Master Thesis

The Impact of European Single Currency on Purchasing Power Parity

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Contents

List of Tables

Chapter 1

Introduction

Purchasing Power Parity (PPP) is a disarmingly simple theory that holds that the nominal exchange rate between two currencies should be equal to the ratio of aggregate price levels between the two countries, so that a unit of currency of one country will have the same purchasing power in a foreign country.

The idea that Purchasing Power Parity may hold because of international goods arbitrage is related to the so-called Law of One Price (LOP), which holds that the price of an internationally traded good should be the same anywhere in the world once that price is expressed in a common currency, since people could make a riskless profit by shipping the goods from locations where the price is low to locations where the price is high. If the same goods enter each country's market basket used to construct the aggregate price level - and with the same weight - then the Law of One Price implies that a PPP exchange rate should hold between the countries concerned.

This concept of PPP is often termed 'absolute PPP'. 'Relative PPP' is said to hold when the rate of depreciation of one currency relative to another matches the difference in aggregate price inflation between the two countries concerned.

The empirical evidence on PPP is extremely large and PPP condition has been widely tested in the literature. However, the empirical evidence on PPP concerning the European Economic and Monetary Union (EMU) is still scant. The purpose of this paper is to test the validity of the PPP hypothesis between the European Union and the USA in the post-Maastricht period and to examine whether the introduction of the new currency has affected the relationship. Since the role of the euro in international financial markets is growing, an extensive investigation of PPP between the Euro Area and the USA is essential.

As far as the Euro Area is concerned, increased trade on a larger and more integrated market, where barriers to trade and all costs associated with exchange rates are eliminated, should, according to theory, lead to a convergence in the price level for the participating countries. However, in the case of the EU and the USA, uncertainty between the two currencies still exists, but, given the existence of a developed futures market, currency risk has decreased; according to theory, this should lead to a convergence in the price level for the EU and the USA. Is this the case? Has the relationship between the EU and the USA changed after the advent of the euro?

The study applies a variety of econometric techniques, in order to test the impact of the single currency on PPP between the Euro Area and the USA. Univariate and panel unit root methods, as well as cointegration analysis were applied, with the latter providing much stronger support for PPP and the former providing almost no evidence in favor of PPP, neither before nor after the advent of the single currency.

The organisation of the paper is as follows. In Chapter 2 previous theoretical work is discussed and the results that have been shown in the literature. Chapter 3 describes the methodology used, while Chapter 4 describes the dataset and summarizes the results. Finally, Chapter 5 concludes. Analytical results of the tests are given in the Appendices, along with graphs of the data.

Chapter 2

Literature Review

2.1 Theory

2.1.1 The Law of One Price

The Law of One Price is the fundamental building-block of the PPP condition (*Sarno and Taylor, 2002*). Formally, the LOP in its absolute version may be written as:

$$P_{i,t} = S_t P^*_{i,t} \ , \qquad i = 1, 2, ..., N, \tag{2.1}$$

where $P_{i,t}$ denotes the price of good i in terms of the domestic currency at time t, $P^*_{i,t}$ is the price of good i in terms of the foreign currency at time t and S_t is the nominal exchange rate expressed as the domestic price of the foreign currency at time t.

In its relative version, the LOP postulates the relatively weaker condition:

$$\frac{P^*_{i,t+1} S_{t+1}}{P_{i,t+1}} = \frac{P^*_{i,t} S_t}{P_{i,t}} \ , \qquad i = 1, 2, ..., N. \tag{2.2}$$

Obviously, the absolute LOP implies the relative LOP, but not vice versa.

Formally, by summing all the traded goods in each country, the absolute version of the PPP hypothesis requires:

$$\sum_{i=1}^{N} \alpha_i P_{i,t} = S_t \sum_{i=1}^{N} \alpha^*_i P^*_{i,t}, \tag{2.3}$$

where the weights in the summation satisfy $\sum_{i=1}^{N} \alpha_i = 1$. If the national price levels are P_t and P^*_t and provided that price levels are the same across countries ($\alpha_i = \alpha^*_i$), we have:

$$P_t = S_t P^*_t. \tag{2.4}$$

Equation (2.4) can also be written as:

$$S_t = \frac{P_t}{P^*_t}, \tag{2.5}$$

or, in logarithmic form:

$$s_t = p_t - p_t^*. \tag{2.6}$$

According to the relative PPP condition, we have in logarithmic form:

$$\hat{s}_t = \pi_t - \pi_t^*, \tag{2.7}$$

where $\hat{s}_t = (S_{t+1} - S_t)/S_t$ is the growth rate of the nominal exchange rate , $\pi_t = (P_{t+1} - P_t)/P_t$ and $\pi_t^* = (P_{t+1}^* - P_t^*)/P_t^*$ are the domestic and foreign inflation rate, respectively.

2.1.2 Real exchange rate

If the nominal exchange rate is defined simply as the price of one currency in terms of another, then the real exchange rate Q_t is the nominal exchange rate adjusted for relative national price level differences, namely:

$$Q_t = S_t \left(\frac{P_t^*}{P_t} \right), \tag{2.8}$$

where the ratio $\frac{P_t^*}{P_t}$ denotes the relative price level, i.e. the price in which domestic goods are traded for foreign goods. In logarithmic form, we have

$$q_t \equiv s_t - p_t + p_t^*. \tag{2.9}$$

When PPP holds, the real exchange rate is a constant so that movements in the real exchange rate represent deviations from PPP. Hence, a discussion of the real exchange rate is tantamount to a discussion of PPP.

The real exchange rate can be used as a measure of domestic goods' competitiveness in international markets, since a higher Q_t means depreciation of the domestic currency and, hence, more competitive domestic goods. In fact, an overall measure of a country's external competitiveness is the effective exchange rate, which is weighted average of a basket of foreign currencies. A nominal effective exchange rate is weighted with trade weights, while a real effective exchange rate adjust nominal by appropriate foreign price level and deflates by the home country price level.

2.1.3 Long-run deviations from PPP

A number of recent studies assume that real exchange rates tend toward purchasing power parity in the very long run (*Rogoff, 1996*). However, there are two unresolved puzzles in the literature. First, it is controversial whether long-run PPP is valid during the recent floating exchange rate regime (*Sarno, 2005*); second, the majority of studies provide strong empirical evidence both that deviations from the LOP are highly volatile and that the volatility of relative prices is considerably lower than the volatility of nominal exchange rates, the so-called Purchasing Power Parity Puzzle (see *Rogoff, 1996*).

