Least Squares (DF-GLS) test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test, are carried out initially to establish whether the variables are of the same order of integration, then the existence of long-run linkages is investigated by performing Johansen's (1991) cointegration tests as appropriate. Model adequacy is assessed by means of various diagnostic tests including the White test for heteroscedasticity, the Breusch-Godfrey Lagrange multiplier

(LM) test for serial correlation, the Wald test of regressor endogeneity and the Gregory-Hansen test for cointegration with regime shifts.

3.2. The Threshold Vector Error Correction Model

A natural extension of the linear model is a nonlinear Threshold VECM (TVECM) which includes two regimes identified through a threshold variable and takes the following form (Tsay, 1989):

$$\Delta Y_t = \left(\mu_1 + \theta_1 z_{t-1} + \sum_{i=1}^{p-1} \Phi_{1,i} \Delta Y_{t-i} \right) 1(d_t \leq \gamma) + \\ + \left(\mu_2 + \theta_2 z_{t-1} + \sum_{i=1}^{p-1} \Phi_{2,i} \Delta Y_{t-i} \right) 1(d_t > \gamma) + u_t \quad (2)$$

where d_t is the threshold variable, γ is the threshold value and the other variables are defined as before. The threshold value is estimated empirically as the one which minimises the residual sum of squares.

In the empirical application below the threshold variable is calculated as the deviations from the Taylor rule adopted by the monetary authorities. Specifically, for each of the countries under examination we estimate the following three different types of rules by using the Generalised Methods of Moments (GMM) method: the classical Taylor rule, the extended Taylor rule, and a Taylor rule with interest rate smoothing. The classical one can be represented as follows:

$$i_t = \alpha + \beta(E_{t-1}\pi_{t+3} - \bar{\pi}) + \gamma(E_{t-1}y_{t+3}) + u_t \quad (3)$$

where i_t is the nominal interest rate set by the central bank, $E_{t-1}\pi_{t+3}$ is the 3-month ahead central bank's expectation of the inflation rate, $\bar{\pi}$ is the target inflation rate, $E_{-1}y_{t+3}$ is the 3-month ahead central bank's expectation of the output gap and u_t is a disturbance term. The output gap is calculated using the Hodrick-Prescott Filter, which is a standard procedure in this area of the empirical literature (Álvarez and Gómez-Loscos, 2018).

The extended Taylor rule includes the real exchange rate as an additional regressor and can be specified as follows:

$$i_t = \alpha + \beta(E_{t-1}\pi_{t+3} - \bar{\pi}) + \gamma(E_{t-1}y_{t+3}) + \delta q_t + u_t \qquad (4)$$

where q_t is the real effective exchange rate and all other variables are defined as before.

Finally, the Taylor rule with interest rate smoothing takes the following form:

$$i_t = \alpha + \rho i_{t-1} + (1-\rho)\big(\beta(E_{t-1}\pi_{t+3} - \bar{\pi}) + \gamma(E_{t-1}y_{t+3})\big) + u_t \qquad (5)$$

where i_{t-1} is the one-period lagged interest rate, ρ is the partial adjustment parameter which measures the fraction of the target rate by which the central bank moves the current interest rate in each period, and all other variables are the same as before. Under interest rate smoothing the central bank changes the interest rate gradually in response to a change in inflation, i.e. i_t is moved towards $\bar{\imath}_t$ over time. Forward-looking policymakers are assumed to make their policy decisions based on their one-quarter ahead forecast for the fundamentals. Since expected inflation and output cannot be observed directly, we use the 3 month-ahead average as in most of the existing literature on Taylor rules (see Clarida et al., 1998, 2000).

The GMM approach requires the identification of suitable instruments, which are correlated with the variables on the right-hand side of the Taylor rule equation and uncorrelated with the innovations. For our purposes we use the first lag of the inflation rate and of the output gap in all cases; in the extended Taylor rule, we also add the first lag of the real exchange rate; finally, in the Taylor rule with interest rate smoothing we include the second lag of the interest rate as well. GMM also requires all variables to be stationary, therefore we perform both the DF-GLS and KPSS test on the individual series to establish their order of integration.

To select the optimal Taylor rule for each country, we use the J-statistic for overidentifying restrictions which tests the validity of the chosen instruments. A relatively large J-statistic indicates that it is questionable whether the model fulfils the GMM moment conditions (Andrews and Lu, 2001). Next we calculate the deviations from the optimal Taylor rule identified for each country as the difference between the policy rate and the target rate determined by the Taylor rule fundamentals (Wilde, 2012; Nikolsko-Rzhevskyy et al., 2014).

3.3. Tests for Threshold-Type Nonlinearity

Prior to estimating the threshold model a test for threshold-type nonlinearity has to be carried out. We perform two of the most widely used tests, namely the sup-Wald test and the Bai-Perron test (Balke and Fomby, 1997). The former was proposed by Seo (2008) and can be expressed as follows:

$$W_n = sup_{r\epsilon\Gamma} n \left\{ \frac{\hat{\sigma}^2}{\hat{\sigma}^2(T)} - 1 \right\} \tag{6}$$

where T is the number of time periods, $\hat{\sigma}^2$ and $\hat{\sigma}^2(T)$ stand for the residual variance for the model under the null and the alternative hypothesis respectively, n is the number of observations and $sup_{r\epsilon\Gamma}$ is the supremum. The test searches for a single threshold value over the entire range $[-\gamma, \gamma]$ of the threshold variable, where $\gamma = max|z_{t-d}|$ is the threshold value and z_{t-d} is the threshold variable. The threshold search is usually restricted to exclude the bottom and top 15% of the observations in the range. The test is constructed in such a way that the break point corresponds to the minimum sum of squares and the highest Wald statistic. Following Seo (2008), we use block bootstrapping with 1000 replications to deal with the problem that the threshold value is unidentified under the linear null. Note that the sup-Wald test is designed to detect the existence of a nonlinear adjustment process towards the long-run equilibrium which is assumed to be a single linear cointegrating vector.

The Bai-Perron test is based instead on a sequential selection method, which tests for the existence and number of thresholds by minimising the sum of squared residuals at the m-partition $(T_1, \dots, T_m)$ of m thresholds, resulting in $m + 1$ regimes. It is an F-Test of the null hypothesis of zero thresholds versus the alternative of one threshold. If the null is rejected, the test can be extended to test sequentially for higher numbers of thresholds. This method allows for the identification of the exact number of thresholds with an external threshold variable (Bai and Perron, 2003). We also carry out some diagnostic tests (specifically the Breusch-Godfrey LM test for serial correlation and the Breusch-Pagan LM test for heteroscedasticity) to check model adequacy in each case.

