DIW Berlin

German Institute
for Economic Research

Discussion Papers

746

Christian Dreger
Eric Girardin

Does the Nominal Exchange Rate Regime Affect the Long Run Properties of Real Exchange Rates?

Berlin, November 2007

Opinions expressed in this paper are those of the author and do not necessarily reflect views of the institute.

IMPRESSUM
© DIW Berlin, 2007
DIW Berlin
German Institute for Economic Research
Mohrenstr. 58
10117 Berlin
Tel. +49 (30) 897 89-0
Fax +49 (30) 897 89-200
http://www.diw.de

ISSN print edition 1433-0210
ISSN electronic edition 1619-4535

Available for free downloading from the DIW Berlin website.

Does the nominal exchange rate regime affect the long run properties of real exchange rates?

Christian Dreger and Eric Girardin[1]

Abstract. This paper examines whether the behaviour of the real exchange rate is associated with a particular regime for the nominal exchange rate, like fixed and flexible exchange rate arrangements. The analysis is based on 16 annual real exchange rates and covers a long time span, 1870-2006. Four subperiods are distinguished and linked to 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 tests. Cross section correlation is embedded via common factor structures. The evidence shows that real exchange rates properties are affected by the exchange rate regime, although the impact is not very strong. A unit root is rejected in both fixed and flexible exchange rate systems. Regarding fixed-rate systems, mean reversion of real exchange rates is more visible for the Gold Standard. The half lives of shocks have increased after WWII, probably due to a higher stickiness of prices and a lower weight of international trade in the determination of exchange rates. Both for the periods before and after WWII, half lives are lower in flexible regimes. This suggests that the nominal exchange rate plays some role in the adjustment process towards PPP.

Keywords: Real exchange rate persistence, exchange rate regime, panel unit roots

JEL: F31, F37, F41

[1] Dreger (corresponding author): DIW Berlin, German Institute for Economic Research, Germany. Phone: +49-30-89789 529, eMail: cdreger@diw.de, Girardin: GREQAM, Université de la Méditerranée, Aix-en-Provence, France, Phone: +33-44 293 5990, eMail: eric.girardin@univmed.fr. The authors would like to thank Alan M. Taylor, University of California, USA, for providing his dataset which enabled us to have a cross check on the results.

1 Introduction

The behaviour of the real exchange rate over time is a key issue in international finance, see MacDonald and Marsh (1999). According to purchasing power parity (PPP) the nominal exchange rate is equal to the purchasing power of two currencies at home and abroad. Then, the real exchange rate is constant or stationary in the long run, implying that shocks have only transitory effects. Real exchange rates are expected to show mean reverting behaviour, and the nominal exchange rate regime should not have an impact on this property.

However, empirical support in favour of stationarity is quite limited. Often unit root tests have failed to reject the null hypothesis of a random walk in the process governing real exchange rates, see Adler and Lehmann (1983), Meese and Rogoff (1988), and Edison and Pauls (1993). The literature has offered different strategies to overcome this deficit. One approach is to analyse very long time periods to allow for sluggish arbitrage processes. In fact, the findings are more in line with the condition. For example, Abuaf and Jorion (1990), Lothian and Taylor (1996), and Taylor and Taylor (2004) have explored a period longer than a century, see also Froot and Rogoff (1995). Some real exchange rates appear to be stationary, while others do not share this property. However, the evidence may be biased due to structural breaks. Control variables such as the nominal exchange rate regime typically do not enter the analysis. Other authors have examined individual real exchange rates simultaneously, see for example MacDonald (1996) and Papell (1997). As the data are extended by the cross section dimension relatively long time periods can be avoided, implying that structural breaks become less important. However, the results might be blurred due to cross section dependencies, which are likely in a PPP analysis. Techniques to control for this issue have been improved recently. In this paper, they are applied to investigate the long run behaviour of the real exchange rate in different nominal exchange rate regimes.

In fact, shocks might have a permanent impact on the path of the real exchange rate, probably due to the institutional setup. Mussa (1986) has attributed a major role to the nominal exchange rate system, see also Liang (1998). Due to sticky prices, changes in the nominal exchange rate lead to similar fluctuations of the real exchange rate. Hence, the time series properties of real exchange rates mimic those of the nominal rates, implying that a unit root in the nominal rate is also be decisive for the real exchange rate. Baxter and Stockman (1989) and Flood and Rose (1995) have emphasized that the exchange rate regime does not affect the evolution of macroeconomic variables, except of the real exchange rate.

