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Does the nominal exchange rate regime affect the real interest parity condition?

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Abstract. The real interest partity (RIP) condition combines two cornerstones in international finance, uncovered interest parity (UIP) and ex ante purchasing power parity (PPP). The extent of deviation from RIP is therefore an indicator of the lack of product and financial market integration. This paper investigates whether the nominal exchange rate regime has an impact on RIP. The analysis is based on 15 annual real interest rates and covers a long time span, 1870-2006. Four subperiods are distinguished and linked to fixed and flexible exchange rate regimes: the Gold Standard, the interwar float, the Bretton Woods system and the current managed float. Panel integration techniques are used to increase the power of the tests. Cross section correlation is embedded via common factor structures. The results suggest that RIP holds as a long run condition irrespectively of the exchange rate regimes. Adjustment towards RIP is affected by the institutional framework and the historical episode. Half lives of shocks tend to be lower under fixed exchange rates and in the first part of the sample, probably due to higher price flexibility before WWII. Although barriers to foreign trade and capital controls were substantially removed after the collapse of the Bretton Woods system, they did not lead to lower half lives during the managed float.

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JEL: C32, F21, F31, F41

1 Introduction

The real interest parity (RIP) condition combines two cornerstones in international economics, uncovered interest parity (UIP) and ex ante purchasing power parity (PPP), see Marston (1995) and MacDonald and Marsh (1999). Therefore, the degree of deviation from parity can serve as an indicator for the lack of products and financial market integration. RIP states that expected real returns are equalised across countries. This proposition has important implications for international investors and policymakers. If national real interest rates converge, the scope for international portfolio diversification is reduced. If the linkages in international real interest rates are almost complete, national stabilization policies could not systematically affect the economy through the real interest rate channel.

Because of the increased integration in international product and financial markets, one might expect that RIP is approximately in line with reality. However, the evidence is less supportive. Early papers like Mishkin (1984), Cumby and Obstfeld (1984) and Cumby and Mishkin (1987) have overwhelmingly rejected the condition for the short run, see Chinn and Frankel (1995) for a review. Despite this negative result, RIP might be well interpreted as a long run anchor for real interest rates. However, previous papers have arrived at quite different conclusions. While Meese and Rogoff (1988) and Edison and Pauls (1993) detected a unit root, Cavaglia (1992) and Wu and Chen (1998) reported mean reversion in real interest differentials. Gagnon and Unferth (1995) extracted a world real interest rate by means of factor analysis that is highly correlated with the national counterparts. Ferreira and

Léon-Ledesma (2003) reported evidence in favour of RIP in a sample of industrialized and emerging countries. Their analysis reveals a high degree of market integration for developed countries and highlights the importance of risk premia, i.e. non zero means in case emerging markets are involved. According to Dreger and Schumacher (2003) and Arghyrou, Gregoriou and Kontonikas (2007) RIP can be seen a long run attractor for national real interest rates especially in the European Monetary Union. On the other hand, real interest rates are persistent over time, probably due to price stickiness (Rapach and Wohar, 2004, Sekioua, 2007). If real interest rate converge, it is likely a gradual process. Furthermore, convergence may be subject to nonlinearities and structural breaks, see Goodwin and Grennes (1994), Hol-mes (2002), Mancuso, Goodwin and Grennes (2003), Camarero, Carrion-i-Silvestre and Tamarit (2006). The results could also depend on the maturities under study. Fountas and Wu (1999) and Fuijii and Chinn (2002) have stressed that the evidence is more in line with RIP if long term interest rates are involved. In contrast, Wu and Fountas (2000) found convergence for the short term rates.

The aforementioned studies are restricted to the period after the collapse of the Bretton Woods system. Thus, the evidence might be blurred by singular events such as oil price hikes and shifts in monetary policies. In fact, there is some indication that the nominal exchange rate regime might be not neutral for RIP. Eventually, the condition could perform better if nominal exchange rates are fixed. The argument can be stated both for the PPP and UIP ingredient. If prices are sticky, real exchange rates almost mimic the time series properties of nominal exchange rates, see Mussa (1986). As the latter behave like random walks in flexible regimes, PPP is likely violated. The UIP relationship can be also affected, as the international transmission of nominal interest rates depends, inter alia, on the choice of the exchange rate regime. Frankel, Schmukler and Servén (2004) have argued that national nominal interest rates respond more slowly to changes in their international counterparts in flexible regimes, implying some capacity for monetary independence.