Clearly, the LOP can be adequately tested only if goods produced internationally are perfect substitutes. Nevertheless, the presence of any sort of tariffs, transportation costs and other non-tariff barriers and duties would induce a violation of the no-arbitrage condition and, inevitably, of the LOP. In general, however, product differentiation across countries creates a wedge between domestic and foreign prices of a product which is proportional to the freedom with which the good itself can be traded. *Engel and Rogers* (*1996*), using Consumer Price Index (CPI) data for both US and Canadian cities, provide evidence that the distance between cities can explain a considerable amount of the price differential of similar goods in different cities of the same country. Nevertheless, the price differentials are considerably larger for two cities in different countries than for two equidistant cities in the same country, the so-called 'border effect'.

Moreover, the appropriate price index to be used in implementing PPP is of crucial importance. Considerable differences may arise where price impulses impinge heterogeneously across the various goods and services in an economy and, in particular, where price inflation differs between the traded and non-traded goods sectors. A particular example of this – the *Balassa–Samuelson effect* – considers that such differences are due to differences in the growth rates of technological progress between traded and non-traded goods sectors, which cause differences in productivity growth. The *Balassa* (*1964*) and *Samuelson* (*1964*) analysis is based on the following assumptions: technological progress is faster in traded goods, while productivity is higher in developed countries; the wages tend to equate among the two sectors in each country, while they are higher in developed countries and, finally, traded goods prices alone tend to equate between countries. According to the previous assumptions, the relative price of non-traded goods will be higher in developed counties, leading to false results due to productivity differences between the countries. Hence, in order to test the PPP hypothesis, not only prices, but productivity changes as well should be taken into account.

According to *Égert et al.* (*2003*), productivity growth in the open sector leads to inflation in non-traded goods and because of the low share of non-tradables and the high share of food items in addition to regulated prices, CPI is misleading when analyzing the *Balassa-Samuelson effect*.

Additionally, *Taylor and Taylor* (*2004*) provide evidence that PPP works much better if it is based on indices made only of tradable goods, such as Producer Price Index (PPI), rather than Consumer Price Indices (CPI).

On the other hand, the 'Big Mac Index' is an informal way of measuring the purchasing power parity between two currencies and was introduced by the *Economist* in 1986 as a humorous illustration. It provides a test of the extent to which market exchange rates result in goods costing the same in different countries, while the basket of goods is considered to be a Big Mac burger as sold by the McDonald's fast food restaurant chain.

2.2 Empirical Evidence

According to *Sarno and Taylor* (*2002*), it is useful to separate the enormous empirical evidence on PPP into six different stages: the early empirical literature on PPP, tests of the random walk hypothesis for the real exchange rate and cointegration studies, long-span studies and panel data studies, in order to overcome the low power problem in testing for mean reversion in the real exchange rate and finally, studies employing nonlinear econometric techniques.

2.2.1 The early empirical literature on PPP

The early empirical literature, until the late 1970s, on testing PPP is based on estimates of equations of the form:

$$s_t = \alpha + \beta_1 p_t + \beta_2 p_t^* + \varepsilon_t, \tag{2.10}$$

where ε_t is a disturbance term. A test of the restrictions $\beta_1 = 1$, $\beta_2 = -1$ would be interpreted as a test of absolute PPP, while a test of the same restrictions applied to the equation with the variables in first differences would be interpreted as a test of relative PPP. In particular, a distinction is often made between the test that β_1 and β_2 are equal and of opposite sign – the symmetry condition – and the test that they are equal to unity and minus unity respectively – the proportionality condition.

Frenkel (*1978, 1981*), using data for three exchange rates over the period 1921-1925, under floating exchange rates regime, finds evidence for PPP on high inflation countries, but rejects the PPP hypothesis on data over the period 1973-1979. Frenkel argues that the rejection of PPP may be due only to temporary real shocks and price stickiness in the goods markets. Similar results are also found by *Krugman* (*1978*), who tests the PPP hypothesis in the industrialized countries over the period 1973-1976.

2.2.2 Tests of a unit root in the real exchange rate

The approach taken by the second stage of tests of PPP is based on testing for the nonstationarity of the real exchange rate. Stationarity of the real exchange rate implies evidence of long-run PPP, while a unit root process implies absence of any tendency to converge on a long-run equilibrium level.

Tests of stationarity in the real exchange rate rely on estimation of equations of the form:

$$q_t = \alpha + \beta q_{t-1} + \varepsilon_t. \tag{2.11}$$

The null of a random walk implies that β is equal to one and the alternative of mean reversion has $\beta < 1$.

Meese and Rogoff (*1988*), using data for the real exchange rate between US, Germany, Japan and UK, cannot reject the null of a unit root for the period 1974-1986. *Mark* (*1990*) comes to a similar conclusion, using data on eight industrial countries during the flexible exchange rate period 1973-1988. Finally, *Chen* (*1995*), testing five EU countries, finds evidence of PPP for most cases.

2.2.3 Cointegration studies of PPP

Cointegration seems to be an ideal approach to testing for PPP (*Sarno and Taylor, 2002*). While allowing q_t, the 'equilibrium error', to vary in the short run, a necessary condition for PPP to hold is that q_t is stationary over time. If this is not the case, then the nominal exchange rate and the relative price will permanently tend to diverge. Cointegration between the nominal exchange rate and the two price levels or the relative price is a necessary condition for them to have a stable long-run relationship. The hypotheses tested are, in particular, those of symmetry and proportionality, which imply 'weak' and 'strong' PPP, respectively.

McNown and Wallace (*1989*) show some evidence in support of PPP, testing for cointegration relations between exchange rates and price indices in four high inflation countries against the US during the 1970s and 1980s. *Choudhry et al.* (*1991*) provide evidence that PPP held as a long run constraint between the US and Canada for the period 1950-1961, as well as between the US and the UK, while not as strong; however, PPP is rejected for the Canadian-UK exchange rate. *MacDonald* (*1993*) finds evidence in favor of weak form PPP, whilst strong form PPP receives practically no support, testing a number of bilateral US dollar exchange rates and their corresponding relative prices, during 1974-1990. *Dockery and Georgellis* (*1994*), testing the PPP hypothesis for nine Greek drachma exchange rates, for the period 1980-1992, provide evidence in favor of the long-run PPP hypothesis only in the case of Portugal, Spain and the UK.