On the other hand, Grilli and Kaminsky (1991) have questioned the non neutrality hypothesis of the nominal exchange rate regime. According to their results, the time series properties of real exchange rates heavily depend on historical episodes rather than on exchange rate arrangements per se. This points to the relevance of structural breaks and casts serious doubts on studies that use long time series on real exchange rates, such as Edison (1987), Abuaf and Jorion (1990), Lothian and Taylor (1996), Taylor (2002) and Taylor and Taylor (2004). The Grilli and Kaminsky (1991) finding has been reinforced by Kent and Naja (1998) in an analysis of effective, i.e. trade weighted real exchange rates.

Overall, the impact of the nominal exchange rate regime on real exchange rates is controversial. The bulk of the previous literature is based on the post WWII experience, where only one main shift (from fixed to flexible exchange rates) has occurred. The evidence might be critically affected by singular events such as oil price hikes and shifts in monetary policies. A few studies have also looked at longer periods, see Grilli and Kaminsky (1991) and Liang (1998), but their findings are limited to specific exchange rates.

In contrast, this paper uses a comprehensive dataset based on 16 annual real exchange rates and a long time span, 1870-2006. Four subperiods are distinguished and linked to particular 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 tests. Cross section dependencies are modelled via common factor structures. This can provide additional insights into the sources of non-stationarities, i.e. whether the unit root is traced to common or country specific components.

The evidence shows that real exchange rate characteristics are affected by the nominal exchange rate regime, although the effects are not very strong. A unit root is rejected in both fixed and flexible exchange rate systems, including the current float. In the fixed systems, mean reversion of real exchange rates is more visible for the Gold Standard. The half lives of shocks have generally increased after WWII, probably due to a higher stickiness of prices and a lower weight of international trade in exchange rate determination. Both for the periods before and after WWII, half lives are lower in flexible regimes. This suggests that the nominal exchange rate plays some role in the adjustment process towards PPP.

The paper is organized in several sections. Section 2 introduces the basic concepts. Section 3 provides a brief chronology of nominal exchange rate regimes since 1870. Panel integration methods are reviewed in section 4. Data issues and empirical results are discussed in section 5. Section 6 offers concluding remarks and provides some guidelines for future research.

2 PPPs and real exchange rates

In its absolute version, PPP implies that one unit of currency, after conversion, should purchase the same bundle of goods at home and abroad. The nominal exchange rate is at PPP if it is equal to the ratio between the domestic and foreign price level, i.e.

$$(1) \qquad s_t = p_t - p_t^*$$

where s is the nominal exchange rate, expressed as units of domestic currency per unit of foreign currency, p is the domestic price level, and an asterisk denotes a foreign variable. All series are in logarithms. Deviations from equation (1) are studied by exploring the time series properties of the real exchange rate (q):

$$(2) \qquad q_t = s_t - p_t + p_t^*$$

which should be equal to 0 if PPP is continuously fulfilled. As real exchange rates exhibit large and persistent fluctuations, PPP is strongly rejected in the short run. Thus, the central question is whether the deviations are mean reverting over time, once forces such as arbitrage in the goods market have had their full effect. If real exchange rates include a unit root, shocks have a permanent impact on their development, and a reaction towards equilibrium cannot be expected even in long time intervals. Under these circumstances, PPP does not hold as a long run condition.

Two puzzles are striking in the development of real exchange rates. First, and already mentioned, there is the lack of evidence in favour of PPP even in the long run. Second, the deviations from PPP are long lasting. Although real exchange rates exhibit a high degree of volatility, the rates of mean reversion are very low (Rogoff, 1996). For example, the speed at which real exchange rates adjust towards PPP is estimated with half lives between 3 and 5 years. The half life indicates how long it takes for the impact of a unit shock to diminish by 50 percent. If median unbiased techniques are used instead of OLS, the half lives turn out to be longer, see Murray and Papell (2005).

3 Classification of nominal exchange rate regimes

The development of real exchange rates is studied here over the 1870-2006 period. Several nominal exchange rate regimes operated since then: the Gold Standard (1870-1914), the interwar float (1920-38), the Bretton Woods system (1948-72) and the current managed float (1973-2006), see Eichengreen (1994). Reinhart and Rogoff (2002) as well as Levy-Yeyati and Sturzenegger (2005) have offered detailed classifications of nominal regimes, thereby differentiating between *de jure* and *de facto* arrangements. While the former are based on official commitments, the latter focus on the actual nominal exchange rate behaviour. The databases are limited, however, to the post WWII period, with a 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 between the participants. The coherence of interest rates across countries reflected the tendency for stable exchange rates as well as the absence of capital controls (Eichengreen, 1994). The US officially resumed gold convertibility in 1879. Then, the Gold Standard was operating over much of the world. As an exception, Japan was not a member until the turn of the century.