On the other hand, the integration of product and financial markets may provide increasing support for RIP, see Goldberg, Lothian and Okunev (2003). Barriers to foreign trade and capital controls have been substantially removed over the last few decades. Country specific risks can be appropriately diversified in the portfolios of international investors. In addition, critical parameters like the degree of price stickiness can change over time. Note that economic integration is by no means a continuous process. For example, international capital controls were more pervasive under the Bretton Woods system when compared to the classical Gold Standard. Overall, RIP can be primarily affected by historical periods and not by institutional arrangements for the nominal exchange rate. See Grilli and Kaminsky (1991) for similar arguments regarding the time series properties of real exchange rates.

Therefore, this paper explores whether or not the nominal exchange rate regime affects the long run validity of the RIP condition. The analysis is built upon a comprehensive dataset based on 15 annual real interest rates and covers a long time span, 1870-2006. Four subperiods are distinguished and linked to fixed and flexible exchange rate regimes: the Gold Standard, the interwar float, the Bretton Woods system and the managed float thereafter. Panel integration techniques are applied to increase the power of the unit root tests. Dependencies between real interest differentials are embedded via common factor structures. This approach can offer new insights into the sources of possible nonstationarities, in particular whether the unit root is mainly driven by common or country specific components. If the latter dominate, a unit root result cannot be generalized.

By focusing on certain episodes, the structural break argument becomes less relevant. In addition, a relatively large sample size can be retained, as a panel is considered instead of specific time series. On the other hand, no individual information is extracted. However, this is not a serious drawback. The argument can be mitigated by the definition of subpanels, where only presumably non stationary real interest differentials are included. Even more important, the usage of RIP as a building bloc in theoretical models for the exchange rate assumes the validity of the condition for the common rather than for the idiosyncratic components. Whether the former shows mean reverting behaviour or not can be examined by standard time series tests.

The analysis provides strong evidence in favour of RIP as a long run condition irrespectively of the nominal exchange rate regimes. However, adjustment towards RIP is affected by the institutional framework and the historical episode. Half lives of shocks tend to be lower under fixed exchange rates and in the first part of the sample, probably due to higher price flexibility before WWII. Although barriers to foreign trade and capital controls were substantially removed after the collapse of the Bretton Woods system, they did not lead to lower half lives during the managed float.

The paper is organized as follows: Section 2 introduces basic concepts. Section 3 provides a brief chronology of nominal exchange rate regimes since 1870. Panel integration methods are reviewed in section 4. Data and results are discussed in section 5, while section 6 offers concluding remarks.

2 Real interest parity

Real interest parity is an overall indicator for the relevance of international factors in the national economic development. Deviations from parity point to a lack of full integration in the product and/or financial markets. RIP assumes the joint validity of three conditions. Following Moosa and Bhatti (1996), the Fisher equation holds for the domestic and foreign country

(1) $E_t r_{t+1} = i_{t,t+1} - E_t \pi_{t+1}$

(2) $E_t r^*_{t+1} = i^*_{t,t+1} - E_t \pi^*_{t+1}$

where π is inflation, and r and i the real and nominal interest rate, respectively. E denotes the rational expectations operator, t is the time index and an asterisk refers to the foreign country. Hence, the ex ante real return of an asset with one period to maturity is equal to its nominal return –which is known in advance- less expected inflation. The real interest rate differential

(3) $E_t(r_{t+1} - r^*_{t+1}) = (i_{t,t+1} - i^*_{t,t+1}) - E_t(\pi_{t+1} - \pi^*_{t+1})$

is stationary, if two further conditions are met. According to UIP, expected fluctuations in the spot exchange rate are reflected by the nominal interest rate differential

(4) $E_t(s_{t+1} - s_t) = i_{t,t+1} - i^*_{t,t+1}$

where the spot rate s is defined as the logarithm of the domestic price of the foreign currency. Ex ante PPP states

(5) $E_t(s_{t+1} - s_t) = E_t(\pi_{t+1} - \pi^*_{t+1})$

that the expected innovation in the exchange rate can be also revealed from the rational forecast of the inflation differential. Ex ante PPP and UIP are based on perfect arbitrage and the absence of risk aversion in the product and financial markets. Equations (3), (4) and (5) can be aggregated to the RIP condition

(6) $E_t(r_{t+1} - r^*_{t+1}) = 0$

where ex ante real interest rates are equalized across countries. Because of the rational expectations assumption, the ex post real interest rate is the sum of the ex ante real interest rate and a serially uncorrelated error u with zero mean. If RIP holds, the ex post real interest rate differential boils down to the difference of two probably correlated rational forecast errors, i.e.