Additionally, *Chen* (*1995*) applies tests for parameter stability of cointegrated system and finds evidence that the cointegrating relationship is stable in most cases between France, Germany, Italy, Belgium and the Netherlands, over the whole floating exchange rate period.

On the other hand, *Cheung et al.* (*1995*) find controversial results, depending on the home country. In particular, when Germany is considered as the home country, the PPP hypothesis receives more support than with France serving as the home country. Moreover, *Dutt* (*1998*) finds evidence in favor of the parity hypothesis within the European Monetary System (EMS), using both CPI and PPI. Finally, *Brissimis et al.* (*2005*) test for long-run PPP during the post-Bretton Woods period 1972-1997 in the case of Greece and France. Using multivariate cointegration analysis, they find very supportive results in the case of Greece, once policy effects are taken into account; otherwise estimation biases are found to be significant, while for France, their results reveal that biases due to policy effects are not as important.

2.2.4 Long-span studies

One well-documented explanation for the inability to find clear-cut evidence of PPP is that the data period for the recent float alone may simply be too short to provide any reasonable degree of test power in the normal statistical tests for stationarity of the real exchange rate (*Taylor, 1995*). The first approach considered in the literature to circumventing the low power problem of conventional unit root tests was to employ long-span data sets.

Lothian and Taylor (*1996*), using annual data that continuously span some two centuries in length, from 1791 to 1990, for dollar-sterling and franc-sterling real exchange rates, find strong evidence in favor of mean-reverting real exchange rate behaviour and reinforce the idea of PPP as a long-run constraint. *Taylor* (*2002*) also finds favorable evidence for long-run PPP, using data for one hundred years.

On the other hand, *Cuddington and Liang* (*2000*), using the two centuries of data from *Lothian and Taylor* (*1996*), find evidence that rejects the long-run PPP hypothesis for the dollar-sterling exchange rate, because of significant time trends in the unit root test equations, which had not been taken into account.

2.2.5 Panel data studies

A different approach found in the literature on testing for PPP in order to circumvent the problem of low power displayed by conventional unit root tests is to increase the number of exchange rates under consideration. According to *Papell and Theodoridis* (*1998*), the evidence of PPP strengthens with panel, but not univariate methods. *Heimonen* (*1999*) provide evidence of PPP in a small panel of four EU countries, namely Germany, the Netherlands, Belgium and France, but finds weaker evidence for PPP in a panel of 13 EU countries.

Culver and Papell (*1999*) also use panel methods is order to test for the presence of a unit root in real exchange rates in the case of several cities of US and Canada, as well as 15 EU countries, for the period 1978-1997, but find much less evidence of PPP with relative prices in the within country panels than with real exchange rates between EU countries. On the other hand, *Flôres et al.* (*1999*) find strong evidence in favor of long-run PPP, using multivariate unit root tests on dollar versus european currencies during flexible exchange rates regime, from 1973 to 1994.

2.2.6 Nonlinear real exchange rate dynamics

One approach to resolving the PPP puzzles lies in allowing for nonlinear dynamics in real exchange rate adjustment. While in a linear framework, the adjustment speed of PPP deviations from parity is assumed to be uniform at all times, there are good reasons for suspecting that the speed of convergence toward the PPP exchange rate should be greater as the deviation from PPP rises in absolute value (*Taylor and Taylor, 2004*). The presence of international transactions costs between separated markets may imply a nonlinear process and cause significant deviations from the LOP.

Michael et al. (*1997*) clearly reject the linear framework and provide strong evidence of mean-reverting behaviour for PPP deviations. *Taylor et al.* (*2001*) use nonlinearly mean-reverting models to real dollar exchange rates over the post-Bretton Woods period 1973-1996. Their results provide strong confirmation that four major real bilateral dollar exchange rates are well characterized by nonlinearly processes. By taking account of statistically significant nonlinearities, they find the speed of real exchange rate adjustment to be typically much faster than the apparently slow speeds of real exchange rate adjustment recorded previously. Moreover, *Kapetanios et. al* (*2003*) provide evidence of nonlinear mean-reversion in real exchange rates, proving that the nonlinear test they propose is able to reject a unit root in many cases, whereas the linear Dickey-Fuller tests fail.

2.3 The Euro

2.3.1 Background

The euro is the official currency of the European Union (EU), used in 15 member states, known collectively as the Eurozone (Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovenia and Spain). It is also used in 9 other states and territories as their sole currency[1].

[1] These states are Akrotiri and Dhekelia, Andorra, Kosovo, Mayotte, Monaco, Montenegro, San Marino, Saint Pierre and Miquelon and Vatican City.

Table 2.1: Yielded currencies of the Eurozone

Currency	Abbr.	Rate	Fixed on	EMU III
Austrian schilling	ATS	13.7603	31/12/1998	1999
Belgian franc	BEF	40.3399	31/12/1998	1999
Dutch gulden	NLG	2.20371	31/12/1998	1999
Finnish markka	FIM	5.94573	31/12/1998	1999
French franc	FRF	6.55957	31/12/1998	1999
German mark	DEM	1.95583	31/12/1998	1999
Irish pound	IEP	0.78756	31/12/1998	1999
Italian lira	ITL	1936.27	31/12/1998	1999
Luxembourg franc	LUF	40.3399	31/12/1998	1999
Portuguese escudo	PTE	200.482	31/12/1998	1999
Spanish peseta	ESP	166.386	31/12/1998	1999
Greek drachma	GRD	340.75	19/06/2000	2001
Slovenian tolar	SIT	239.64	11/07/2006	2007
Cypriot pound	CYP	0.58527	10/07/2007	2008
Maltese lira	MTL	0.4293	10/07/2007	2008

Notes: rate is defined as domestic currency per euro

The Eurozone (also called Euro Area, Eurosystem or Euroland) is the third and final step in the process of creating the European Economic and Monetary Union (EMU). All member states of the European Union participate in the EMU, although the United Kingdom, Denmark and Sweden have not accepted the third stage and the three EU members still use their own currency today.