Exchange rates were fully determined by market forces after WWI, where governments intervened only by exception (Eichengreen, 1994). As wartime divergences in national price levels exceeded those in exchange rates, a restoration of PPP seemed to require further revaluations, most notably an additional fall in the European currencies against the US dollar. A transition to a fixed exchange rate system took place in the mid 1920s, but lasted only a few years. Deflation pressures and the exhaustion of foreign currency reserves in deficit countries raised doubts about its sustainability. During the Great Depression, the return to a floating system took place, but with massive government intervention. Countries devalued their currencies to foster the competitiveness of exports and reduce balance of payments deficits. International trade became largely restricted to currency blocs i.e. countries that were tied to the same currency.

The Bretton Woods conference established a regime of fixed rates after WWII. All currencies were pegged to the US dollar, the currency with the highest purchasing power, while the US dollar was pegged to gold. In case of imbalances, deficit countries had to take the burden of adjustment. Instead of restrictive policies, they could use the credit facilities of the IMF. Realignments in the value of currencies were allowed to correct for fundamental disequilibria. Since foreign currency reserves were denominated in dollar, US trade deficits could persist and ensured international liquidity. The lack of policy coordination across 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, 2004). In principle, bilateral exchange rates are determined by supply and demand. However, it should be noted that the breakdown of Bretton Woods system had a less radical impact. Some countries have tried to influence the development by intervening in the foreign exchange market to keep the exchange rates within target zones. Another strategy is to peg the value of domestic money to a major currency or to establish a crawling peg. Even before the introduction of the euro area, the Deutschemark was an anchor for the Western European countries over several decades. Asian countries have implemented policies for export-led growth and resisted the appreciation of their currencies against the US dollar. At the same time, foreign currency reserves have become more diversified. After a rise in the aftermath of the oil crises in the 1970s and 1980s, inflation rates have been reduced markedly.

4 Panel unit root analysis

The presence or absence of random walks is decisive for the long run behaviour of real exchange rates. However, it is widely acknowledged that time series tests on nonstationarity might 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 the 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.

Given that the panel members are independent, a Gaussian distribution is justified by central limit arguments. However, dependencies can lead to substantial size distortions, see Banerjee, Marcellino and Osbat (2004, 2005). The test statistics are no longer standard normal, but converge to non-degenerate distributions (Gengenbach, Palm and Urbain, 2004). This problem is very relevant in the analysis of exchange rates, as currencies are expressed relative to the same foreign country.

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 might be used with mean adjusted data, i.e. the cross sectional mean has to be 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 also employed. 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. Specifically, the ADF regression is extended by cross sectional averages of lagged levels and differences of the series of interest. In the model

(3) $$\Delta q_{it} = a_{0i} + \alpha_{1i} q_{i,\,t-1} + \alpha_{2i} \overline{q}_{t-1} + \alpha_{3i} \Delta \overline{q}_{t-1} + \varepsilon_{it}$$

$$\overline{q}_t = n^{-1} \sum_{i=1}^{n} q_{it} \ , \ \ \Delta \overline{q}_t = n^{-1} \sum_{i=1}^{n} \Delta q_{it}$$

the cross sectional average of n real exchange rates serves as a proxy for the single factor. Testing for the null of a unit root is based on the t-ratio of the first order autoregressive parameter. Equation (3) can be interpreted as an alternative to the ADF in a time series setting, where information from 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. Deviations from normality depend on the deterministic terms included in the model (Pesaran, 2007).

In the PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common components) approach suggested by Bai and Ng (2004), real exchange rates are interpreted as the sum of a deterministic component, a common component, and an idiosyncratic component, which accounts for the error term in the model. The unit root hypothesis is tested separately for the common and idiosyncratic components. In this sense, further information on the sources of nonstationarity is provided. The analysis is built on the decomposition

(4) $$q_{it} = \alpha_i + \lambda_i ' f_t + u_{it}$$

where α_i is a 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 embedded in all real exchange rates, but with probably different loadings, while the idiosyncratic component is specific for individual series. The parameter r denotes the number of factors, and is estimated by using the information criteria discussed in Bai and Ng (2002). Real exchange rates contain 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 employed to obtain a consistent estimate of the common factors. But, as the factors might be integrated, a transformation is required in advance. Bai and Ng (2004) suggest to estimate PCs for differenced data, which are stationary by assumption. Once the components have been 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 explored efficiently by first-generation panel unit root tests. The analysis of the common component depends on the number of factors involved. If there is only a single factor, a standard ADF regression with a constant

$$(5) \qquad \Delta F_t = \alpha + \phi_0 F_{t-1} + \sum\nolimits_{i=1}^{p} \phi_i \Delta F_{t-i} + u_t$$

is appropriate, and inference is based on the Dickey Fuller distribution. In case of multiple common factors, a procedure similar to the Johansen (1995) trace test can determine their number.