(7) $r_{t+1} - r^*_{t+1} = E_t r_{t+1} + u_{t+1} - (E_t r^*_{t+1} + u^*_{t+1}) = u_{t+1} - u^*_{t+1}$.

Equation (7) provides the basis for the empirical analysis. The validity of RIP in the long run is efficiently tested by examining whether real interest differentials are mean reverting. This is explored by a unit root analysis. If mean reversion is detected, shocks have only temporary effects, where the estimated autoregressive root serves as an indicator for the degree of shock persistence. A non zero constant might be justified, inter alia, due to the existence of transaction costs, non-traded goods, non-zero country risk premia or differences in national tax rates.

3 Classification of nominal exchange rate regimes

The evolution of real interest differentials is studied over the 1870-2006 period. Fixed and flexible nominal exchange rate regimes operated since then: the Gold Standard (1870-1914), the interwar float (1920-38), the Bretton Woods system (1950-72) and the current managed float (1973-2006), see Eichengreen for an exposition (1994). Reinhart and Rogoff (2002) and Levy-Yeyati and Sturzenegger (2005) have offered detailed classifications of exchange rate regimes, thereby differentiating between *de jure* and *de facto* arrangements. While the former are based on official commitments, the latter focus on actual nominal exchange rate behaviour. As a drawback, these databases are limited to the post WWII period, with special emphasis on the current float.

In the Gold Standard, bilateral exchange rates were pegged indirectly, as countries declared parities of their currencies to gold. Arbitrage in the international gold market and flexible prices ensured the functioning of the system. Exchange rate stability implied the convergence of inflation rates between the participants, leading to similar long term interest rates. The coherence of interest rates across countries reflected the tendency for stable exchange rates and the absence of capital controls (Eichengreen, 1994, Officer, 1996). The US officially resumed gold convertibility in 1879. At that time, the Gold Standard was operating over much of the world. As an exception, Japan was not a member until the turn of the century.

During the first few years after WWI, exchange rates were fully determined by market forces. Governments intervened only by exception. As wartime divergencies in national price levels exceeded those of nominal exchange rates, a restoration of fixed exchange rates seemed to require further revaluations, most notably an additional fall of European currencies against the US dollar (Bernanke and James, 1990, Eichengreen, 1994). However, policymakers affirmed their commitment to restore nominal exchange rates to pre-war levels. In fact, a return to the Gold Standard took place in the mid 1920s, but lasted only for a few years. Deflation pressures and the exhaustion of foreign reserves in deficit countries worsened unemployment and raised doubts on the sustainability of the system. During the Great Depression, a floating regime emerged, but with massive government intervention.

Countries devaluated their currencies in order to improve the competitiveness of exports and reduce balance of payments deficits. International trade became largely restricted within currency blocs i.e. countries that were tied to the same currency. Capital controls were imposed to minimize the impact of international capital movements on the exchange rate.

The Bretton Woods conference re-established a system of fixed exchange rates after WWII. All currencies were pegged to the US dollar, while the US dollar was pegged to gold. In case of imbalances in the current account, deficit countries had to take the burden of adjustment. Instead of restrictive policies as under the Gold Standard, they could use credit facilities of the IMF. Realignments in the value of currencies were allowed to correct for fundamental disequilibria. Because foreign currency reserves were denominated in dollar, US trade deficits could persist and ensured the provision of international liquidity. Contrary to the Gold Standard, capital controls were pervasive (Eichengreen, 1994). For example, the Bundesbank imposed discriminatory measures in 1970 to discourage purchases of German assets by foreign residents in order to limit the appreciation of the Deutsche Mark. The lack of international policy coordination across the participating countries and speculative attacks against weak currencies eroded the system in the early 1970s.

The current regime of flexible rates can be characterised as managed float (Eichengreen, 1994). In principle, bilateral exchange rates are determined by supply and demand conditions in the foreign exchange market. However, the breakdown of Bretton Woods system had a less radical impact. Dooley, Folkerts-Landau, and Garber (2003) have argued that the current regime operates much like a system of fixed exchange rates. Some countries have tried to affect the development by intervening in the market to keep the exchange rates within desired target zones. Another strategy is to peg the value of domestic money to a major currency or to establish a crawling peg. Policymakers moved towards an agreement to stabilize exchange rates within Europe while permitting them to fluctuate against a dollar

(De Grauwe, 2007). In particular, the Deutschemark was an anchor for the Western European currencies long before the introduction of the euro. Asian countries have often implemented export-led growth policies and successfully resisted a appreciation of their currencies against the US dollar. They became net accumulators of foreign reserves. US foreign debt deteriorated and foreign reserves became more diversified. Currently, the US current account deficit absorbs roughly 75 percent of the current account surpluses of all world's surplus countries (Obstfeld and Rogoff, 2005). Inflation declined substantially in the aftermath of the oil crises, as monetary policy focused more on price stability.