The Treaty of Maastricht in 1992 established the completion of the EMU as a formal objective and set a number of economic convergence criteria, concerning the inflation rate, public finances, interest rates and exchange rate stability, while, from the start of 1999, the euro became a real currency and a single monetary policy was introduced under the authority of the European Central Bank, ECB. A three-year transition period began before the introduction of actual euro notes and coins, but legally the national currencies had already ceased to exist. In 1998 eleven EU member states had met the convergence criteria and the Eurozone came into existence with the official launch of the euro on 1 January 1999. Greece qualified in 2000 and was admitted on 1 January 2001, while the euro notes and coins were introduced on 1 January 2002; Slovenia qualified in 2006 and was admitted on 1 January 2007 with Cyprus and Malta joining on 1 January 2008.

2.3.2 What should we expect from the advent of the single currency?

The advent of a single currency, along with a customs union, like the EU, should lead to a great increase in trade, according to *Rose* (*2000*). Such a union reduces transaction costs for foreign trade (*Alesina and Barro, 2000*) as well as eliminates nominal exchange rate volatility (*Tenreyro and Barro, 2003*), since there are no longer barriers to trade and currency risk within the union. Consequently, competition among member countries increases and prices on commonly traded goods are expected to converge, causing inflation in some regions and deflation in others during the transition. However, *Honohan and Lane* (*2003*) underline the importance of extra-union trade; a member country that trades with a non-member country may experience different inflationary pressures, compared to a country which trades only within the union.

The other aspect of such a union is the single monetary policy. All member countries face the same nominal interest rate, set by the ECB. Since this is a tool for price stability, a single interest rate should lead to price convergence across the member countries. Nevertheless, the lack of domestic monetary policy may lead to difficulties from recovering from asymmetric shocks, such as price shocks, output shocks, supply shocks etc. (*Alesina and Barro, 2000*), while *Honohan and Lane* (*2003*) argue that domestic fiscal policy is not an effective counterweight. Moreover, the countries' initial price level plays an important role, since the common interest rate may affect each country differently, during the transition.

In the case of EU versus USA, however, though the currency risk is not eliminated, it is decreased, due to the fact that one could employ the futures market for hedging, since they are the most traded currencies, so that the uncertainty between them be reduced. If this is the case, prices between EU and US are expected to converge, as well.

Overall, the european economic integration process is expected to lead to price comovements across the member countries, as well as between them and the US, while this may not be clear due to extra-union trade and the initial domestic price level.

2.3.3 Empirical evidence on the impact of the Euro on PPP

The influence of the european economic integration process on price convergence and the stationarity of real exchange rates has fuelled the interest of several authors in the last years. *Koedijk et al.* (*2004*), using a panel of real exchange rates, test the PPP hypothesis within the Euro Area. For this purpose they collect a dataset of consumer price index (CPI) and nominal exchange rates against the US dollar for 10 euro area countries for the period 1973-2003 and construct the real exchange rates using the German Mark as the numéraire currency. They provide evidence in favor of

PPP, when a common mean reversion coefficient is assumed, while with different mean reversion coefficients they find evidence in support of PPP only for Belgium, Finland, France and Spain.

They also test the PPP hypothesis between the Euro Area, as a separate economic entity, and other major economies, such as UK, Canada, Denmark, Japan, Norway, Switzerland, Sweden and US, using the 'synthetic' euro[2] up to December 1998. Evidence of PPP is only detected between the Euro Area and Switzerland, when heterogeneous mean reversion is assumed, while the assumption of homogeneous mean reversion presents evidence in favor of PPP for the full panel.

Finally, they assess the impact of the Maastricht Treaty and the introduction of the euro on the convergence toward PPP. They confirm that especially the former event had an important impact on the stationarity of real exchange rates in the Euro Area, since strong evidence in favor of PPP is detected after 1992.

Gadea et al. (*2004*) study the evolution of the US dollar real exchange rate vis-à-vis the EU currencies during the recent floating regime, before and after the birth of the euro, over the period 1974-2001. They argue that the omission of some structural breaks which affect the behaviour of the real exchange rates may cause the unit root hypothesis to be accepted, resulting the apparent lack of evidence in support of PPP and allow for three breaks; the first at the beginning of the 1980's, the second around 1985, while the third break appearing in 1996.

They split the period into two subperiods which reflect the pre and post-euro creation process, with 1997 the key year which marked the beginning of the process of monetary union. The economies considered are 14 EU Euro Area and non-Euro Area countries.

They find no evidence in favor of the PPP hypothesis when the whole period is considered; nevertheless, strong evidence of PPP is provided for the period prior to the transition to the euro for those currencies closely related to the German Mark, namely those of Austria, Belgium, Denmark, France and the Netherlands, when allowing for two changes in the mean. Thus, they consider that a weaker version or quasi long-run PPP holds.

Lopez and Papell (*2007*) claim that the choice of the numéraire currency plays an important role on the evidence of PPP. They use panel data on CPI and nominal exchange rates in US dollars for 23 countries from 1973 to 2001 and split the countries into 5 groups, namely the Eurozone, other Europe countries, negotiating countries, industrialized countries and Mediterranean countries.

They find strong evidence of convergence to PPP within the Eurozone, with the

[2] The synthetic euro consists of the exchange rates of the euro legacy currencies, which are geometrically weighted together using trade weights.

three largest members, France, Germany and Italy, as the numéraire currency, but they find no evidence of PPP before 1992; however, there is rapid convergence to PPP, starting in 1996. Moreover, they test the PPP hypothesis between the Eurozone and the other countries, but the evidence is weaker. When the US dollar is used as the numéraire currency, however, strong evidence of PPP is provided, with the process of convergence starting in 1993 and a rejection of the unit root hypothesis beginning in 1998.

Dwyer et al. (*2007*), on the other hand, find evidence not supportive of PPP within the Eurozone, using data of real exchange rates for eleven countries, from 1957 to 2005, with Germany being the numéraire country. Using univariate, as well as panel unit root tests, there is scant support for PPP in the Euro Area. The unit root hypothesis is inconsistent with the data for half of the countries during the whole period, while there is even less support when they split the sample into two subperiods, namely from 1973 to 2005 and from 1993 to 2005.

They also use Bayesian analysis in order to test the probability of a unit root versus the probability of there not being a unit root and conclude that a unit root is less likely; in other words PPP receives support from these data.

Stronger support for PPP is provided by *Zhou et al.* (*2008*), using the nonlinear unit root test proposed by *Kapetanios et. al* (*2003*) to the bilateral real exchange rates of both European and other industrial countries, with the French franc and German mark (and the euro after 1998), as well as the US dollar as numéraire currencies. They suggest that convergence toward PPP between the EU countries, especially the Euro Area countries, tends to be nonlinear, because of factors such as transportation costs and trade barriers, as well as official interventions in the foreign exchange market. Using two sample periods, 1975-1998 and 1975-2006, they test whether the adoption of the euro has contributed to PPP to hold better.