5 Panel analysis of real exchange rates

The data set consists of nominal exchange rates, measured as units of domestic currency per US Dollar, and price indices proxied by consumer price indices. The variables are taken in natural logarithms, and real exchange rates are constructed according to equation (2), see figure 1.

The analysis relies on annual data for 16 countries: Belgium, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and the US. All historical series up to 1950 have been taken from the GFD database, see http://www.globalfinancialdata.com. Starting with 1951, the World Market Monitor from Global Insight Inc. is used. The sample runs from 1870 to 2006. Four regimes of the nominal exchange rate are distinguished within this time frame: the Gold Standard (1870-1914), the interwar float (1920-38), the Bretton Woods system (1948-72) and the managed float (1973-2006).

-Figure 1 about here-

To get preliminary evidence into the long run properties of the data, standard ADF tests are carried out for real exchange rates, see table 1. Two striking findings emerge from the regressions. First, the evidence turns out to be unequally strong for individual real exchange rates, eventually due to the low power of the tests. In each regime some exchange rates appear to be stationary, while others are not. Second and even more in contrast with the common belief, the null hypothesis of nonstationarity is rejected quite often in the current floating period even for major currencies. This result might be traced to the inclusion of the last decade. If only data up to the middle of the 1990s is considered, the indication against the unit root is rather weak. Thus, the evidence in favour of PPP might have gradually improved over the recent period.

-Table 1 about here-

The panel unit root tests show inconclusive evidence across different periods, see table 2. The IPS test with mean-adjusted data rejects the random walk for all exchange rate regimes, except of the Bretton Woods system. However, this result relies on the strong assumption that common time effects are appropriate to capture the cross correlation issue. In fact, the strategy might reduce the average size of contemporaneous correlation coefficients, but some substantial dependencies could remain. To be on the safe side, other tests are more reliable.

-Table 2 about here-

The Pesaran (2007) test rejects a random walk only for the Gold Standard. In contrast, the Bai and Ng (2004) procedure points to the stationarity of real exchange rates in each regime of the nominal exchange rate. According to the information criteria suggested by Bai and Ng (2002), the number of factors is restricted to one. Fortunately, the results do not heavily depend on this parameter. While the first principal component presents roughly 50 percent of the variances of individual real exchange rate changes in the pre WWII period, this share rises to almost 70 percent in the past WWII period. Thus, the dependencies along the cross section have increased over time. In any case, the addition of further components raises the cumulative proportion only modestly. Thus the choice is made in favour of the single factor model. Since both the common and idiosyncratic component are stationary, the unit root is rejected. Because the Bai and Ng approach has better small sample properties (Jang and Shin, 2005), this results dominates the outcome of the Pesaran (2007) test.

Note that the panel results broadly underpin the findings from the univariate unit root analysis, as stationarity has been detected for some of the real exchange rates over certain periods (table 1). In principle the random walk might be rejected when only one real exchange rate is stationary while the others are nonstationary. To overcome this ambiguity, the panel unit root tests have been also conducted for a subsample focusing on nonstationary real exchange rates. The separation has been made on the 0.05 level according to the evidence of table 1. Stationarity remains robust, in particular for the Gold Standard and the recent floating period. Therefore, table 2 provides genuine additional evidence that cannot be inferred from table 1.

-Table 3 about here-

Finally, half lives have been estimated in a panel setting for the different nominal exchange rate regimes, see table 3. In general, the deviations from PPP seem to be very persistent. Nevertheless, even longer half lives have been observed in empirical studies exploring price convergence, see for example Cechetti, Mark and Sonara (2000), Rogers (2002) and Dreger et al (2008) for the US and EU experience. Thus, the long half lives might be a consequence of a lack of price convergence. This topic would certainly deserve further research. In addition, the half lives have increased after WWII, probably due to a higher stickiness of prices and a reduced weight of international trade in exchange rate determination. For the period before and after WWII, respectively, the half life in flexible exchange rate systems tend be lower than in regimes with fixed parities. This suggests that the nominal exchange rate plays a role in the adjustment process towards PPP.

