Department of
Economics and Finance

1. Introduction

Interest rate linkages have been analysed in numerous empirical studies. There are two main ways to interpret them (see Barassi et al., 2005). If interest rates are viewed as similar to other asset prices, then financial flows should be their main determinant. In particular, the uncovered interest parity condition (or the open arbitrage condition) implies that interest rate differentials should equal the (expected) change in exchange rates. Therefore if exchange rates are at most I(1) series (a common finding in the literature for the G-7), and if the risk premium is stationary, one should find that interest rates are cointegrated on a bilateral basis. It is noteworthy that in recent years many countries have liberalized their capital accounts, and therehas been a shift in capital flows towards portfolio and other short-term flows. Cross-border capital flows have risen in search of higher yields given the low interest rates resulting from a global liquidity surplus. It has been suggested that these recent developments in international financial markets and their increasing globalization might have led to interest rate convergence.

By contrast, if interest rates are seen as policy instruments, policy objectives should be their main driving factor, and therefore co-movement should result from policy convergence.A key question is the extent to which domestic monetary authorities can still conduct an independent interest rate policy despite the fact that international financial markets have become increasingly integrated. Another important issue is whether the creation of EMU and the role of the euro as an international currency has resulted in the Eurozone having a more global role.

The present study focuses on central bank policy rates in the US, Japan, the Eurozone, the UK, Canada and Australia, and makes a twofold contribution. First, it applies long-memory techniques to provide evidence on the stochastic properties (in particular, the degree of persistence) of the interest rates series. Second, it examines their long-run linkages on a bilateral basis using a cointegration approach. Unlike the majority of earlier studies, it adopts a *fractional* integration/cointegration framework that is much more general than the standard approach based on the I(0)/I(1) dichotomy since it allows for fractional values of the integration/cointegration parameter and therefore does not impose restrictive assumptions on the dynamic behaviour of the individual series and their linkages.

The structure of the paper is as follows: Section 2 provides a brief review of the empirical literature on interest rates, focusing specifically on the stationarity/nonstationariy debate and its relation to fractional integration and cointegration; Section 3 outlines the empirical methodology; Section 4 describes the data and the main empirical findings; Section 5 offers some concluding remarks.

2. Are Interest Rates Stationary?

The statistical properties of interest rates have been extensively analysed in the literature. Earlier studies usually focusedst(8.55( )/ ET3080( ) 594.5O 0rn4-181(v06)-179(foc)7(used)46 Th-9(tens[th)-11(e)4( )-

degree of integration to be between 0 and 1, as well as above 1. This is particularly useful for series which, although mean-reverting, might exhibit long memory and therefore be characterised by a high degree of persistence. For example, Shea (1991) investigated the consequences of long memory in interest rates for tests of the expectations hypothesis of the term structure; he found that that allowing for long memory and fractional integration can significantly improve the performance of the model, even though the expectations hypothesis cannot be fully resurrected. In a related study, Backus and Zin (1993) reported that the volatility of bond yields does not decline exponentially when the maturity of the bond increases; in fact, they noticed that the decline is hyperbolic, which is consistent with a fractionally integrated specification. Lai (1997) provided evidence based on semi-parametric methods that ex-ante and ex-post US real interest rates are fractionally integrated. Tsay (2000) employed an Autoregressive Fractionally Integrated Moving Average (ARFIMA) model to show that US real interest rates can be described as an I(d) process. Further evidence can be found in Barkoulas and Baum (1997), Tkacz (2001), Meade and Maier (2003), Sun and Phillips (2004), Gil-Alana (2004a, b), and Karanasos, Sekioua and Zeng (2006). Couchman, Gounder and Su (2006) estimated ARFIMA models for ex-post and ex-ante interest rates in sixteen countries. Their results suggest that, for the majority of countries, the fractional differencing parameter lies between 0 and 1, and is considerably smaller for the ex-post than for the ex-ante real rates.

Fractional cointegration tests have also been employed in recent studies. Lardic and Mignon (2003) tested for fractional cointegration between nominal interest rates and inflation under the assumption that both individual series were I(1). They tested this hypothesis with standard unit root procedures (Dickey-Fuller, ADF, 1979; Phillips-Perron, PP, 1988; and the Kwiatkowski t na nominal interest rates and found evidence of long memory in the differenced series. Mean reversion in nominal rates was reported for Asian and emerging countries respectively in Gil-Alana (2004a) and Candelon and Gil-Alana (2006).