4 Panel unit root analysis

The presence or absence of random walks is decisive for the long run behaviour of real interest rate differentials. However, it has been widely acknowledged that standard time series tests on nonstationarity may not be appropriate since they have low power against stationary alternatives, see Campbell and Perron (1991). Panel unit root tests offer a promising way to proceed. As the time series dimension is enhanced by the cross section, the results rely on a broader information set. Gains in power are expected and more reliable evidence can be obtained, even in shorter sample periods (Levin, Lin and Chu, 2002).

Early panel unit root tests have been proposed by Levin, Lin and Chu (2002), hereafter LLC and Im, Pesaran and Shin (2004), hereafter IPS. Heterogeneity across panel members is allowed to some extent due to individual deterministic components (constants and time trends) and short run dynamics. The tests differ in the alternative considered. In the LLC approach, a homogeneous first order autoregressive parameter is assumed. The statistic is built on the *t*-value of its estimator in a pooled regression. The IPS test emerges as a standardized average of individual ADF tests. If the null of a unit root is rejected, the series are stationary for at least one individual. Hence, the IPS test extends heterogeneity to the long run behaviour.

In case the panel members are independent, a Gaussian distribution can be justified by central limit arguments. In contrast, dependencies across the panel members can lead to substantial size distortions, see Banerjee, Marcellino and Osbat (2004, 2005). The test statistics are no longer standard normal and converge to non-degenerate distributions (Gengenbach, Palm and Urbain, 2004). Note that this problem is especially relevant in the analysis presented here, since real interest rate differentials are often expressed relative to the same benchmark.

Therefore, modern tests have relaxed the independency assumption, see Hurlin (2004), Gengenbach, Palm and Urbain (2004) and Breitung and Das (2006) for recent surveys. If dependencies arise due to common time effects, panel tests can be used with mean adjusted data, where cross sectional means are subtracted in advance (Im, Pesaran and Shin, 2004). However, this approach is rather restrictive, and might not remove the actual correlation in the data. Thus, the tests suggested by Pesaran (2007) and Bai and Ng (2004) are preferred. Both capture the cross sectional correlation pattern by a common factor structure.

Pesaran (2007) has motivated a single factor approach. The common component is assumed to be stationary and embedded in the error process of the model. The procedure is a cross sectional extension of the ADF framework. The ADF regression is extended by cross sectional averages of lagged levels and differences of the series of interest (y). In the model

$$(8) \qquad \Delta y_{it} = a_{0i} + \alpha_{1i} y_{i,t-1} + \alpha_{2i} \bar{y}_{t-1} + \alpha_{3i} \Delta \bar{y}_{t-1} + v_{it} \quad , \quad \bar{y}_t = n^{-1} \sum\nolimits_{i=1}^{n} y_{it}$$

the cross sectional average of y observed for n panel members serves as a proxy to capture the effects of a single factor. Testing for the null of a unit root is based on the t-ratio of the first order autoregressive parameter. Equation (8) can be seen as an alternative to the ADF test in a time series setting, where information of other individuals is allowed to enter through the common component. Due to this extension, the critical values exceed those in the standard ADF setting in absolute value. The panel version arises from a cross sectional extension of the IPS test, where *t*-ratios are pooled across individuals. The limiting distribution is non-standard and depends on the deterministic terms included in the model (Pesaran, 2007).

In the PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common components) approach advocated by Bai and Ng (2004), the variable is interpreted as the sum of a deterministic, a common and an idiosyncratic component, the latter accounting for the error term. A unit root is tested separately for common and idiosyncratic components. Thus, further information on the sources of nonstationarity can be revealed. The analysis is built on the decomposition

(9) $$y_{it} = \alpha_i + \lambda_i ' f_t + u_{it}$$

where α_i is a country fixed effect, which might contain a linear time trend, f_t is the *r*-vector of common factors, λ_i is an *r*-vector of factor loadings and u_{it} is the idiosyncratic part. The common component is relevant for all cross sections, but with probably different loadings, while the idiosyncratic component is specific for individual series. The parameter *r* denotes the number of factors, and can be estimated by the information criteria discussed in Bai and Ng (2002). The variable under study contains a unit root if one or more of the common factors are nonstationary, or the idiosyncratic part is nonstationary, or both.