6 Conclusion

This paper examines whether the behaviour of the real exchange rate is associated with a particular regime for the nominal exchange rate, like fixed and flexible exchange rate arrangements. The analysis is based on 16 annual real exchange rates and covers a long time span, 1870-2006. Four subperiods are distinguished and linked to 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 tests. Cross section correlation is embedded via common factor structures. The evidence shows that real exchange rates properties are affected by the exchange rate regime, although the impact is not very strong. A unit root is rejected in both fixed and flexible exchange rate systems. In the fixed-rate systems, mean reversion of real exchange rates is more visible for the Gold Standard. The half lives of shocks have increased after WWII, probably due to a greater stickiness of prices and a lower weight of international trade in the determination of exchange rates. Both for the periods before and after WWII, half lives are lower in flexible regimes. This suggests that the nominal exchange rate plays a role in the adjustment process towards PPP.

References

Abuaf, N., Jorion, P. (1990): Purchasing power parity in the long run, Journal of Finance 45, 157-174.

Adler, M., Lehmann, B. (1983): Deviations from purchasing power parity in the long run, Journal of Finance 38, 1471-1487.

Aznar, A., Salvador, M. (2002): Selecting the rank of the cointegration space and the form of the intercept using an information criterion, Econometric Theory 18, 926-947.

Bai, J., Ng, S. (2002): Determining the number of factors in approximate factor models, Econometrica 70, 191-221.

Bai, J. Ng, S. (2004): A PANIC attack on unit roots and cointegration, Econometrica 72, 1127-1177.

Banerjee, A., Marcellino, M., Osbat, C. (2004): Some cautious on the use of panel methods for integrated series in macroeconomic data, Econometrics Journal 7, 322-340.

Banerjee, A., Marcellino, M., Osbat, C. (2005): Testing for PPP: Should we use Panel Methods?, Empirical Economics 30, 77-91.

Baxter, M., Stockman, A. (1989): Business cycles and the exchange rate regime: Some international evidence, Journal of Monetary Economics 23, 377-400.

Breitung, J., Das, S. (2006): Testing for unit roots in panels with a factor structure, Econometric Theory, forthcoming.

Campbell, J.Y., Perron, P. (1991): Pitfalls and opportunities. What macroeconomists should know about unit roots, NBER Technical Working Paper 0100.

Dreger, C., Kholodilin, K., Lommatzsch, K., Slacalek, J., Wozniak, P. (2008): Price convergence in the enlarged internal market. Eastern European Economics, forthcoming.

Edison, H.J. (1987): Purchasing power parity in the long run: A test of the Dollar/Pound exchange rate, 1890-1978, Journal of Money, Credit and Banking 19, 376-387.

Edison, H.J., Pauls, D. (1993): A re-assessment of the relationship between real exchange rates and real interest rates: 1974-1990, Journal of Monetary Economics, 165-188.

Eichengreen, B. (1994): History of the international monetary system: Implications for research in international macroeconomics and finance, in Ploeg, F. (ed.): Handbook of International Macroeconomics, Blackwell, Oxford, 153-197.

Eichengreen, B. (2004): Global imbalances and the lessons of Bretton Woods, NBER Working Paper 10497.

Engel, C., Rogers, J.H. (2001): Violating the Law of One Price: Should we make a federal case out of it? Journal of Money, Credit and Banking 33, 1-15.

Flood, R., Rose, A. (1995): Fixing exchange rates: A virtual quest for fundamentals, Journal of Monetary Economics 36, 3-37.

Froot, K.A., Rogoff, K. (1995): Perspectives on PPP and long run real exchange rates, in Grossman, G., Rogoff, K. (eds): Handbook of International Economics, Amsterdam, North Holland, 1647-1688.

Gengenbach, C., Palm, F., Urbain, J.-P. (2004): Panel unit root tests in the presence of cross-sectional dependencies: Comparison and implications for modelling, Research Memorandum 040, University of Maastricht.

Grilli, V., Kaminsky, G. (1991): Nominal exchange rate regimes and the real exchange rate, Journal of Monetary Economics 27, 191-212.

Hurlin, C. (2004): Nelson and Plosser revisited: A re-examination using OECD panel data, University of Orléans, France.

Im, K.S., Pesaran, M.H., Shin, Y. (2003): Testing for unit roots in heterogeneous panels; Journal of Econometrics 115, 53-74.

Johansen, S. (1995): Likelihood based inference in cointegrated vector autoregressive models, Oxford University Press, Oxford.

Kent, C., Naja, R. (1998): Effective exchange rates and irrelevant nominal exchange rate regimes, Reserve Bank of Australia, Discussion paper 9811.