4. Data and Empirical Results

4.1. Data Description

As already mentioned, we investigate five inflation targeting countries (the UK, Canada, Australia, New Zealand and Sweden), and three with other monetary policy arrangements (the US, the Euro-area and Switzerland) which have often been examined in the literature (Cecchetti and Ehrmann, 1999; Mishkin and Schmidt-Hebbel, 2001; Neumann and Von Hagen, 2002). The series are monthly and span the time period from January 1993 to December 2020. Inflation is calculated as the annual percentage change in CPI; the data sources for Australia and New Zealand are their respective Reserve Banks; for the other countries the series have been obtained from the OECD Statistics. Interest rates are nominal short-term rates, specifically the monthly averages of daily three-month money market rates; these series have also been taken from the OECD Statistics. The nominal exchange rate series come from the Pacific Exchange Rate Service database. The real GDP series are volume estimates of real GDP in national currency and have been obtained from the Federal Reserve Bank of St Louis Economic Database. The real effective exchange rates series are CPI-based measures and are taken from the BIS (Bank for International Settlements) Statistics Warehouse. All variables are logged for the analysis.

4.2. Unit Root and Cointegration Tests

As a first step we perform the DF-GLS and KPSS unit root tests on the nominal exchange rate, interest rate differential and inflation differential series. The results are reported in Table 1 and indicate that all series are integrated of the same order $I(1)$.

Table 1. Unit Root Test Results for Differential Series

	Level series		Differenced series	
	DF-GLS	KPSS	DF-GLS	KPSS
	Nominal Exchange Rates			
GBPCAD	-1.535	2.95***	-4.546***	0.0982
GBPAUD	-1.913	3.59***	-4.121***	0.0912
GBPNZD	-2.166	4.01***	-4.302***	0.083
GBPSEK	-1.996	3.5***	-3.966***	0.0752
CADAUD	-2.547	2.26***	-9.382***	0.0554
CADNZD	-2.115	2.39***	-9.050***	0.0986
CADSEK	-2.093	0.948***	-6.271***	0.0349
AUDNZD	-2.020	2.24***	-3.649***	0.0576
AUDSEK	-2.840	1.81***	-4.931***	0.0273
NZDSEK	-2.146	2.26***	-5.684***	0.0428
USDEUR	-2.084	3.05***	-9.568***	0.101
USDCHF	-2.244	2.89***	-9.643***	0.0725
EURCHF	-1.788	4.62***	-5.670***	0.0995

	Level series		Differenced series		Level series		Differenced series	
	DF-GLS	**KPSS**	**DF-GLS**	**KPSS**	**DF-GLS**	**KPSS**	**DF-GLS**	**KPSS**
	Interest Rate Differentials				**Inflation Differentials**			
UK-Canada	-2.432	3.57***	-4.480***	0.0663	-2.364	1.21***	-4.101***	0.0102
UK-Australia	-1.935	3.07***	-4.249***	0.104	-2.031	1.42***	-4.349***	0.0326
UK-New Zealand	-1.446	2.56***	-9.103***	0.0955	-2.392	1.39***	-7.074***	0.0263
UK-Sweden	-2.586	1.94***	-4.021***	0.0948	-2.523	1.04***	-6.496***	0.016
Canada-Australia	-1.492	4.68***	-6.940***	0.0709	-2.364	0.743***	-4.724***	0.0105
Canada-New Zealand	-2.118	3.75***	-8.238***	0.0467	-2.674	0.815***	-4.407***	0.0116
Canada-Sweden	-2.041	2.35***	-8.851***	0.0966	-1.778	1.24***	-4.610***	0.0074
Australia-New Zealand	-2.627	1.75***	-6.884***	0.0717	-2.625	0.604***	-6.133***	0.0211
Australia-Sweden	-2.455	1.37***	-7.455***	0.0987	-1.397	1.53***	-6.498***	0.019
New Zealand Sweden	-2.665	0.954***	-9.155***	0.0992	-1.728	1.33***	-7.407***	0.0181
US- Euro Area	-1.882	3.91***	-6.364***	0.0949	-2.220	1.14***	-3.582***	0.0286
US-Switzerland	-1.945	3.96***	-4.652***	0.0712	-2.555	0.508***	-6.244***	0.0228
Euro Area-Switzerland	-2.795	1.11***	-4.935***	0.0162	-2.151	0.422***	-4.809***	0.0156

*** significant at 1% level
Critical values:
DF-GLS: 1%: -3.452; 5%: -2.876; 10%: -2.570
H_0: variable contains a unit root
H_1: variable is stationary

KPSS: 1%: 0.216; 5%: 0.146; 10%: 0.119
H_0: variable is stationary
H_1: variable is not stationary

Therefore we proceed to test for cointegration between the series. The results of the Johansen cointegration trace and eigenvalue tests are reported in Table 2 and show that in each case there exists a single cointegration relation which can be interpreted as being consistent with PPP and UIP simultaneously.

Table 2. Johansen Test for Cointegration

	Trace Test			Eigenvalue Test		
	Test 1	**Test 2**	**Test 3**	**Test 1**	**Test 2**	**Test 3**
UK-Canada	0.0189**	0.3049	0.2905	0.0231**	0.5082	0.2905
UK-Australia	0.0240**	0.0808	0.9260	0.0015***	0.1681	0.1565
UK-New Zealand	0.0380**	0.6693	0.2834	0.0360**	0.5519	0.2834
UK-Sweden	0.0373**	0.3066	0.3054	0.0486**	0.7100	0.3540
Canada-Australia	0.0047***	0.3884	0.8716	0.0025***	0.2333	0.8716
Canada-New Zealand	0.0118**	0.1329	0.1000	0.0333**	0.2232	0.1000
Canada-Sweden	0.0135**	0.1800	0.3150	0.0047***	0.3751	0.8910
Australia-New Zealand	0.0245**	0.2624	0.6578	0.0399**	0.2080	0.6578
Australia-Sweden	0.0220**	0.2546	0.6729	0.0079***	0.2152	0.4430
New Zealand-Sweden	0.0388**	0.2482	0.6560	0.0201**	0.4559	0.6448
US-Euro Area	0.0465**	0.5256	0.0999	0.0237**	0.6005	0.9109
US-Switzerland	0.0152**	0.4826	0.2577	0.0088***	0.5425	0.2577
Euro Area-Switzerland	0.0065***	0.4059	0.8809	0.0006***	0.0921	0.6530

Trace Test:
Test 1:$H_0: r = 0;\ H_1: r = 1$; 95% Critical value: 42.92
Test 2:$H_0: r \leq 1;\ H_1: r = 2$; 95% Critical value: 25.87
Test 3:$H_0: r \leq 2;\ H_1: r = 3$; 95% Critical value: 12.52

Eigenvalue Test:
Test 1:$H_0: r = 0;\ H_1: r = 1$; 95% Critical value: 25.82
Test 2:$H_0: r \leq 1;\ H_1: r = 2$; 95% Critical value: 19.39
Test 3:$H_0: r \leq 2;\ H_1: r = 3$; 95% Critical value: 12.52

r denotes the cointegration rank and number of significant vectors.