Their results show that, during the first period, there is evidence of PPP for most of the counties, by either the linear or the nonlinear tests. As far as the second period is concerned, the evidence of PPP is even stronger, with the nonlinear tests showing more evidence to reject the null of nonstationarity, when the real exchange rates are expressed with respect to the currencies of France and Germany; however, when they are expressed with respect to the US dollar, the linear tests show more evidence to reject the null.

Overall, *Zhou et al.* (*2008*) suggest that PPP tends to hold well within the EU even before the adoption of the euro, while there is no evidence that the use of the euro has played an essential role for better performance of the PPP hypothesis within the Eurozone.

Chapter 3

Methodology

The empirical analysis presented in this paper consists of two parts. In the first part PPP hypothesis is tested using unit root methods, while in the second part PPP is tested using cointegration approach. A brief description of the tests used is given below.

3.1 Unit root tests

3.1.1 Unit root tests on real exchange rates

For each country i, the bilateral real exchange rate with US dollar is difined as follows:

$$q_i = s_i - p_i + p_{us}, \tag{3.1}$$

where q_i is the real exchange rate, s_i is country i's currency price of a dollar, p_i and p_{us} are the price indices of country i and the US, respectively. All these variables are in their logaritmic form.

As stipulated earlier, if PPP holds perfectly, the real exchange rate is constant. This means that the process q_i does not contain any unit root, then the process is defined as stationary.

Several unit root and stationarity tests, disribed below, were applied to the data. Apart from the real exchange rates, prices, relative prices and nominal exchange rates were also tested.

The Augmented Dickey-Fuller (1979) unit root test (ADF)

The standard DF test is carried out by estimating equation (2.11) after substracting q_{t-1} from both sides of the equation:

$$\Delta q_t = \alpha + \eta t + \delta q_{t-1} + \varepsilon_t, \tag{3.2}$$

where $\delta = \beta - 1$, t is the time or trend variable and ε_t is assumed to be white noise. The null and alternative hypotheses may be written as:

$$\begin{aligned} H_0 &: \delta = 0 \\ H_A &: \delta < 0. \end{aligned}$$

Under the null, there is a unit root, while under the alternative, there is no unit root. The null hypothesis is evaluated using the conventional t-ratio for δ:

$$t_\delta = \frac{\hat{\delta}}{se(\hat{\delta})}, \tag{3.3}$$

where $\hat{\delta}$ is the estimate of δ and $se(\hat{\delta})$ is the coefficient standard error.

The simple *Dickey-Fuller* unit root test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances ε_t is violated. The ADF test constructs a parametric correction for higher-order correlation by assuming that the q series follows an AR(p) process and adding p lagged difference terms of the dependent variable q to the right-hand side of the test regression:

$$\Delta q_t = \alpha + \eta t + \delta q_{t-1} + \sum_{i=1}^{p} \beta_i \Delta q_{t-i} + \varepsilon_t. \tag{3.4}$$

This augmented specification is then used to test the null hypothesis, using the t-ratio.

The Phillips-Perron (1988) unit root test (PP)

An important assumption of the DF test is that the error terms ε_t are independently and identically distributed. The ADF test adjusts the DF test to take care of possible serial correlation in the error terms by adding the lagged difference terms of the regressand. *Phillips and Perron* (*1988*) use nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. The asymptotic distribution of the PP test is the same as the ADF test statistic.

The Kwiatkowski, Phillips, Schmidt, and Shin (1992) stationarity test (KPSS)

The KPSS test differs from the other unit root tests described here in that the series q_t is assumed to be (trend-) stationary under the null. The KPSS statistic is based on the the residuals from the OLS regression of q_t on a constant or a constant and trend:

$$q_t = \alpha + \eta t + \varepsilon_t. \tag{3.5}$$

The LM statistic is defined as:

$$LM = \frac{1}{\hat{\sigma}^2 T^2} \sum_{t=1}^{T} S_t^2, \tag{3.6}$$

where S_t is the partial sum of the residuals and $\hat{\sigma}^2$ is an estimate of the long run variance of the residuals. The stationary null is rejected when LM statistic is large, since that is evidence that the series wanders from its mean.

3.1.2 Unit root tests with structural break

A stationary time-series may look like nonstationary when there are structural breaks in the intercept or trend, leading to false nonrejection of the null hypothesis.Therefore, a shift function may be added to the deterministic term of q_t. Hence, a model

$$q_t = \alpha + \eta t + \gamma f_t(\theta) + \varepsilon_t \tag{3.7}$$

is considered, where θ and γ are unknown parameters. The first one is confined to the positive real line, whereas the second one may assume any value. The shift function $f_t(\theta)$ used in this paper is based on the exponential distribution function which allows for a nonlinear gradual shift to a new level starting at time T_B,

$$f_t(\theta) = \begin{Bmatrix} 0, & t < T_B \\ 1 - \exp\{-\theta(t - T_B + 1)\}, & t \geq T_B \end{Bmatrix} \tag{3.8}$$

Lanne et al. (*2002*) propose unit root tests for the model (3.7), which are based on estimating the deterministic term first by a generalized least squares (GLS) procedure under the unit root null hypothesis and subtracting it from the original series. Then an ADF type test is performed on the adjusted series, which also includes terms to correct for estimation errors in the parameters of the deterministic part.