Principal components (PCs) are used to obtain a consistent estimate of the common factors. However, since the factors might be integrated, a transformation is required in advance. Bai and Ng (2004) estimate PCs for the differenced data, which are stationary by assumption.

Once the components are estimated, they are re-cumulated to match the integration properties of the original series. Since the defactored series are independent, the nonstationarity of the idiosyncratic component can be efficiently explored by first generation panel unit root tests.

The analysis of the common component depends on the number of factors involved. In case of a single factor, an ADF regression with a constant is appropriate, and inference is based on the Dickey Fuller distribution. Multiple common factors can be investigated by separate ADF regressions. A procedure similar to the Johansen (1995) trace test is also available. Jang and Shin (2005) conclude that the PANIC approach has better small sample properties than the Pesaran (2007) test.

5 Panel analysis of real interest parity

The analysis is based on 15 countries obtained at the annual frequency: Belgium, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the US and covers a long time span, 1870 to 2006. Information is available for long term nominal interest rates (7-10 years to maturity) and CPI inflation. All series prior to 1950 are taken from GFD database (http://www.global-financialdata.com). Starting in 1951, the World Market Monitor of Global Insight is used. After controlling for wartimes and transition years, four regimes of the nominal exchange rate are distinguished within the overall period: the Gold Standard (1870-1914), the interwar float (1920-38), the Bretton Woods system (1950-72) and the managed float (1973-2006).

-Figure 1 about here-

Ex post real interest rates are obtained by subtracting annual CPI inflation from nominal interest rates. Real interest differentials are defined as the difference between the real interest rates in a particular country and the US. The series are shown in figure 1.

-Table 1 about here-

Panel unit root tests show strong evidence in favour of the RIP condition, see table 1. The IPS test with mean-adjusted data rejects the random walk for all real interest rate differentials. However, this result relies on the assumption that common time effects are appropriate to capture the cross correlation issue. In principle, the strategy might reduce correlation structures, but substantial dependencies could remain. To be on the safe side, other tests are more reliable.

The more elaborated tests confirm the IPS results. Both the Pesaran (2007) test and the Bai and Ng (2004) procedure points to the stationarity of real interest differentials in each regime of the nominal exchange rate. The first principal component for the various exchange rate regimes is exhibited in figure 2. It presents roughly 50 percent of the variances of the changes of real interest rate differentials under the Gold Standard, 40 percent during the interwar, 30 percent under the Bretton Woods system, and 40 percent in the managed float.

-Figure 2 about here-

According to the information criteria suggested by Bai and Ng (2002), the number of factors is not unique. However, as rhe addition of further components raises the cumulative proportion of the variance only modestly, the choice is made in favour of the single factor model. The results are not critically affected by this parameter. Since both the common and idiosyncratic component are stationary, the unit root in real interest differentials is rejected.

While the long run validity of the RIP condition holds irrespectively of the nominal exchange rate regime, the adjustment process is affected by these arrangements, see table 2. In particular, half lives of shocks tend to be lower under fixed exchange rates. This implies, for example, that an individual real interest rate channel to stimulate domestic consumption and investment is less available for the countries participating in the euro area. Furthermore, the choice of the historical period is relevant. The movement towards RIP has been shorter during the first part of the sample, probably due to higher price flexibility and a larger weight of foreign trade in nominal exchange rate determination before WWII. These issues are left for further research. Moreover, the increased liberalization of product and financial markets in the era of economic globalization did not reduce the effectiveness of national monetary policies.

-*Table 2 about here*-

6 Conclusion

The real interest partity (RIP) condition combines two cornerstones in international finance, uncovered interest parity (UIP) and ex ante purchasing power parity (PPP). The extent of deviation from RIP is therefore a measure of the lack of product and financial market integration. This paper investigates whether the nominal exchange rate regime has an impact on RIP. The analysis is based on 15 annual real interest rates and covers a long time span, 1870-2006. Four subperiods are distinguished and linked to fixed and flexible exchange rate regimes: the Gold Standard, the interwar float, the Bretton Woods system and the current managed float. Panel integration techniques are employed to increase the power of the tests. Cross section correlation is embedded via common factor structures.