4.3. The Linear Model

Tables 3a and 3b report the estimation results for the linear VECM. Most of the short-run coefficients are not significant. As for the adjustment coefficient θ, in some cases it is only significant and negative in the inflation equations, where its estimated value implies that between 3% and 28% of any deviations from the parity equilibrium is corrected within one month. In other cases, the adjustment instead occurs only in the interest rate equation, where between 3% and 6% of any deviation from the equilibrium is corrected within one month. There is no observable difference in the adjustment speed between inflation targeting and non-targeting economies**.**

We perform a series of diagnostic tests to establish whether the linear models are data congruent. The results are reported in Table 4 and show that they suffer from heteroscedasticity. Furthermore, the Gregory-Hansen test indicates the presence of regime shifts in several cases. Therefore next we estimate a Threshold VECM (TVECM), where the threshold variable is given by deviations from the Taylor rule since these are an important indicator of central bank credibility and could affect the adjustment towards the long-run equilibrium.

Table 3a. Linear Vector Error Correction Model Results for Inflation Targeting Countries

	GBPNZD			CADAUD			CADNZD			CADSEK			NZDSEK		
	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$
μ	0.00107	-0.00004	0.00004	0.000398	-0.00006	0.000127	0.000869	-0.000022	0.000335	-0.000251	0.000014	0.000670	-0.000955	0.00004	0.000242
	(0.00134)	(0.00817)	(0.00238)	(0.00104)	(0.0167)	(0.00218)	(0.00120)	(0.0159)	(0.00248)	(0.00114)	(0.0143)	(0.00329)	(0.00128)	(0.0123)	(0.00288)
s_{t-1}	0.137**	0.0228	-0.103	0.180***	0.237	-0.0847	0.191***	-0.954	-0.0845	0.132**	0.301	0.00923	0.201***	0.101	-0.172
	(0.0564)	(0.344)	(0.100)	(0.0555)	(0.892)	(0.117)	(0.0549)	(0.729)	(0.114)	(0.0543)	(0.680)	(0.157)	(0.0542)	(0.521)	(0.122)
$\tilde{\pi}_{t-1}$	0.00225	0.0103	-0.00829	0.00234	-0.0585	-0.00729	0.00293	-0.0543	-0.00708	0.00494	0.0454	-0.00916	-0.00500	0.116**	-0.0197
	(0.00902)	(0.0550)	(0.0160)	(0.00341)	(0.0548)	(0.00718)	(0.00414)	(0.0550)	(0.00858)	(0.00445)	(0.0558)	(0.0129)	(0.00562)	(0.0541)	(0.0126)
$\tilde{i}_{t-1}$	-0.0301	-0.0951	0.333***	-0.0241	0.938**	0.486***	-0.000366	0.268	0.358***	-0.00934	0.0369	0.355***	-0.00636	-0.197	0.349***
	(0.0304)	(0.186)	(0.0540)	(0.0236)	(0.378)	(0.0496)	(0.0253)	(0.335)	(0.0523)	(0.0182)	(0.228)	(0.0527)	(0.0230)	(0.221)	(0.0517)
θ	0.00312	0.0846***	-0.00183	0.00231***	0.0776***	-0.00338**	0.00414**	0.134***	-0.00178	0.00212***	0.0440***	-0.0001	-0.0001	0.205***	-0.00328
	(0.00350)	(0.0213)	(0.00621)	(0.000781)	(0.0126)	(0.00164)	(0.00196)	(0.0260)	(0.00406)	(0.000615)	(0.00771)	(0.00178)	(0.00427)	(0.0411)	(0.00960)
	GBPCAD			GBPAUD			GBPSEK			AUDNZD			AUDSEK		
	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{i}_t$
μ	0.000185	0.000096	-0.000573	0.000620	-0.00004	0.00006	0.00005	0.00002	0.000340	-0.0182	-0.289***	-0.0676***	-0.000730	0.00006	0.000682
	(0.00112)	(0.0135)	(0.00284)	(0.00140)	(0.00812)	(0.00224)	(0.00108)	(0.00988)	(0.00275)	(0.0111)	(0.111)	(0.0233)	(0.00120)	(0.0131)	(0.00271)
s_{t-1}	0.119**	-1.303*	-0.0469	0.128**	0.621*	-0.202**	0.125**	0.172	-0.220	0.265***	-0.644	-0.284**	0.150***	1.076*	0.0492
	(0.0574)	(0.692)	(0.146)	(0.0601)	(0.349)	(0.0966)	(0.0585)	(0.534)	(0.149)	(0.0558)	(0.555)	(0.117)	(0.0563)	(0.619)	(0.127)
s_{t-2}	-0.0380	0.235	-0.0828	-0.158***	0.797**	0.0104	-0.0808	-0.267	0.200	-0.0777	1.192**	0.0817	-0.224***	0.661	-0.152
	(0.0562)	(0.677)	(0.143)	(0.0598)	(0.348)	(0.0962)	(0.0576)	(0.526)	(0.146)	(0.0564)	(0.561)	(0.118)	(0.0546)	(0.600)	(0.124)
s_{t-3}							-0.0263	-0.955*	0.262*				-0.0323	0.0626	0.245*
							(0.0575)	(0.525)	(0.146)				(0.0554)	(0.609)	(0.125)
$\tilde{\pi}_{t-1}$	0.00604	-0.0830	-0.0148	0.00343	0.0344	-0.00430	0.00386	0.0315	-0.00148	-0.00113	0.00828	0.0131	-0.00148	0.0238	-0.00673
	(0.00460)	(0.0555)	(0.0117)	(0.00871)	(0.0507)	(0.0140)	(0.00603)	(0.0551)	(0.0153)	(0.00540)	(0.0537)	(0.0113)	(0.00493)	(0.0542)	(0.0112)
$\tilde{\pi}_{t-2}$	-0.00254	0.175***	-0.0229**	-0.00408	-0.129**	0.0279**	0.00645	-0.0911*	0.0191	0.00603	0.0112	0.0190*	0.00321	-0.00393	0.0133
	(0.00451)	(0.0543)	(0.0115)	(0.00865)	(0.0503)	(0.0139)	(0.00592)	(0.0541)	(0.0151)	(0.00535)	(0.0532)	(0.0112)	(0.00482)	(0.0530)	(0.0109)
$\tilde{\pi}_{t-3}$							-0.00715	0.0357	-0.00191				0.00556	-0.0139	0.00286
							(0.00596)	(0.0544)	(0.0152)				(0.00481)	(0.0529)	(0.0109)
$\tilde{i}_{t-1}$	-0.0133	0.217	0.297***	-0.0393	-0.419*	0.311***	-0.0474**	-0.217	0.290***	0.0158	0.373	0.318***	0.00320	0.202	0.277***
	(0.0224)	(0.270)	(0.0570)	(0.0371)	(0.216)	(0.0597)	(0.0224)	(0.205)	(0.0570)	(0.0264)	(0.263)	(0.0552)	(0.0248)	(0.272)	(0.0561)
$\tilde{i}_{t-2}$	0.00709	0.00880	-0.0133	0.0116	1.276***	-0.0486	0.0455**	-0.136	-0.102*	0.0245	0.490*	-0.0665	-0.00110	0.428	0.0192
	(0.0224)	(0.270)	(0.0572)	(0.0366)	(0.213)	(0.0588)	(0.0231)	(0.211)	(0.0587)	(0.0263)	(0.261)	(0.0549)	(0.0253)	(0.278)	(0.0572)
$\tilde{i}_{t-3}$							-0.0463**	0.492**	0.217***				-0.0296	1.098***	0.153***
							(0.0222)	(0.203)	(0.0565)				(0.0247)	(0.271)	(0.0558)
θ	0.00543	0.428***	0.00871	0.00750	0.147***	0.00930	0.00456	0.194***	0.0126	-0.0182	-0.289***	-0.0676***	-0.00470**	-0.105***	0.00368
	(0.00619)	(0.0745)	(0.0158)	(0.00708)	(0.0412)	(0.0114)	(0.00498)	(0.0455)	(0.0127)	(0.0111)	(0.111)	(0.0233)	(0.00184)	(0.0202)	(0.00417)

