Real interest rate parity in OECD countries: New evidence from time series and panel cointegration techniques

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We examine the existence of real interest rate parity (RIRP) for a number of OECD countries. Using time series techniques, we manage to identify cointegrating relationships. For a subset of counties our findings suggest the existence of a structural break. The panel results also are in favour of the RIRP.

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I. Introduction

This paper aims to contribute to the empirical investigation of one of the main building blocks of modern macroeconomics; that is, the real interest parity condition (hereafter RIRP). It is an issue of great importance, since the rapid changes that took place in the international markets the last three decades (deregulation, capital market openness, abolishment of restrictions on capital flows around the world and so on) have greatly affected markets' functioning and, as a result, the kind of policy prescriptions that have to be followed by monetary authorities.

According to theory, if we assume that PPP and UIRP hold, this will lead to a convergence of real interest rates; that is, $r_t = r_t^*$, where the r_t^* denotes the real interest rate of the benchmark economy. In the recent empirical work, there are two main paths followed in the RIRP examination. First, a great number of studies examine the existence of real interest rate parity looking into the stationarity properties of the real interest rate differentials through the employment of unit root and stationarity tests[1]. The results are rather mixed.

On the other hand, a methodological framework that has also been used is based on the existence of a comovement between r_t and r_t^*. More precisely, assuming the general form

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

between real interest rates, several cointegration techniques have been applied so as to examine whether such a relation holds. Evidently, the strict form of RIRP requires that $\beta = 1$; that is parity condition. Johansen's technique has been the most popular

[1] Some representative papers from this strand of the literature are the ones from Ferreira and Leon-Ledesma (2007), Arghyrou *et al.* (2009), Maveyraud-Tricoire and Rous (2009) and Su et al. (2012).

approach here[2]. With the aim of gaining statistical power, Jenkins and Madzharova (2008) perform panel cointegration tests for the EU-15 countries without finding any evidence of RIPR. Interestingly, they characterize their results quite strange since the European financial markets are open, putting emphasis on the fact that 12 economies of their sample share the same currency and, thus, a common monetary policy. An attempt to consider structural break in the cointegration equation is made by Wu and Fountas (2000) who find that the real interest rates of seven European economies converge to the German one. Also, the same is true for the G-7 economies using the US as the reference country. An alternative approach is to take into account possible asymmetries. Holmes and Maghrebi (2006) employ the momentum threshold autoregressive (MTAR) model for eight OECD countries with respect to the US, finding that positive deviations from the long run equilibrium are eliminated faster than negative ones.

Willing to contribute to this field of research, we proceed to an econometric investigation of the ex-ante version of RIRP, examining whether real interest rates of seventeen OECD countries co-move in the long run with the US real interest rate. Additionally, we employ the test proposed by Carrion-i-Silvestre and Sanso (2006) to identify a potential structural break in the cointegrating equations under investigation. To our knowledge, this is the first paper utilizing this test, in order to examine for potential breaks on RIRP model. Apart from examining individual countries, we employ Westerlund (2007) panel cointegration test, to examine the countries sample as a panel.

The remainder of the paper is organized as follows: Section 2 describes the methodology applied for the analysis. Section 3 discusses the data used in this piece of work, together with the empirical findings. Section 4 concludes.

[2] See, among others, Monadjemi (1998) and Chung and Crowder (2004).

II. Econometric Methodology

One of the crucial issues concerning the RIRP is the calculation of the real interest rates. Given that the real interest rate is the nominal interest rate minus the expected inflation,

$$r_t = i_t - E_t(\pi_{t+i}) \quad (2)$$

it becomes evident that the measurement of the inflation expectations needs special attention. Here, we measure expected inflation calculating forecasts from a Markov Switching model. Specifically, we use 12-step ahead forecasts from a Markov switching model; that is,

$$r_t = i_t - E_t\pi_{t+12} \quad (3)$$

The choice for this method has driven from the fact that the resulting Markov switching estimates have the advantage that they incorporate the process of agents' learning when making the forecasts[3]. This constitutes other methods based on forecasts from AR models quite naïve. Moreover, there are not available reported forecasts for the majority of the examined economies.