The results suggest that RIP holds as a long run condition irrespectively of the exchange rate regimes. Adjustment towards RIP is affected by the institutional framework and the historical episode. Half lives of shocks tend to be lower under fixed exchange rates and in the first part of the sample, probably due to higher price flexibility before WWII. Although barriers to foreign trade and capital controls were substantially removed after the collapse of the Bretton Woods system, they did not lead to lower half lives during the managed float.

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Figure 1: Real interest differentials relative to the US, 1870-2006

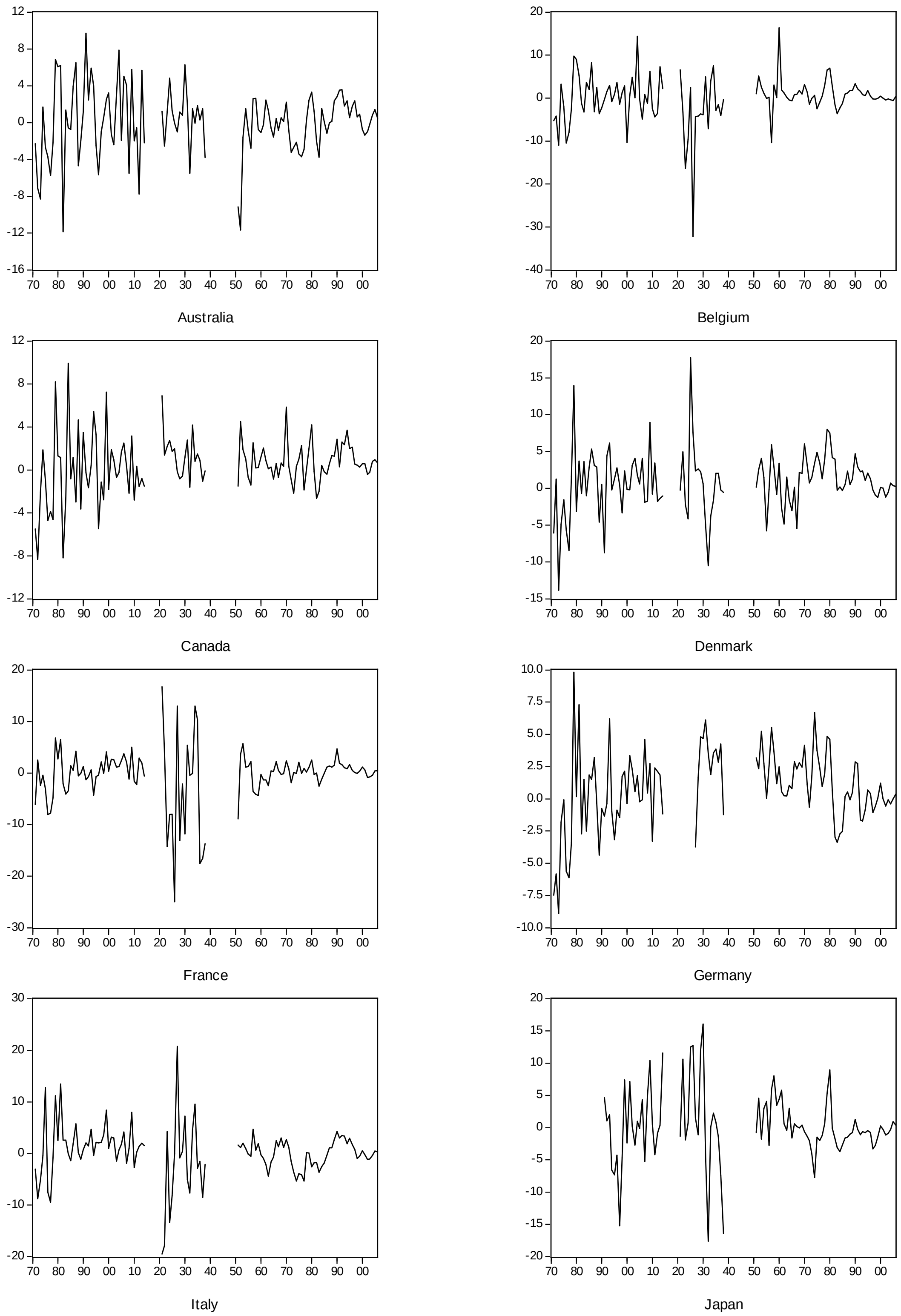
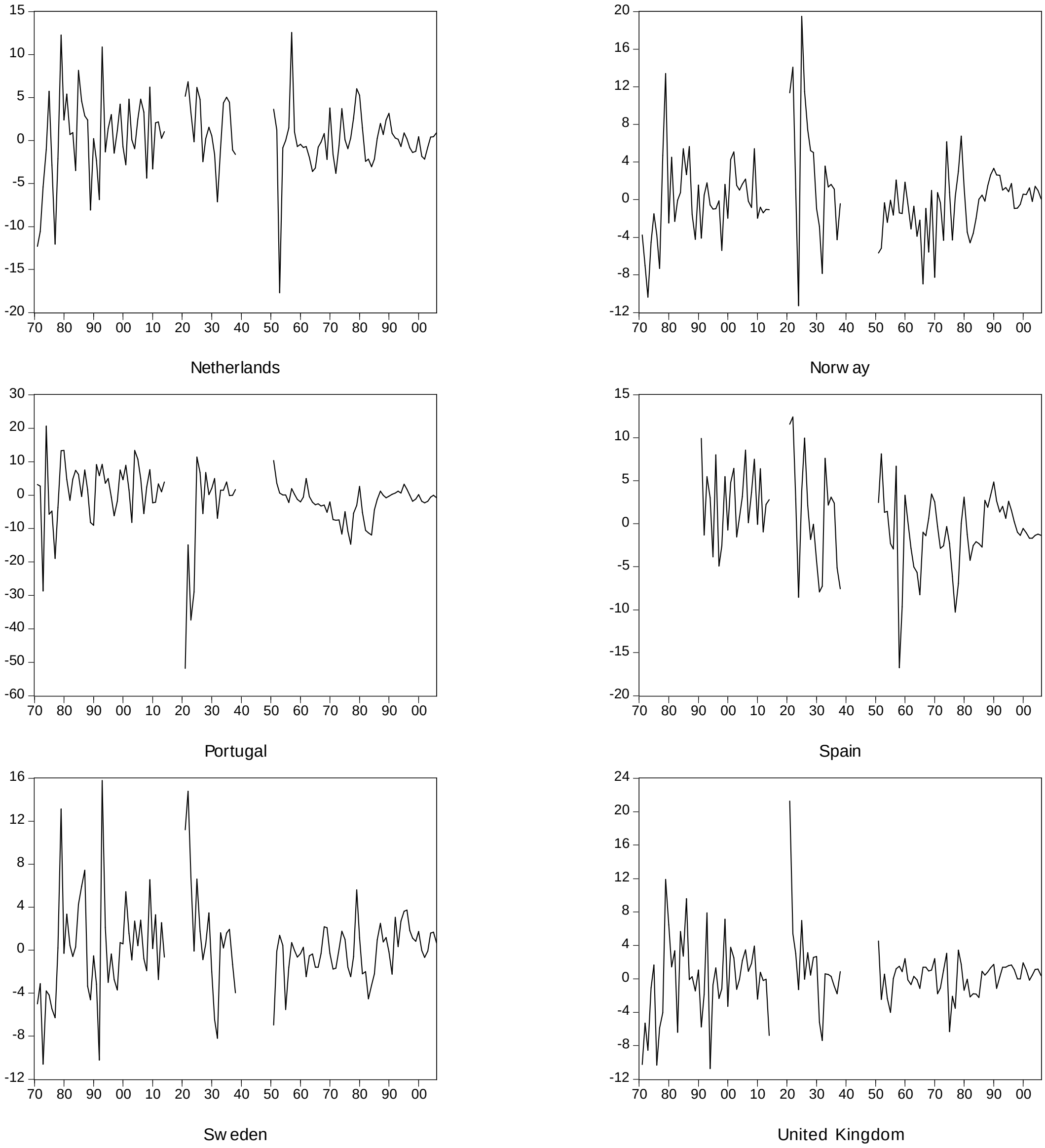
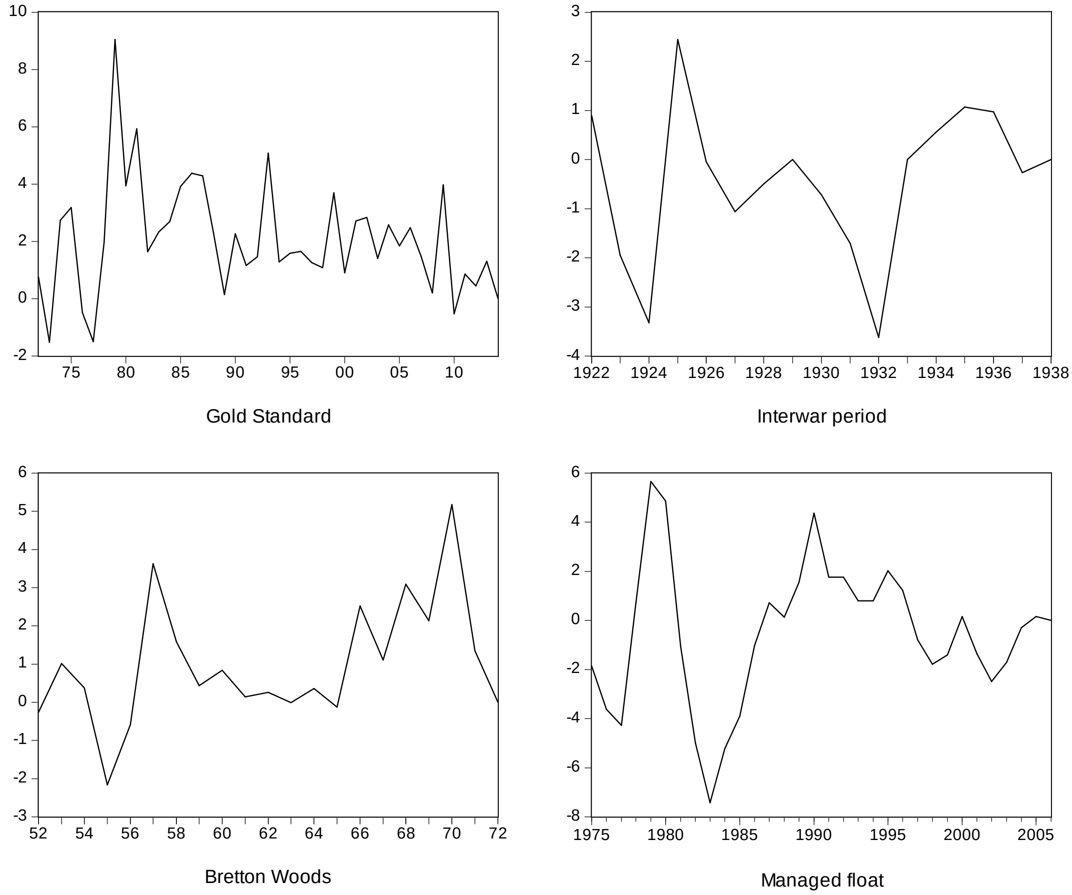