* significant at 10% level, ** significant at 5% level, *** significant at 1% level. Standard errors in parentheses.

Table 3b. Linear Vector Error Correction Model Results for Non-Targeting Countries

	USDEUR			USDCHF			EURCHF		
	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{\imath}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{\imath}_t$	Δs_t	$\Delta\tilde{\pi}_t$	$\Delta\tilde{\imath}_t$
μ	-0.000526	0.00269	0.00549	0.00164	0.000191	0.00702	0.00137*	0.00006	-0.000437
	(0.00117)	(0.00711)	(0.00401)	(0.00130)	(0.00985)	(0.00816)	(0.000707)	(0.0114)	(0.00754)
s_{t-1}	0.299***	1.106***	-0.340*	0.178***	0.0863	-0.480	0.170***	0.550	0.566
	(0.0552)	(0.335)	(0.189)	(0.0552)	(0.417)	(0.346)	(0.0599)	(0.970)	(0.639)
s_{t-2}	-0.127**	0.744**	0.395**	-0.0752	-0.104	0.291	-0.0580	0.635	0.653
	(0.0565)	(0.343)	(0.193)	(0.0552)	(0.417)	(0.346)	(0.0596)	(0.965)	(0.636)
$\tilde{\pi}_{t-1}$	0.00615	-0.271***	-0.0474	-0.00300	0.0642	-0.0260	-0.00272	0.0467	-0.0442
	(0.00979)	(0.0594)	(0.0335)	(0.00723)	(0.0546)	(0.0452)	(0.00329)	(0.0532)	(0.0350)
$\tilde{\pi}_{t-2}$	0.0110	0.117**	-0.0171	-0.0119*	0.149***	-0.0287	0.00258	0.305***	-0.0153
	(0.00936)	(0.0568)	(0.0320)	(0.00721)	(0.0545)	(0.0451)	(0.00324)	(0.0525)	(0.0346)
$\tilde{\imath}_{t-1}$	-0.0123	0.0339	0.212***	-0.00833	-0.143**	0.0182	0.00380	0.138	-0.107*
	(0.0162)	(0.0982)	(0.0553)	(0.00889)	(0.0672)	(0.0556)	(0.00564)	(0.0912)	(0.0601)
$\tilde{\imath}_{t-2}$	-0.0118	0.0481	-0.0327	-0.0137	0.0179	-0.0923*	0.00379	0.188**	-0.137**
	(0.0161)	(0.0978)	(0.0551)	(0.00894)	(0.0675)	(0.0559)	(0.00564)	(0.0912)	(0.0601)
θ	-0.00876***	-0.0297*	0.0137	0.00003	0.129***	-0.00354	0.00237*	0.110***	0.0224
	(0.00258)	(0.0157)	(0.00883)	(0.00366)	(0.0277)	(0.0229)	(0.00133)	(0.0215)	(0.0142)

* significant at 10% level, ** significant at 5% level, *** significant at 1% level. Standard errors in parentheses.

Table 4. Misspecification Tests for the Linear Models

	Selected Lag	White Test	Breusch-Godfrey LM Test	Wald test	Gregory-Hansen test
GBPCAD	2	0.0000***	0.9665	0.5998	-4.76
GBPAUD	2	0.0000***	0.2640	0.0000***	-5.69**
GBPNZD	1	0.0000***	0.1733	0.8550	-5.71**
GBPSEK	3	0.0000***	0.3223	0.0135**	-4.87
CADAUD	1	0.0000***	0.0655*	0.0441**	-5.92**
CADNZD	1	0.0000***	0.4053	0.2634	-5.77**
CADSEK	1	0.0000***	0.1711	0.9011	-4.62
AUDNZD	2	0.0000***	0.1328	0.0229**	-5.95**
AUDSEK	3	0.0000***	0.3530	0.0000***	-6.03***
NZDSEK	1	0.0000***	0.2004	0.6425	-5.71**
USDEUR	2	0.0000***	0.5313	0.0004***	-4.92
USDCHF	2	0.0000***	0.1919	0.3340	-5.57**
EURCHF	2	0.0000***	0.1306	0.0357**	-4.95

* significant at 10% level, ** significant at 5% level, *** significant at 1% level. P-values reported for the first three tests. Test statistic reported for the last test.

White Test for Heteroscedasticity:
$H_0: homoscedastic\ errors$
$H_1: heteroscedastic\ errors$

Breusch-Godfrey LM Test for serial correlation:
$H_0: no\ serial\ correlation$
$H_1: serial\ correlation$

Wald F-Test for weak exogeneity:
$H_0: no\ endogeneity$
$H_1: weak\ endogenity$

Gregory-Hansen test for cointegration with regime shifts:
$H_0: no\ cointegration$
$H_1: cointegration\ with\ regime\ shifts$
Critical values: 10%: -5.23; 5%: -5.50; 1%: -5.97.

4.4. Taylor Rule Deviations

Prior to the estimation of the threshold model, we need to obtain a measure of Taylor rule deviations. As already mentioned, the GMM method, which we use to estimate the Taylor rules, requires all variables to be stationary, wherefore we test the individual series for a unit root using the DF-GLS and KPSS tests. The results of these tests are reported in Table 5. As can be seen, the interest rate and real effective exchange rate series are integrated of order $I(1)$, whilst the inflation rate series and the output gap series are integrated of order $I(0)$ and $I(2)$ respectively.