3.1.3 Nonlinear unit root tests

A nonlinear unit root test, proposed by *Kapetanios et. al* (*2003*) and employed by *Zhou et al.* (*2008*), was also applied to the real exchange rates. *Kapetanios, Shin and Snell* (*KSS*) (*2003*), developed a new technique for the null hypothesis of a unit root against an alternative of nonlinear stationary smooth transition. Their test is based on the following exponential smooth transition autoregressive (ESTAR) specification:

$$\Delta q_t = \gamma q_{t-1}[1 - \exp\{-\theta q_{t-1}^2\}] + \varepsilon_t, \quad \theta \geq 0 \tag{3.9}$$

where q_t is the series of real exchange rates and $[1 - \exp\{-\theta q_{t-1}^2\}]$ is the exponential transition function adopted in the test to present the nonlinear adjustment. The null hypothesis of a unit root in q_t implies that $\theta = 0$, hence we test

$$H_0 : \theta = 0$$

against the alternative

$$H_A : \theta > 0.$$

Because γ in equation (3.9) is not identified under the null, we cannot directly test $H_0 : \theta = 0$. To deal with this issue, KSS suggest reparametrize equation (3.9) by computing a first-order Taylor series approximation to specification equation (3.9) to obtain the auxiliary regression:

$$\Delta q_t = \delta q_{t-1}^3 + \varepsilon_t. \tag{3.10}$$

Assuming a more general case where the errors are serially correlated, regression (3.10) is extended to:

$$\Delta q_t = \sum_{j=1}^{p} \rho_j \Delta q_{t-j} + \delta q_{t-1}^3 + \varepsilon_t. \tag{3.11}$$

with the p augmentations, which are used to correct for serially correlated errors. The null hypothesis of nonstationarity to be tested with either equation (3.10) or (3.11) is

$$H_0 : \delta = 0$$

against the alternative

$$H_A : \delta < 0$$

and the t-statistic is

$$t_{NL} = \frac{\hat{\delta}}{se(\hat{\delta})}. \tag{3.12}$$

KSS show that the t_{NL} statistic does not have an asymptotic standard normal distribution. They tabulate the asymptotic critical values of the t_{NL} statistics via stochastic simulations.

To accommodate stochastic processes with nonzero means and/or linear deterministic trends, KSS modify the data as follows. In the case where the data has nonzero mean they use the de-meaned data, while for the case with nonzero mean and nonzero linear trend they use the de-meaned and de-trended data.

In this paper, t_{NL} statistics were estimated using regression (3.10), due to the fact that the optimal number of lags, according to the *Schwarz Information Criterion* (*SIC*), was zero. The maximum number of lags was set to 12, for the monthly data. To obtain the de-meaned or de-trended data, we first regress each series on a constant or on both a constant and a time trend, respectively, and then we save the residuals, that are used to carry out the test.

3.1.4 Panel unit root tests

Adding the cross-sectional dimension to the usual time dimension is very important in the context of nonstationary series, because it allows to solve the low power issue of unit root tests in small samples. However, the issue of heterogeneity in the parameters is introduced, when using panel data instead of individual time series, and this heterogeneity must be taken into account.

Five types of panel unit root tests were applied to the real exchange rates. Such tests are the *Levin, Lin and Chu* (*2002*) test (LLC) , the *Breitung* (*2000*) test (BR), the Im, Pesaran and Shin (*2003*) test (IPS), Fisher-type tests using ADF and PP tests (the *Maddala and Wu* (*1999*) test (MW) and the *Choi* (*2001*) test (CH)) and, finally, the *Hadri* (*2000*) test (HAD).

Panel unit root tests are similar, but not identical, to unit root tests carried out on a single series. Consider a following AR(1) process for panel data:

$$q_{i,t} = \rho_i q_{i,t-1} + X_{i,t}\delta_i + \varepsilon_{i,t}, \tag{3.13}$$

where $i = 1, 2, ..., N$ cross-section units or series, that are observed over periods $t = 1, 2, ..., T$. The $X_{i,t}$ represent the exogenous variables in the model, including any fixed effects or individual trends, ρ_i are the autoregressive coefficients, and the errors $\varepsilon_{i,t}$ are assumed to be mutually independent idiosyncratic disturbance. If $|\rho_i| < 1$, $q_{i,t}$ is said to be weakly (trend-) stationary. On the other hand, if $|\rho_i| = 1$, then $q_{i,t}$ contains a unit root.

For purposes of testing, there are two natural assumptions that we can make about the ρ_i. First, one can assume that the persistence parameters are common across cross-sections so that $\rho_i = \rho$ for all i (homogeneity assumption). The LLC, BR, and HAD tests all employ this assumption. Alternatively, one can allow ρ_i to vary freely across cross-sections (heterogeneity assumption). The IPS, MW and CH tests are of this form. With the exception of the HAD test, all tests employ a null hypothesis of a unit root.

Tests with Common Unit Root Process

LLC and BR both consider the following basic ADF specification:

$$\Delta q_{i,t} = \alpha_i q_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta q_{i,t-j} + X_{i,t}\delta_i + \varepsilon_{i,t}, \tag{3.14}$$

where we assume a common $\alpha = \rho - 1$, but allow the lag order for the difference terms, p_i, to vary across cross-sections. The null and alternative hypotheses for the tests may be written as:

$$H_0 \;:\; \alpha_i = 0$$
$$H_A \;:\; \alpha_i < 0.$$

Under the null hypothesis, there is a unit root, while under the alternative, there is no unit root.

The method described in LLC derives estimates of α from proxies for $\Delta q_{i,t}$ and $q_{i,t}$ that are standardized and free of autocorrelations and deterministic components. LLC suggest using the following modified t-statistic:

$$t^*_\alpha = \frac{t_\alpha - (N\tilde{T})S_N\hat{\sigma}^{-2}se(\hat{\alpha})\mu^*_{\tilde{T}}}{\sigma^*_{\tilde{T}}}, \tag{3.15}$$

where t_α is the standard t-statistic for $\hat{\alpha} = 0$, $\hat{\sigma}^2$ is the estimated variance of the error term, $se(\hat{\alpha})$ is the standard error of $\hat{\alpha}$ and

$$\tilde{T} = T - \frac{\sum_{i=1}^N p_i}{N} - 1. \tag{3.16}$$

Finally, S_N is the average standard deviation ratio and $\mu^*_{\tilde{T}}$ and $\sigma^*_{\tilde{T}}$ are adjustment terms for the mean and standard deviation. In LLC test, we reject the null hypothesis when the t-statistic is smaller than a critical value from the lower tail of a standard normal distribution. The BR method differs in constructing the standardized proxies.