Levin, A., Lin, C.-F., Chu, C.-S. (2002): Unit root tests in panel data: Asymptotic and finite sample properties, Journal of Econometrics 108, 1-24.

Levy-Yeyati, E., Sturzenegger, F. (2005): Classifying exchange rate regimes: Deeds vs. words, European Economic Review 49, 1603-1635.

Liang, H. (1998): Real exchange rate volatility: Does the nominal exchange rate regime matter, IMF working paper 98/147.

Lothian, J.R., Taylor, M.P. (1996): Real exchange rate behaviour. The recent float from the perspective of the past two centuries, Journal of Political Economy 104, 488-509.

MacDonald (1996): Panel unit root tests and real exchange rates, Economics Letters 50, 7-11.

MacDonald, Marsh, I.W. (1999): Exchange rate modelling, Kluwer Academic Publishers, Boston.

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

Mussa, M. (1986): Nominal exchange rate regimes and the behaviour of real exchange rates: Evidence and implications, Carnegie-Rochester Conference Series on Public Policy 25, 117-214.

Papell, D. (1997): Searching for stationarity: Purchasing power parity under the current float, Journal of International Economics 43, 313-332.

Pesaran, M.H. (2007): A simple panel unit root test in the presence of cross section dependence, Journal of Applied Econometrics 22, 265-312.

Reinhart, C., Rogoff, K. (2002): The modern history of exchange rate arrangements: A reinterpretation, NBER Working paper 8963.

Rogers, J.H. (2002): Monetary union, price level convergence, and inflation: How close is Europe to the United States?, International Finance Discussion Papers 740. Washington: Board of Governors of the Federal Reserve System.

Rogoff, K. (1996): The purchasing power parity puzzle, Journal of the Economic Literature 34, 647-668.

Taylor, A.M. (2002): A century of purchasing power parity, Review of Economics and Statistics 84, 139-150.

Taylor, A.M., Taylor, M.P. (2004): The purchasing power parity debate, Journal of Economic Perspectives 18, 135-158.