Table 5. Unit Root Test Results for Individual Series Entering the Taylor Rule

		Level series		Differenced series	
		DF-GLS	**KPSS**	**DF-GLS**	**KPSS**
Interest Rates	UK	-2.193	2.64***	-4.678***	0.0911
	Canada	-2.092	1.0***	-6.613***	0.0657
	Australia	-0.880	4.9***	-4.820***	0.0918
	New Zealand	-2.049	2.94***	-5.188***	0.0821
	Sweden	-2.428	1.55***	-4.077***	0.0928
	US	-1.557	1.79***	-3.259***	0.0971
	Euro Area	-2.134	4.09***	-4.870***	0.0858
	Switzerland	-2.672	3.41***	-5.017***	0.0338
Inflation Rates	UK	-3.560***	1.42***	-4.834***	0.0558
	Canada	-4.352***	0.519***	-5.291***	0.0091
	Australia	-3.167**	1.65***	-4.630***	0.0243
	New Zealand	-3.919***	1.59***	-8.055***	0.0284
	Sweden	-3.497***	0.54***	-6.205***	0.0204
	US	-4.159***	0.329***	-6.339***	0.0201
	Euro Area	-3.333**	0.865***	-5.426***	0.0296
	Switzerland	-3.396**	0.544***	-6.557***	0.0251
Output Gap	UK	-2.299	3.86***	-0.932	5.86***
	Canada	-1.805	2.65***	-0.906	4.89***
	Australia	-0.471	2.66***	-1.939	1.42***
	New Zealand	-1.295	3.99***	-2.351	3.07***
	Sweden	-1.316	3.58***	-1.734	2.66***
	US	-0.674	3.84***	-1.619	3.72***
	Euro Area	-0.618	6.08***	-2.679	2.07***
	Switzerland	-2.121	5.03***	-1.891	4.21***
Real Effective Exchange Rates	UK	-1.618	4.32***	-4.991***	0.0758
	Canada	-1.654	4.47***	-3.773***	0.017
	Australia	-1.906	2.76***	-11.342***	0.0642
	New Zealand	-2.497	1.25***	-9.201***	0.0648
	Sweden	-2.593	1.56***	-6.511***	0.0482
	US	-1.637	3.56***	-5.051***	0.0989
	Euro Area	-2.010	2.32***	-11.045***	0.0991
	Switzerland	-1.706	4.81***	-4.887***	0.0715

*** significant at 1% level

DF-GLS: 1%: -3.452; 5%: -2.876; 10%: -2.570
H_0: variable contains a unit root
H_1: variable is stationary

KPSS: 1%: 0.216; 5%: 0.146; 10%: 0.119
H_0: variable is stationary
H_1: variable is not stationary

Therefore the $I(1)$ series are included in the GMM model in first differences and the $I(2)$ series are included in second differences. The results of the GMM Taylor rule estimations for the individual countries are reported in Tables 6a and 6b.

The optimal Taylor rule is selected by using the J-statistic of overidentifying restrictions. This turns out to be the extended Taylor rule in all cases except Switzerland, for which the classical Taylor rule is instead selected. Our findings are consistent with those of other studies, since the extended Taylor rule, which includes the real exchange rate, should provide a more accurate description of monetary policy than the classical rule in open-economy inflation targeting countries (Svensson, 2000). Next we calculate the Taylor rule deviations in a similar manner to Wilde (2012) and Nikolsko-Rzhevskyy et al. (2014), namely as the difference between the central bank interest rate and the target interest rate which is determined by the Taylor rule fundamentals.

Table 6a. GMM Results for Individual Taylor Rules in Countries with Alternative Monetary Regimes

		α	β	γ	δ	ρ
United States	Classical	9.349***	1.087***	-6.027***		
		(1.516)	(0.148)	(0.814)		
	Extended	0.626	1.236***	-4.897***	0.0591***	
		(1.751)	(0.148)	(0.737)	(0.00800)	
	Smoothing	0.138	0.0227	-9.599		0.976***
		(0.210)	(0.0261)	(0.118)		(0.00713)
Euro-Area	Classical	29.89***	1.000***	-3.076***		
		(1.571)	(0.110)	(0.151)		
	Extended	25.61***	0.921***	-3.116***	0.0501***	
		(1.836)	(0.0965)	(0.139)	(0.00868)	
	Smoothing	0.634	0.0372**	-6.848		0.971***
		(0.548)	(0.0183)	(0.559)		(0.0153)
Switzerland	**Classical**	8.371***	1.281***	-1.395***		
		(0.773)	(0.0471)	(0.130)		
	Extended	8.867***	1.290***	-1.615***	0.00772	
		(1.070)	(0.0476)	(0.345)	(0.0110)	
	Smoothing	0.346*	0.0574***	-5.907*		0.946***
		(0.202)	(0.0217)	(0.330)		(0.0161)

Standard errors in parentheses. Selected Taylor rule models in bold.
The instruments are the first lag of the inflation gap and the output gap. In the extended Taylor rule the first lag of the real exchange rate serves as an additional instrument and in the interest rate smoothing Taylor rule, the second lag of the interest rate serves as an additional instrument. We account for heteroscedasticity and autocorrelation by using Newey-West consistent errors. All models are exactly identified. Model selection according to the J-statistic.

Table 6b. GMM Results for Individual Taylor Rules in Inflation Targeting Countries						
		α	β	γ	δ	ρ
United Kingdom	Classical	30.92***	0.471***	-1.725***		
		(1.393)	(0.0746)	(0.769)		
	Extended	8.140***	0.733***	-1.000***	0.111***	
		(1.161)	(0.0440)	(0.511)	(0.00483)	
	Smoothing	0.227	-0.0236*	-1.000		0.989***
		(0.336)	(0.0127)	(0.187)		(0.00671)
Canada	Classical	19.60***	0.895***	-1.096***		
		(1.024)	(0.120)	(0.564)		
	Extended	21.35***	0.976***	-1.050***	-0.0303***	
		(1.034)	(0.120)	(0.568)	(0.00827)	
	Smoothing	0.540	-0.0413	-2.457		0.973***
		(0.416)	(0.0317)	(0.221)		(0.0125)
Australia	Classical	15.97***	1.005***	-1.065***		
		(0.607)	(0.0797)	(0.404)		
	Extended	11.96***	0.983***	-1.135***	0.0557***	
		(0.759)	(0.0639)	(0.370)	(0.00711)	
	Smoothing	0.288	-0.0273*	-1.177		0.977***
		(0.230)	(0.0163)	(0.153)		(0.0120)
New Zealand	Classical	11.78***	0.969***	-4.175***		
		(0.379)	(0.0934)	(0.135)		
	Extended	4.185***	0.967***	-5.455***	0.102***	
		(0.577)	(0.0869)	(0.151)	(0.00641)	
	Smoothing	0.381**	-0.0223	-1.126*		0.973***
		(0.175)	(0.0223)	(0.611)		(0.0124)
Sweden	Classical	31.18***	0.742***	-8.496***		
		(1.117)	(0.0396)	(0.305)		
	Extended	17.86***	0.585***	-7.236***	0.0898***	
		(2.144)	(0.0513)	(0.187)	(0.0177)	
	Smoothing	3.060	0.0721	-8.330		0.892***
		(2.392)	(0.0774)	(0.527)		(0.0908)

Standard errors in parentheses. Selected Taylor rule models in bold.
The instruments are the first lag of the inflation gap and the output gap. In the extended Taylor rule the first lag of the real exchange rate serves as an additional instrument and in the interest rate smoothing Taylor rule, the second lag of the interest rate serves as an additional instrument. We account for heteroscedasticity and autocorrelation by using Newey-West consistent errors. All models are exactly identified. Model selection according to the J-statistic.