The first step is to examine the stationarity properties of the real interest rates series. We perform the Elliot *et al.* (1996) unit root tests. The results suggest that all the series have one unit root. As a robustness check we also apply the stationarity test proposed by Kwiatkowski *et al.* (1992). In this case, we reject the null of stationarity. Thus, both testing procedures lead to the same conclusion; the series are I(1)[4]. Next we examine the existence of cointegration. Specifically, we examine the comovement

[3] The estimatios were performed in Krolzig's code written in Ox.

[4] To save space, we do not show the results but they are available upon request.

between the real interest rates of 17 OECD economies and the US real interest rate[5]. This is done through the Johansen technique.

For the cases that there is no evidence of cointegration we perform the Carrion-i-Silvestre and Sanso (2006) test in order to examine the possible existence of a structural break. Specifically, this test is a multivariate extension of KPSS test and examines the null of cointegration under a break in the parameters of the cointegrating vector (including the deterministic components of the vector) against the alternative of no cointegration. The break can be consider either as given or treated as unknown. In the latter case, Carrion-i-Silvestre and Sanso propose to estimate using the algorithm of Bai and Perron (1998, 2003). We choose to consider the break as unknown and to endogenously estimate it. Without assuming trend in the deterministic components, we estimate the following equation using DOLS:

$$r_t = a + \theta DU_t + \beta_1 r_t^* + \beta_2 r_t^* DU_t + \sum_{j=-k}^{k} \gamma_j \Delta r_t^* + \varepsilon_t \qquad (4)$$

where DU_t is a dummy that takes the value of zero before the break and one after the break. Then, we compute the test statistic as;

$$SC(\lambda) = T^{-2}\hat{\omega}^{-2}\sum_{t=1}^{T}(S_t)^2 \qquad (5)$$

where $\hat{\omega}$ is a consistent estimator of the long-run variance of ε_t using the estimated residuals $\hat{e}_t$ and $S_t = \sum_{t=1}^{T}\hat{e}_t$.

As a final step we perform the panel cointegration tests proposed by Westerlund (2007). The testing procedure is based on the estimation of an error correction model

[5] The examined counties are: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Luxemburg, Netherlands, Portugal, Spain, Sweden, Switzerland and UK.

and examines whether the coefficient of the error correction term is equal to zero. Specifically,

$$\Delta r_{it} = a + \psi_i r_{i,t-1} + \beta_i r^*_{i,t-1} + \sum_{j=1}^{p} \psi_{ij} \Delta r_{i,t-j} + \sum_{j=-q}^{q} \mu_{ij} \Delta r^*_{i,t-j} + u_{i,t} \qquad (6)$$

If $\psi_i = 0$, then there is not error correction term, and, thus, there is no cointegration. If the null of no error correction is rejected, then the null of no cointegration is also rejected. The first two tests ("group-mean"tests) G_t and G_α, do not require ψ_i to be equal for all panels. On the other hand, the last two tests ("panel" tests) P_t and P_α, assume that ψ_i is equal for all *i*s. The test is normally distributed. However, in order to capture possible cross-sectional dependencies among our variables we also provide the bootstrap values.

III. Data and Empirical Results

We use the 10-year government bonds as nominal rates and the CPI-index for the inflation rates. The frequency is monthly and covers the period 1977:01-2010:03. All data are collected from the IMF-IFS database. Table 1 shows the results from Johansen cointegration test. Particularly, we report the ten countries for which the null of no cointegration is rejected; i.e. there is one cointegrating equation. In the second column, the trace statistic is shown. The optimal number of lags is depicted in the third column. The inference based on max-eigenvalue statistic concludes to the same results. For this reason we skip it. For six of these ten countries, the parity condition seems to be hold at 5%. This can be viewed in the last column where the LR-test restriction that $\beta = 1$ is reported.