The HAD test is similar to the KPSS test, and has a null hypothesis of no unit root in any of the series in the panel. Like the KPSS test, the HAD test is based on the residuals from the individual OLS regressions of $q_{i,t}$ on a constant, or on a constant and a trend:

$$q_{i,t} = \alpha_i + \eta_i t + \varepsilon_{i,t}. \tag{3.17}$$

Given the residuals, the HAD test is defined by:

$$LM = \frac{1}{\hat{\sigma}_i^2 NT^2}\left(\sum_{i=1}^N \sum_{t=1}^T S_{i,t}^2\right), \tag{3.18}$$

where $S_{i,t}$ is the partial sum of the residuals and $\hat{\sigma}_i^2$ is an estimate of the long run variance of $q_{i,t}$. HAD shows that under mild assumptions,

$$Z = \frac{\sqrt{N}(LM - \xi)}{\zeta} \rightarrow N(0,1), \tag{3.19}$$

where $\xi = \frac{1}{6}$ and $\zeta = \frac{1}{45}$, if the model only includes constants and $\xi = \frac{1}{15}$ and $\zeta = \frac{11}{6300}$, otherwise. Thus, we should use the right-hand tail of a standard normal distribution for critical values of Hadri's test.

Tests with Individual Unit Root Processes

The IPS, and the Fisher-ADF and PP tests all allow for individual unit root processes so that ρ_i may vary across cross-sections. The tests are all characterized by the combining of individual unit root tests to derive a panel-specific result.

The IPS test is based on

$$\Delta q_{i,t} = \alpha_i q_{i,t-1} + \sum_{j=1}^{p_i} \beta_{i,j} \Delta q_{i,t-j} + X_{i,t}\delta_i + \varepsilon_{i,t}. \tag{3.20}$$

The null hypothesis of a unit root can be now defined as

$$H_0 : \alpha_i = 0, \text{ for all } i$$

against the alternative

$$H_A : \alpha_i < 0 \text{ for } i = 1, 2, ..., N_0 \text{ and } \alpha_i = 0 \text{ for } i = N_0 + 1, ..., N, \text{ with } 0 < N_0 \leq N.$$

The alternative hypothesis allows unit roots for some (but not all) of the individual. Therefore, the IPS test evaluates the null hypothesis that all the series contain a unit root against the alternative that some of the series are stationary.

After estimating the separate ADF regressions, the average of the t-statistics for α_i from the individual ADF regressions, $t_{iTi}(p_i)$:

$$\bar{t}_{N,T} = \frac{1}{N} \sum_{i=1}^{N} t_{iTi}(p_i) \tag{3.21}$$

is then adjusted to arrive at the desired test statistics. Under the assumption of cross-sectional independence, this statistic is shown to converge to a normal distribution. IPS propose a standardized statistic, denoted $W_{\bar{t}}$, which is based on the theoretical means and variances of $t_{iTi}(p_i)$, $E(t_{iTi})$ and $Var(t_{iTi})$ respectively.

MW and CH independently suggested a test against the heterogenous alternative that is based on the p-values of the individual statistic as originally suggested by *Fisher* (*1932*). If we define π_i as the p-value from any individual unit root test for cross-section i, then under the null of unit root for all N cross-sections, we have the asymptotic result that:

$$P = -2 \sum_{i=1}^{N} \ln(\pi_i) \rightarrow \chi^2_{2N}. \tag{3.22}$$

In addition, CH demonstrates that:

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \Phi^{-1}(\pi_i) \rightarrow N(0, 1), \tag{3.23}$$

where Φ^{-1} is the inverse of the standard normal cumulative distribution function.

3.2 Cointegration analysis

3.2.1 Johansen cointegration test

A linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables.

As mentioned above, cointegration between the nominal exchange rate s_t and the relative price $\frac{p}{p*}$ is a necessary condition for them to have a stable long-run relationship and is tested using the *Johansen trace test*. The test developed by *Johansen* (*1991, 1995*) is based on VAR (vector autoregression) methodology and forms the basis of the VEC (vector error correction) specification.

Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t, \tag{3.24}$$

where y_t is a vector of the non-stationary I(1) variables $y_t = \left[s_t,\ \frac{p}{p*}\right]$, x_t is a vector of deterministic variables and $\varepsilon_t \sim (0, \sum_\varepsilon)$ is standard white noise. This model may be rewritten as:

$$\Delta y_t = \Pi y_{t-1} + Bx_t + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t, \tag{3.25}$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j. \tag{3.26}$$

The rank r of the coefficient matrix Π determines the number of cointegrating relations (the cointegrating rank).

In order to carry out the test, we need to make an assumption regarding the trend underlying the data. The most common deterministic trend cases are as follows:

a) The level data y_t have no deterministic trends and the cointegrating equations have intercepts;

b) The level data y_t have linear trends but the cointegrating equations have only intercepts;

c) The level data y_t and the cointegrating equations have linear trends.

To determine the number of cointegrating relations r, conditional on the assumptions made about the trend, we can proceed sequentially from $r = 0$ to $r = \kappa - 1$ until we fail to reject.

The trace statistic tests the null hypothesis of r cointegrating relations against the alternative of κ cointegrating relations, where κ is the number of endogenous variables, for $r = 0, 1, ..., \kappa - 1$. Here $\kappa = 2$, so the null and alternative hypotheses are:

$$H_0 \; : \; r = 0$$
$$H_A \; : \; r \leq 1.$$

The alternative of κ cointegrating relations corresponds to the case where none of the series has a unit root and a stationary VAR may be specified in terms of the levels of all of the series. The trace statistic for the null hypothesis of r cointegrating relations is computed as:

$$LR(r/\kappa) = -T \sum_{i=r+1}^{\kappa} \log(1 - \lambda_i), \tag{3.27}$$

where λ_i is the i-th largest eigenvalue of the Π matrix. The asymptotic distribution of the LR test statistic does not have the usual χ^2 distribution and depends on the assumptions made with respect to deterministic trends. In this paper only case (a) was assumed, regarding the trend underlying the data.

A test specification in case of structural breaks were also applied to the data, with one and two breaks in levels considered.

3.2.2 Cointegration test with structural breaks

Johansen et al. (*2000*) discuss the test specification in case of structural breaks, where the observed time series is divided into sub-samples according to the position of the break points. The model (3.25) is now defined by the equation:

$$\Delta y_t = \Pi y_{t-1} + B x_t + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \sum_{i=1}^{p} \sum_{j=2}^{q} k_{j,i} D_{j,t-i} + \varepsilon_t, \tag{3.28}$$

where the $k_{j,i}$ dummy parameters are defined as:

$$D_{j,t} = \begin{Bmatrix} 1, & t = T_{j-1} \\ 0, & \text{otherwise} \end{Bmatrix}, \quad j = 1, ..., q; \;\; t = ..., -1, 0, 1, ..., \tag{3.29}$$

so that $D_{j,t-i}$ is an indicator function for the $i - th$ observation in the $j - th$ period and T_j is the break point.