4.5. Nonlinearity Tests

The results of the threshold-type nonlinearity tests (both the sup-Wald and the Bai-Perron tests) are reported in Table 7. In all cases a single threshold is identified and therefore there exist two regimes characterised respectively by small and large Taylor rule deviations. The estimated coefficients indicate that there is a significant error correction mechanism only in the inflation equations and therefore we focus on the differences in the adjustment speed only in this case. This finding suggests that, while there is a connection between goods and asset markets, the adjustment occurs only in the former.

Table 7. Nonlinearity Test and Model Selection				
	Threshold variable	**Lag**	**sup-Wald Test**	**Bai-Perron Threshold Test**
GBPCAD	UK Taylor rule deviation	3	0.0000***	36.66**
	CA Taylor rule deviation	3	0.0000***	69.80**
GBPAUD	UK Taylor rule deviation	3	0.0000***	27.71**
	AU Taylor rule deviation	3	0.0000***	37.08**
GBPNZD	UK Taylor rule deviation	3	0.0000***	39.93**
	NZ Taylor rule deviation	3	0.0000***	58.77**
GBPSEK	UK Taylor rule deviation	3	0.0000***	47.77**
	SE Taylor rule deviation	3	0.0000***	34.61**
CADAUD	CA Taylor rule deviation	3	0.0000***	39.68**
	AU Taylor rule deviation	3	0.0000***	37.97**
CADNZD	CA Taylor rule deviation	3	0.0000***	44.83**
	NZ Taylor rule deviation	3	0.0000***	37.88**
CADSEK	CA Taylor rule deviation	3	0.0000***	31.99**
	SE Taylor rule deviation	3	0.0000***	32.37**
AUDNZD	AU Taylor rule deviation	3	0.0000***	96.64**
	NZ Taylor rule deviation	3	0.0000***	43.66**
AUDSEK	AU Taylor rule deviation	3	0.0000***	37.03**
	SE Taylor rule deviation	3	0.0000***	51.11**
NZDSEK	NZ Taylor rule deviation	3	0.0000***	41.06**
	SE Taylor rule deviation	3	0.0000***	33.73**
USDEUR	US Taylor rule deviation	3	0.0000***	34.20**
	EU Taylor rule deviation	3	0.0000***	27.19**
USDCHF	US Taylor rule deviation	3	0.0000***	49.81**
	CH Taylor rule deviation	3	0.0000***	61.98**
EURCHF	EU Taylor rule deviation	3	0.0000***	32.76**
	CH Taylor rule deviation	3	0.0000***	29.24**

UK = United Kingdom; CA = Canada; AU = Australia; NZ = New Zealand; SE = Sweden; US = United States; EU = Euro Area; CH = Switzerland

Sup-Wald test hypothesis:
H_0: $linear\ error\ correction$
H_1: $threshold\ error\ correction$

Bai-Perron 5% Critical Value for Threshold Test: 27.03
H_0: $zero\ thresholds$
H_1: $one\ threshold$

Table 8 reports the threshold value for each model along with the adjustment coefficient in the inflation equation for both regimes, where regime one and two correspond respectively to small and large Taylor rule deviations. It can be seen that the adjustment speed is twice as fast in the former (when Taylor rule deviations are small) compared to the latter (when Taylor rule deviations are large). For some models, the adjustment only occurs with small Taylor rule deviations, i.e. the error correction coefficient is only significant in regime one. When Taylor rule deviations are small between 6% and 41% of any deviations from the PPP- and UIP-implied equilibrium is corrected within one month; the corresponding percentages for large Taylor rule deviations are 6% and 21%. It would appear that small Taylor rule deviations are seen by agents as pointing to temporary monetary policy discretion, while large deviations are perceived as an indication of a permanent shift in monetary policy (Neuenkirch and Tillmann, 2014; Kahn, 2010), which lowers the adjustment speed to PPP and UIP.

Table 8. Differences in Adjustment Speed Between Regimes in the Inflation Equation

	Threshold variable d_t	Threshold Value γ	θ in Regime 1	θ in Regime 2
GBPCAD	UK Taylor rule deviation	-0.7806	-0.3143***	-0.1117***
	CA Taylor rule deviation	-0.6977	-0.4083***	-0.0649
GBPAUD	UK Taylor rule deviation	1.2467	-0.0784***	-0.0687
	AU Taylor rule deviation	-0.4828	-0.0762	-0.0742**
GBPNZD	UK Taylor rule deviation	0.6558	-0.0614*	-0.2092
	NZ Taylor rule deviation	0.2724	-0.1778***	0.0156
GBPSEK	UK Taylor rule deviation	-1.2101	-0.2131***	-0.0669**
	SE Taylor rule deviation	-0.9102	-0.2203***	-0.0132
CADAUD	CA Taylor rule deviation	-0.4582	-0.4100***	-0.1524***
	AU Taylor rule deviation	-0.3214	-0.2370**	-0.2196***
CADNZD	CA Taylor rule deviation	-0.6514	-0.3437***	-0.0535
	NZ Taylor rule deviation	-0.8776	-0.3761***	-0.0555
CADSEK	CA Taylor rule deviation	-1.5045	-0.3253***	-0.1450***
	SE Taylor rule deviation	-0.1495	-0.2070**	-0.1291**
AUDNZD	AU Taylor rule deviation	1.0051	-0.1084***	-0.0028
	NZ Taylor rule deviation	-0.5349	-0.2195***	-0.0200
AUDSEK	AU Taylor rule deviation	-0.4861	-0.1000	-0.1866***
	SE Taylor rule deviation	-0.1639	-0.3103***	-0.0665*
NZDSEK	NZ Taylor rule deviation	-1.2343	-0.1936**	-0.1023***
	SE Taylor rule deviation	-0.1589	-0.2770***	-0.0391
USDEUR	US Taylor rule deviation	-0.1473	-0.0689	-0.0771
	EU Taylor rule deviation	0.8818	-0.1015**	0.3329
USDCHF	US Taylor rule deviation	0.2033	-0.0972**	-0.0870**
	CH Taylor rule deviation	1.0755	-0.1306***	0.1241
EURCHF	EU Taylor rule deviation	0.6664	-0.0929**	-0.1420
	CH Taylor rule deviation	0.6913	-0.2456***	-0.0671

Threshold value γ with d_t as the threshold variable.
$\boldsymbol{\theta}$ = adjustment coefficient in the inflation equation.
UK = United Kingdom; CA = Canada; AU = Australia; NZ = New Zealand; SE = Sweden; US = United States; EU = Euro Area; CH = Switzerland

In inflation targeting countries, the adjustment in the small Taylor rule deviations regime is more than twice as fast as in non-targeting ones – more precisely, between 6% and 41% of any deviations from the PPP- and UIP-implied equilibrium is corrected within one month, the corresponding percentages for non-targeting economies being 6% and 24%.