3. Fractional integration and Cointegration

As already mentioned, a fractional integration

The same happens with (weakly) autocorrelated errors: the unit root null hypothesis is rejected in all cases in favor of d > 1 except for Japan (d = 1.07); in the other cases, d ranges between 1.39 (US) and 1.66 (Australia).

[Insert Table 3 about here]

We alsoemploy a semi-parametric approach based on a "local" Whittle estimate that degenerates to zero (Robinson, 1995a). We report in Table 3 the values of d for a selected number of bandwidth parameters from m = 10 to 20. Focusing on those where m is approximately $(T)^{0.5}$, i.e., 12 and 13 one can see that the unit root null cannot be rejected for Australia, Japan and the UK, whilst it is in the remaining cases in favor of higher degrees of integration. Similar results were obtained using the extension of this method as in Abadir et al. (2007).On the whole, the univariate results indicate a high degree of persistence, with orders of integration equal to or higher than 1 in all cases, which implies that shocks have permanent effects.

[Insert Tables4and 5 about here]

Next we carry out the bivariate analysis. Tables 4 and 5 report the statistics of Robinson and Yajima (2003) for the equality in the order of integration using respectively m =12 and m = 13 as the bandwidth parameters: Australia displays the same degree of integration as Japan (with m = 12)4().)TJETBT1hr quite small (around 0.2-0.3 with respect to the parent series), indicating slow mean reversionin the dynamic adjustment towards the long-run equilibrium.

5. Conclusions

developments in the Eurozone, since linkages are found only with Australian rates; it is the UK instead that appears to have a more global role, perhaps because of the size of its financial sector.

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Table 4: Homogeneity condition tests (Robinson and Yajima, 2002)

m = 12	CANADA	EUROZONE	JAPAN	U.K.	U.S.A.

Table 6: Testing the null hypothesis of no cointegration against fractional cointegration

m = 12	EUROZONE	JAPAN	U.K.	U.S.A.
AUSTRALIA	**H_{10}: 5.529** **H_{20}: 17.833** **$d_1 = 1.089$** **$d_2 = 1.280$** **$d_* = 0.849$**	H_{10}: 2.645 H_{20}: 1.190 $d_1 = 1.089$ $d_2 = 1.067$ $d_* = 0.923$	H_{10}: **8.697** **H_{20}: 14.978** **$d_1 = 1.089$** **$d_2 = 1.183$** **$d_* = 0.788$**	xxxxx
CANADA	H_{10}: 2.973 H_{20}: 2.074 $d_1 = 1.309$ $d_2 = 1.280$ $d_* = 1.133$	xxxxx	**H_{10}: 27.374** **H_{20}: 15.980** **$d_1 = 1.309$** **$d_2 = 1.183$** **$d_* = 0.775$**	**H_{10}: 21.660** **H_{20}: 42.581** **$d_1 = 1.309$** **$d_2 = 1.500$** **$d_* = 0.834$**
EUROZONE	xxxxx	xxxxx	H_{10}: 1.291 H_{20}: 4.355 $d_1 = 1.280$ $d_2 = 1.183$ $d_* = 1.396$	xxxxx
JAPAN	xxxxx	xxxxx		

Table 7: Testing the null hypothesis of no cointegration against fractional cointegration

m = 13	EUROZONE	JAPAN	U.K.	U.S.A.
AUSTRALIA	**H_{10}: 5.483** **H_{20}: 13.789** **d_1 = 1.184** **d_2 = 1.324** **d_* = 0.945**	H_{10}: 4.274 H_{20}: 0.018 d_1 = 1.184 d_2 = 0.959 d_* = 0.973	H_{10}: **8.989** **H_{20}: 8.686** **d_1 = 1.184** **d_2 = 1.179** **d_* = 0.890**	xxxxx
CANADA	H_{10}: 1.951 H_{20}: 1.019 d_1 = 1.362 d_2 = 1.324 d_* = 1.225	xxxxx	**H_{10}: 23.564** **H_{20}: 8.928** **d_1 = 1.362** **d_2 = 1.179** **d_* = 0.886**	**H_{10}: 21.173** **H_{20}: 36.079** **d_1 = 1.362** **d_2 = 1.500** **d_* = 0.911**
EUROZONE	xxxxx	xxxxx	H_{10}: 2.695 H_{20}: 9.738 d_1 = 1.324 d_2 = 1.179 d_* = 1.485	xxxxx
JAPAN	xxxxx	xxxxx	**H_{10}: 4.499** **H_{20}: 19.051** **d_1 = 0.959** **d_2 = 1.179** **d_***	