Figure 1: Real interest differentials relative to the US, 1870-2006 (cont'd)



Note: Global financial database for historical data up to 1950 and World Market Monitor (Global Insight) thereafter. Wartimes and transition years are excluded.

Figure 2: Common component of real interest differentials



Note: First principal component of real interest differentials relative to the US.

Table 1: Panel unit root tests for real exchange rates

	1870-1914	1920-1938	1950-1972	1973-2006
IPS (2003)	-17.19*	-5.243*	-8.669*	-5.884*
Pesaran (2007)	-4.838*	-2.285*	-3.004*	-2.544*
Bai and Ng (2004)				
Common component (ADF)	-5.136*	-3.615*	-3.244*	-4.606*
Idiosycratic component (IPS)	-18.11*	-2.605*	-5.727*	-5.580*

Note: A balanced panel is required for the panel unit root tests. As data for Japan and Spain are not available before 1890, these countries are excluded from the analysis of the Gold Standard. Due to the hyperinflation period in the first part of the 1920s, Germany is removed from the interwar sample. The optimal lag length in the regressions is determined by the general-to-simple approach suggested by Campbell and Perron (1991), where a maximum delay of 2 years is allowed. An asterisk denotes the rejection of the unit root hypothesis at least at the 0.05 level.

Table 2: Estimation of half lives

	1870-1914	1920-1938	1950-1972	1973-2006
AR parameter	0.064 (0.046)	0.232 (0.060)	0.152 (0.056)	0.599 (0.036)
Half-life of shocks	0.252 (0.065)	0.473 (0.082)	0.368 (0.071)	1.352 (0.155)

Note: Half lives calculated according to $-\log(2)/\log(\delta)$, where δ is the AR parameter from a panel regression of the real interest differential on its previous value with country fixed effects. Standard errors in parantheses. For half lives, the errors are approximated by the Delta method (Rossi, 2005).