Finally, we check the adequacy of the nonlinear models by testing for serial correlation and heteroscedasticity. The results of these tests are reported in Table 9 and confirm the data congruency of the nonlinear models.

Table 9. Diagnostic Tests for the Nonlinear Model			
	Threshold variable	**Breusch-Godfrey Test for Serial Correlation**	**Breusch-Pagan Test for Heteroscedasticity**
GBPCAD	UK Taylor rule deviation	0.5097	0.1497
	CA Taylor rule deviation	0.7554	0.1924
GBPAUD	UK Taylor rule deviation	0.1933	0.2215
	AU Taylor rule deviation	0.4888	0.5948
GBPNZD	UK Taylor rule deviation	0.0624	0.4208
	NZ Taylor rule deviation	0.8720	0.8064
GBPSEK	UK Taylor rule deviation	0.3121	0.1202
	SE Taylor rule deviation	0.1047	0.0010***
CADAUD	CA Taylor rule deviation	0.3476	0.5688
	AU Taylor rule deviation	0.6826	0.4962
CADNZD	CA Taylor rule deviation	0.4125	0.7766
	NZ Taylor rule deviation	0.3252	0.9309
CADSEK	CA Taylor rule deviation	0.5078	0.3709
	SE Taylor rule deviation	0.9002	0.9994
AUDNZD	AU Taylor rule deviation	0.1392	0.6479
	NZ Taylor rule deviation	0.7432	0.9984
AUDSEK	AU Taylor rule deviation	0.1001	0.9815
	SE Taylor rule deviation	0.9237	0.7708
NZDSEK	NZ Taylor rule deviation	0.8747	0.8699
	SE Taylor rule deviation	0.3778	0.8394
USDEUR	US Taylor rule deviation	0.8456	0.9182
	EU Taylor rule deviation	0.4092	0.0108**
USDCHF	US Taylor rule deviation	0.4872	0.0000***
	CH Taylor rule deviation	0.1998	0.7473
EURCHF	EU Taylor rule deviation	0.9009	0.7772
	CH Taylor rule deviation	0.4470	0.4451

Breusch-Godfrey LM Test for serial correlation:
H_0: *no serial correlation*
H_1: *serial correlation*

Breusch-Pagan LM Test for heteroscedasticity:
H_0: *homoscedasticity*
H_1: *heteroscedasticity*

5. Conclusions

The aim of this paper is to provide new evidence on the empirical validity of PPP and UIP by taking into account possible nonlinearities and also investigating the role of Taylor rule deviations under alternative monetary policy frameworks. The analysis is conducted using monthly data from January 1993 to December 2020 for five countries that have adopted inflation targeting (the UK, Canada, Australia, New Zealand and Sweden) and also three economies with other monetary regimes (the US, the Euro-Area and Switzerland). Both a benchmark linear VECM and a nonlinear Threshold VECM are estimated; the latter includes Taylor rule deviations as the threshold variable.

The results can be summarised as follows. First, taking into account nonlinearities provides much stronger evidence for the PPP and UIP conditions. In particular, the dynamic adjustment towards equilibrium, which only occurs in the inflation equations, is more than twice as fast compared to the linear case and the joint goods and asset market equilibrium is reinstated through an adjustment taking place in the goods market only. Second, Taylor rule deviations play an important role: the adjustment speed is twice as fast when they are small and are perceived as temporary departures from the monetary policy rule, large deviations being interpreted instead as an indication of permanent shifts in monetary policy. This finding is consistent with those of previous studies (Neuenkirch and Tillmann, 2014; Kahn, 2010), and implies that the credibility of the central bank has an impact on the exchange rate path. Third, the evidence is more supportive of the PPP and UIP parities in inflation targeting countries, where the speed of adjustment towards the long-run equilibrium is twice as fast compared to non-targeting economies. This suggests that, irrespective of the size of Taylor rule deviations, the inflation targeting framework tends to generate a higher degree of credibility for monetary authorities thereby reducing deviations of the exchange rate from the PPP- and UIP-implied equilibrium.

References

Álvarez, L.J. and Gómez-Loscos, A., 2018. A menu on output gap estimation methods. *Journal of Policy Modeling*, *40*(4), pp.827-850.

Andrews, D.W. and Lu, B., 2001. Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models. *Journal of Econometrics*, *101*(1), pp.123-164.

Backus, D.K., Gavazzoni, F., Telmer, C. and Zin, S.E., 2010. *Monetary policy and the uncovered interest parity puzzle* (No. w16218). National Bureau of Economic Research.

Bai, J. and Perron, P., 2003. Computation and analysis of multiple structural change models. *Journal of Applied Econometrics*, *18*(1), pp.1-22.

Balke, N.S. and Fomby, T.B., 1997. Threshold cointegration. *International Economic Review*, pp.627-645.

Beckmann, J. and Wilde, W., 2013. Taylor rule equilibrium exchange rates and nonlinear mean reversion. *Applied Financial Economics*, *23*(13), pp.1097-1107.

Biswas, R., Piccotti, L.R. and B.Z. Schreiber, 2020. Differential risk premiums and the UIP puzzle. *Financial Management*, 50, 1, 139-167.

Camarero, M. and Tamarit, C., 1996. Cointegration and the PPP and the UIP hypotheses: An application to the Spanish integration in the EC. *Open Economies Review*, *7*(1), pp.61-76.

Canterbery, E.R., 2000. Rational bubbles and uncovered interest-rate parity: retrospective and prospective. *Editorial Policy*, *1*(2000), pp.167-178.

Caporale, G.M., Kalyvitis, S. and Pittis, N., 2001. Testing for PPP and UIP in an FIML framework: Some evidence for Germany and Japan. *Journal of Policy Modeling*, *23*(6), pp.637-650.