Figure 1: Real exchange rates relative to the US Dollar, 1870-2006

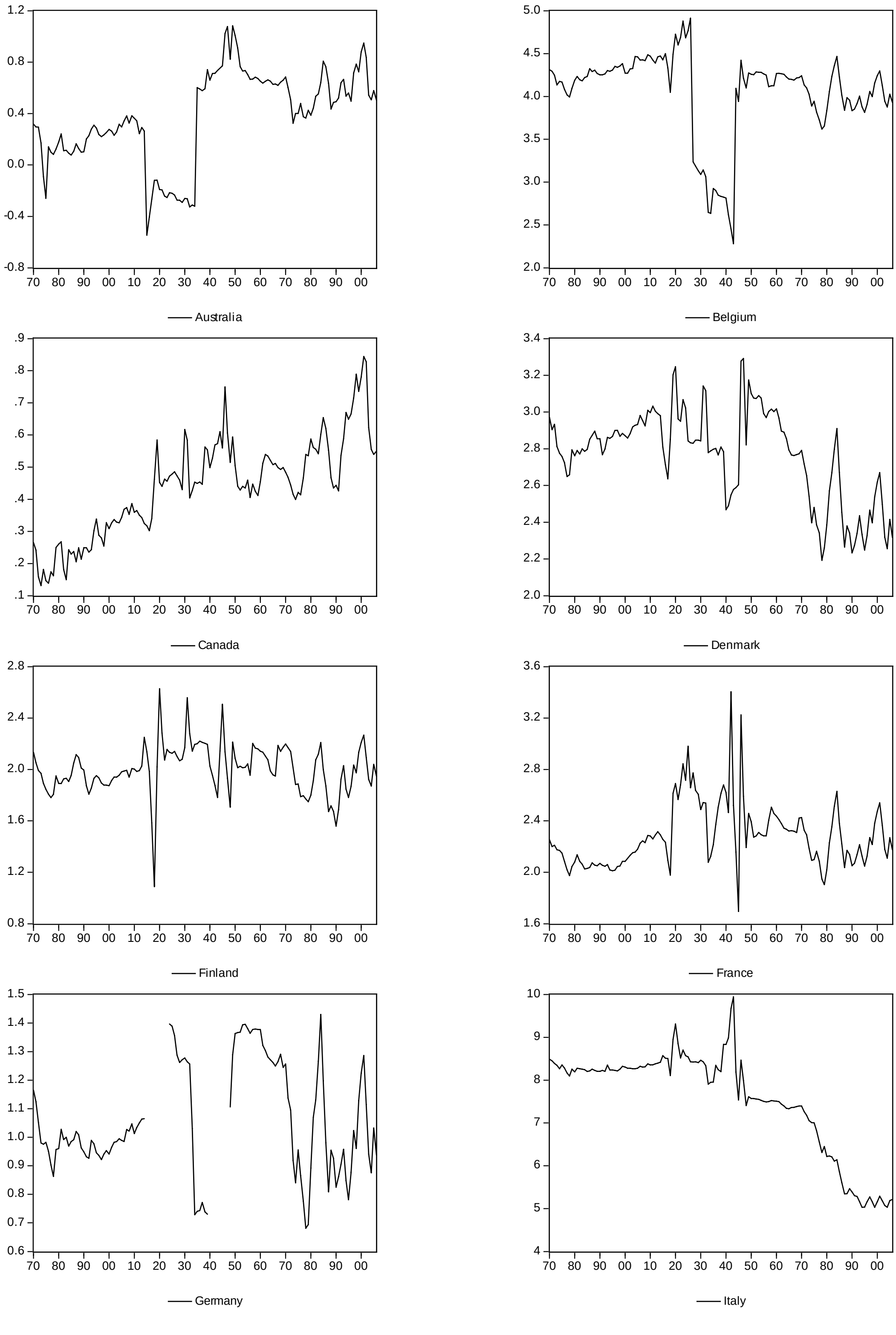
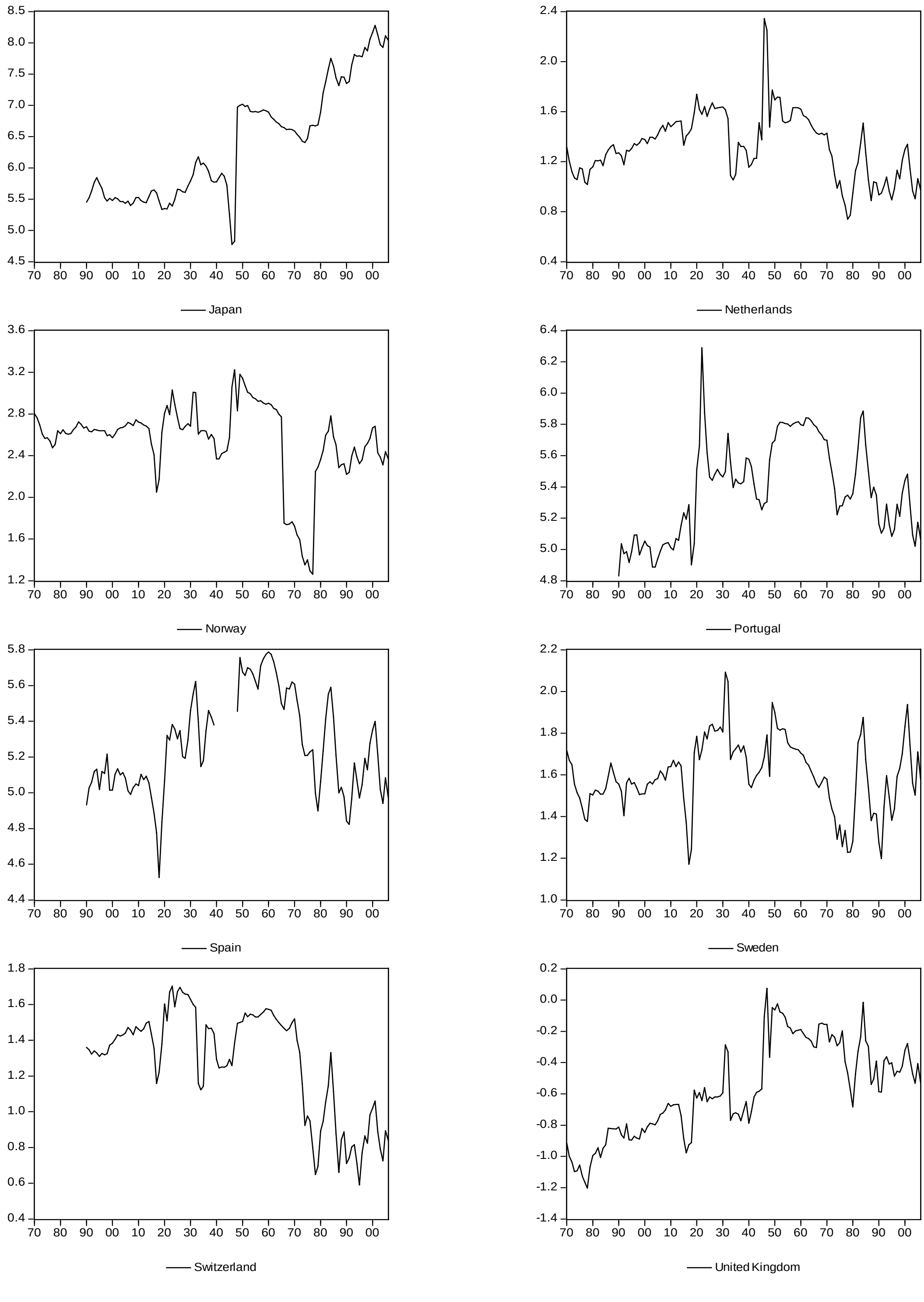