For the rest seven countries we perform the Carrion-i-Silvestre and Sanso test. The results are shown in Table 2. For Belgium, Denmark, Luxemburg and Netherlands the null hypothesis of cointegration with one structural break is accepted at 5%. On contrary for Austria, France and Germany the null is rejected and there is no evidence for cointegration. The values and the corresponding break dates are reported in the second and third column, respectively. For the four countries that there is one break we, subsequently, perform Johansen test for the sample periods before and after the breaks. For all the cases, cointegration found to be hold only for the period after the break, as it is evident in the fourth column. Lastly, at 5% level the parity condition holds for three counties. The final step is to perform the four panel tests developed by Westerlund (2007). As shown in Table 3 the null of no cointegration is strongly rejected using either the normal or the bootstrap distribution.

IV. Conclusions

We provide evidence in favour of RIRP. For ten economies the cointegration of real interest rates hold for the whole period. For four countries our finding suggests a break in the cointegrating relation, while only for three economies there is not such evidence. Taking the advantages of the increased power using panel data, the null of no cointegration is strongly rejected suggesting that RIRP is hold.

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Tables

Table 1. Johansen Cointegration Tests

Country	Trace test[a]	Lags[b]	LR test[c]
Canada	24.864*** (0.011)	11	0.766
Finland	27.102*** (0.005)	11	0.000***
Italy	24.507*** (0.012)	3	0.982
Japan	18.670* (0.082)	12	0.123
Korea	23.829*** (0.016)	11	0.312
Portugal	30.521*** (0.005)	8	0.013**
Spain	30.540*** (0.001)	3	0.179
Sweden	27.457*** (0.004)	9	0.045**
Switzerland	32.079*** (0.001)	11	0.001***
UK	23.803*** (0.017)	12	0.082*

Notes: [a]Values of the trace statistic. The numbers in parentheses are the p-values according to MacKinnon, Haug and Michelis (1999).
[b]The optimal number of lags is chosen according to the sequential modified Lakilihood Ratio test statistic.
[c]p-values of the LR test for parity restriction (Ho: β=1).
***,**,* indicate statistical significance at 1%, 5% and 10%, respectively.

Table 2. Test for break in the Cointegration Equations

Country	Break test[a]	Break date[b]	Sample[c]	Trace test	Lags	LR test
Austria	0.180**	-	-	-	-	-
Belgium	0.119	1996m7	1996m8-2010m3	18.360* (0.089)	12	0.570
Denmark	0.130	1996m7	1996m8-2010m3	20.810*** (0.042)	3	0.190
France	0.316***	-	-	-	-	-
Germany	0.199**	-	-	-	-	-
Luxemburg	0.153	1986m1	1986m2-2010m3	34.106*** (0.000)	12	0.047**
Netherlands	0.112	1996m11	1996m12-2010m3	20.262*** (0.004)	1	0.356

Notes: a: values of Carrion-i-Sylvestre and Sanso's (2006) test. Critical values are taken from Table 2 of their paper.
b: The break is endogenously estimated.
c: Sample period for which there is evidence for cointegration.
*** and ** indicate statistical significance at 1% and 5%, respectively

Table 3. Panel Cointegration Tests

Test	value[a]	p-value[b]	Bootstrap p-value[c]
G_t	-3.151	0.000	0.000
G_a	-17.152	0.000	0.000
P_t	-12.795	0.000	0.000
P_a	-15.467	0.000	0.000

aThe tests are fitted with a constant and three lags and leads. The kernel bandwidth is set according to the rule $4(T/100)^{2/9}$.

b The p-values are for a one-sided test based on the normal distribution

c The p-values are for a one-sided test based on 500 bootstrap replications.