Cecchetti, S.G. and Ehrmann, M., 1999. *Does inflation targeting increase output volatility? An international comparison of policymakers' preferences and outcomes* (No. w7426). National Bureau of Economic Research.

Chinn, M.D. and Quayyum, S., 2012. *Long horizon uncovered interest parity re-assessed* (No. w18482). National Bureau of economic research.

Clarida, R., Gali, J. and Gertler, M., 1998. Monetary policy rules in practice: Some international evidence. *European Economic Review*, *42*(6), pp.1033-1067.

Clarida, R., Gali, J. and Gertler, M., 2000. Monetary policy rules and macroeconomic stability: evidence and some theory. *The Quarterly Journal of Economics*, *115*(1), pp.147-180.

Cumby, R.E. and Obstfeld, M., 1981. A note on exchange-rate expectations and nominal interest differentials: A test of the Fisher hypothesis. *The Journal of Finance*, *36*(3), pp.697-703.

Diebold, F.X., Husted, S. and Rush, M., 1991. Real exchange rates under the gold standard. *Journal of Political Economy*, *99*(6), pp.1252-1271.

Ford, N. and Horioka, C.Y., 2017. The 'real'explanation of the PPP puzzle. *Applied Economics Letters*, *24*(5), pp.325-328.

Gregory, A.W., 1987. Testing interest rate parity and rational expectations for Canada and the United States. *Canadian Journal of Economics*, pp.289-305.

Hakkio, C.S., 1984. A re-examination of purchasing power parity: A multi-country and multi-period study. *Journal of International Economics*, *17*(3-4), pp.265-277.

Holmes, M.J. and Maghrebi, N., 2004. Asian real interest rates, nonlinear dynamics, and international parity. *International Review of Economics & Finance*, *13*(4), pp.387-405.

Hunter, J., 1992. Tests of cointegrating exogeneity for PPP and uncovered interest rate parity in the United Kingdom. *Journal of Policy Modeling*, *14*(4), pp.453-463.

Jaramillo, M. and Serván, S., 2012. Modeling exchange rate dynamics in Peru: A cointegration approach using the UIP and PPP. *SBS Documents de Trabajo*.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, pp.1551-1580.

Johansen, S. and Juselius, K., 1992. Testing structural hypothesis in a multivariate cointegration analysis of the PPP and the UIP for UK. *Journal of Econometrics,* 53, 211-244.

Juselius, K., 1995. Do purchasing power parity and uncovered interest rate parity hold in the long run? An example of likelihood inference in a multivariate time-series model. *Journal of Econometrics*, *69*(1), pp.211-240.

Kahn, G.A., 2010. Taylor rule deviations and financial imbalances. *Federal Reserve Bank of Kansas City Economic Review, Second Quarter*, *2010*, pp.63-99.

Kapetanios, G., Shin, Y. and Snell, A., 2003. Testing for a unit root in the nonlinear STAR framework. *Journal of Econometrics*, *112*(2), pp.359-379.

Kim, Y., 1990. Purchasing power parity in the long run: A cointegration approach. *Journal of Money, Credit and Banking*, *22*(4), pp.491-503.

Kim, H., Fujiwara, I., Hansen, B.E. and M. Ogaki, 2014. Purchasing Power Parity and the Taylor Rule. *Journal of Applied Econometrics*, 30. 6, 874-903.

Li, D., Ghoshray, A. and Morley, B., 2012. Measuring the risk premium in uncovered interest parity using the component GARCH-M model. *International Review of Economics & Finance*, *24*, pp.167-176.

Londono, J.M. and Zhou, H., 2017. Variance risk premiums and the forward premium puzzle. *Journal of Financial Economics*, *124*(2), pp.415-440.

MacDonald, R., 1985. Do deviations of the real effective exchange rate follow a random walk?. *Economic Notes*, pp.63-70.

McNown, R. and Wallace, M.S., 1990. Cointegration tests of purchasing power parity among four industrial countries: results for fixed and flexible rates. *Applied Economics*, *22*(12), pp.1729-1737.

Mishkin, F.S. and Schmidt-Hebbel, K., 2001. *One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?* (No. w8397). National Bureau of Economic Research.

Murray, C.J. and Papell, D.H., 2005. The purchasing power parity puzzle is worse than you think. *Empirical Economics*, *30*(3), pp.783-790.

Mylonidis, N. and Semertzidou, M., 2010. Uncovered interest parity puzzle: does it really exist?. *Applied Economics Letters*, *17*(10), pp.1023-1026.

Neuenkirch, M. and Tillmann, P., 2014. Inflation targeting, credibility, and non-linear Taylor rules. *Journal of International Money and Finance*, *41*, pp.30-45.

Neumann, M.J. and Von Hagen, J., 2002. *Does inflation targeting matter?* (No. B 01-2002). ZEI working paper.

Nikolsko-Rzhevskyy, A., Papell, D.H. and Prodan, R., 2014. Deviations from rules-based policy and their effects. *Journal of Economic Dynamics and Control*, *49*, pp.4-17.

Obstfeld, M., 1987. *Peso problems, bubbles, and risk in the empirical assessment of exchange-rate behavior* (No. w2203). National Bureau of Economic Research.

Sarno, L. and Chowdhury, I., 2003. The behaviour of the real exchange rate: evidence from an alternative price index. *Economic Notes*, *32*(3), pp.295-333.

Sarno, L., Valente, G. and Leon, H., 2006. Nonlinearity in deviations from uncovered interest parity: an explanation of the forward bias puzzle. *Review of Finance*, *10*(3), pp.443-482.

Seo, M.H., 2008. Unit root test in a threshold autoregression: asymptotic theory and residual-based block bootstrap. *Econometric Theory*, pp.1699-1716.

Svensson, L.E., 2000. Open-economy inflation targeting. *Journal of International Economics*, *50*(1), pp.155-183.

Taylor, M.P., 1988. An empirical examination of long-run purchasing power parity using cointegration techniques. *Applied Economics*, *20*(10), pp.1369-1381.

Taylor, M.P., 1987. Risk premia and foreign exchange: a multiple time series approach to testing uncovered interest-rate parity. *Weltwirtschaftliches Archiv*, *123*(4), pp.579-591.

Taylor, M.P., 1992. Dollar-sterling exchange rate in the 1920s: purchasing power parity and the Norman conquest of $4.86. *Applied Economics*, *24*(8), pp.803-811.

Taylor, M.P., Peel, D.A. and Sarno, L., 2001. Nonlinear mean-reversion in real exchange rates: toward a solution to the purchasing power parity puzzles. *International Economic Review*, 42(4), pp.1015-1042.

Tsay, R.S., 1989. Testing and modeling threshold autoregressive processes. *Journal of the American Statistical Association*, *84*(405), pp.231-240.

Wilde, W., 2012. The influence of Taylor rule deviations on the real exchange rate. *International Review of Economics & Finance*, *24*, pp.51-61.