Figure 1 (cont’d): Real exchange rates relative to US dollar, 1870-2006



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

In the analysis wartime years have been excluded.

Table 1: ADF unit root tests for real exchange rates

	1870-1914	1920-1938	1948-1972	1973-2006
Australia	-2.625 (0.096)	-0.615 (0.845)	-2.317 (0.233)	-2.074 (0.256)
Belgium	-1.039 (0.731)	-0.976 (0.740)	-2.812 (0.071)	-3.324 (0.022)
Canada	-1.646 (0.451)	-4.389 (0.003)	-2.901 (0.059)	-2.218 (0.204)
Denmark	-1.634 (0.457)	-3.222 (0.035)	-1.726 (0.406)	-3.306 (0.022)
Finland	-1.655 (0.447)	-6.789 (0.000)	-3.755 (0.009)	-3.261 (0.025)
France	-0.880 (0.785)	-1.734 (0.400)	-2.905 (0.059)	-3.472 (0.015)
Germany	-3.468 (0.014)	-0.387 (0.887)	-1.544 (0.495)	-3.399 (0.018)
Italy	-2.624 (0.096)	-1.478 (0.523)	-1.617 (0.459)	-2.356 (0.162)
Japan	-1.601 (0.467)	-1.411 (0.555)	-0.148 (0.933)	-1.821 (0.364)
Netherlands	-0.687 (0.839)	-1.288 (0.613)	-1.362 (0.584)	-3.610 (0.011)
Norway	-2.923 (0.051)	-2.466 (0.139)	-0.434 (0.889)	-1.853 (0.349)
Portugal	-3.385 (0.022)	-4.498 (0.003)	-3.824 (0.008)	-2.345 (0.165)
Spain	-4.371 (0.002)	-3.512 (0.019)	-1.022 (0.727)	-3.448 (0.016)
Sweden	-2.723 (0.078)	-2.728 (0.088)	-0.233 (0.922)	-2.737 (0.078)
Switzerland	-0.109 (0.938)	-1.869 (0.338)	-1.314 (0.607)	-3.850 (0.006)
UK	-0.935 (0.768)	-2.514 (0.128)	-1.279 (0.623)	-2.911 (0.055)

Note: ADF regressions include a constant, but no trend. 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 has been allowed. Numbers in parentheses denote *p*-values. Gold Standard period for Japan, Portugal, Spain and Switzerland 1890-1914. Due to the period of hyperinflation after WWI, German series start 1924 in the interwar sample.

Table 2: Panel unit root tests for real exchange rates

	1870-1914	1920-1938	1948-1972	1973-2006
IPS (2003)	-2.496*	-2.426*	-0.955	-3.513*
Pesaran (2007)	-2.170*	-1.780	-1.546	-1.404
Bai and Ng (2004)				
Common component (ADF)	-5.892*	-4.601*	-2.583*	-4.058*
Idiosycratic component (IPS)	-5.135*	-2.380*	-2.331*	-5.502*

Note: A balanced panel is required for the panel unit root tests. As data for Japan, Portugal, Spain and Switzerland are not available before 1890, these countries are excluded from the analysis of the Gold Standard. Due to the hyperinflation 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. A '*' implies rejection of the null hypothesis of a unit root in the real exchange rate at least at the 0.05 level of significance.

Table 3: Estimation of half lives

	1870-1914	1920-1938	1948-1972	1973-2006
AR parameter	0.853 (0.022)	0.794 (0.013)	0.905 (0.014)	0.858 (0.019)
Half-life of shocks	4.4	3.0	6.9	4.5

Note: Half lives calculated according to –log(2)/log(δ), where δ is the AR parameter from a panel regression of the real exchange rate on its previous value with country fixed effects. Standard errors in parantheses.