The likelihood ratio test statistic for the hypothesis of at most r cointegrating relations is still given by equation (3.27).

In this paper up to two structural breaks in levels have been considered, which have been identified in the univariate level by the procedure described in section 3.1.2.

3.2.3 Estimation of the cointegrating vector

In order to test the symmetry and proportionality conditions, which, respectively, imply 'weak' and 'strong' PPP, an estimation of the cointegrating vector is necessary, using a vector error correction (VEC) model. A VEC model is a restricted VAR, designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships, while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term, since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The general setup of a VECM is of the form:

$$\Gamma(L)\Delta y_t = \alpha\beta' y_{t-1} + \varepsilon_t, \tag{3.30}$$

where $\Gamma(L)$ is a lag operator matrix, y_t is a vector of the two endogenous variables $y_t = \left[s_t,\ \frac{p}{p*}\right]$ and $\varepsilon_t \sim (0, \sum_\varepsilon)$ is standard white noise. The parameter matrices α and β have dimensions $\kappa \times r$ (2×1) and they have to have rank r. They specify the long-run part of the model with β containing the cointegrating relations and α representing the loading coefficients. The proportionality condition implies cointegrating vector $\beta' = [1,\ -1]$, which is tested using a Wald test, with a χ^2_1 distribution.

Chapter 4

Empirical Investigation

4.1 Data

The dataset used comprises period-ending nominal exchange rates against the US dollar, as well as consumer and producer price indices (CPI and PPI, respectively) for the fifteen countries of the EU-15. The countries under consideration are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Additionally to the twelve member states of the Eurozone, Denmark, Sweden and the UK were also considered, in order to test the impact of the euro outside the Euro Area.

All series are monthly and seasonally adjusted and the sample period spans from 1992:1 to 2007:12, the post-Maastricht period. Two subperiods are also considered, the first from 1992:1 to 1998:12 and the second from 1999:1 to 2007:12, before and after the advent of the single currency. CPI and PPI data[1] are obtained from the OECD Economic Indicators, while nominal exchange rates data are obtained from the International Monetary Fund (IMF)'s International Financial Statistics.

For 1999-2007, the dollar exchange rates of the Euro Area countries are calculated by $s_i = s_{euro} + s_j$, where s_{euro} is the log of the euro price of a dollar and s_j is the log of a Eurozone country's currency conversion rate of a euro.

Figure 1 plots data on CPI and PPI. Both are expressed in US dollar terms, which means that country i's CPI and PPI were divided by the number of domestic currency units exchanging for one US dollar at that point of time. It is obvious from the figure that, although the national price levels of the countries, expressed in a common currency, tend to move together, absolute PPP does not hold.

Moreover, Figure 2 plots the real exchange rates against the US dollar. As can be seen, there seems to be a break in these real exchange rates, following the launch of

[1] The PPI data for Greece exist only after 1995:1.

the Eurozone.

4.2 Results

As mentioned earlier, unit root tests were applied to prices (both CPI and PPI), relative prices, nominal and real exchange rates. All series have been tested at 5% level of significance. Tables 7.2 to 7.18 show the results of the univariate unit root tests, while Tables 8.1 to 8.5 show the results of unit root tests with structural break, nonlinear and panel unit root tests. Prices, relative prices and nominal exchange rates are found to contain a unit root, according to most tests, except for the case of CPI in Greece and Portugal, which is found to be I(0) by ADF and PP and I(2) by KPSS.

Table 4.1: Summary results of KPSS stationarity test on real exchange rates

Sample	1992-2007		1992-1998		1999-2007	
Country	CPI	PPI	CPI	PPI	CPI	PPI
Austria	I(1)	I(1)	$I(0)^c$ $I(1)^@$	I(1)	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Belgium	I(1)	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	I(1)	$I(1)^c$ $I(0)^@$
Denmark	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Finland	I(1)	I(1)	I(0)	$I(0)^c$ $I(1)^@$	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
France	I(1)	I(1)	I(1)	I(1)	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Germany	I(1)	I(1)	$I(0)^c$ $I(1)^@$	I(1)	I(1)	$I(1)^c$ $I(0)^@$
Greece	$I(0)^c$ $I(1)^@$	I(1)	$I(0)^c$ $I(1)^@$	$I(1)^c$ $I(0)^@$	I(1)	$I(1)^c$ $I(2)^@$
Ireland	$I(0)^c$ $I(1)^@$	I(1)	I(0)	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$	I(0)
Italy	$I(0)^c$ $I(1)^@$	I(1)	$I(1)^c$ $I(0)^@$	I(0)	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Luxembourg	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	I(0)	I(1)	$I(1)^c$ $I(0)^@$	$I(2)^c$ $I(1)^@$
Netherlands	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(1)^c$ $I(0)^@$	I(1)
Portugal	$I(0)^c$ $I(1)^@$	I(1)	I(0)	I(0)	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Spain	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$	$I(1)^c$ $I(0)^@$
Sweden	I(1)	I(1)	$I(1)^c$ $I(0)^@$	I(0)	$I(1)^c$ $I(0)^@$	I(1)
UK	$I(0)^c$ $I(1)^@$	I(1)	$I(0)^c$ $I(1)^@$	$I(0)^c$ $I(1)^@$	I(1)	I(1)

Notes: superscripts c and @ denote respectively intercept and trend in test equation, no superscript denotes both intercept and trend, I(0) and I(1) denote the integration order at 5% significance level.

As far as PPP is concerned, unit root tests on real exchange rates do not give very supportive results, regardless of the price index that is used. The ADF and PP unit root tests reject the PPP condition in all periods under consideration, finding a unit root in all series; nevertheless, the KPSS stationarity test gives more supportive results, accepting the stationarity null in many cases, as it is seen in Table 4.1, which summarizes the results of the test. The most evidence in favor of PPP is given in the case of CPI, before the introduction of the euro. More specifically, with CPI used,

Table 4.2: Summary results of unit root test with structural break on real exchange rates

	CPI		PPI	
Country	Break date	Integration order	Break date	Integration order
Austria	7/1997	I(1)	9/2003	I(1)
Belgium	7/1997	I(1)	6/1993	I(1)
Denmark	7/1997	I(1)	7/1997	I(1)
Finland	5/2003	I(1)	7/1997	I(1)
France	10/1992	I(1)	10/1992	I(1)
Germany	10/1992	I(1)	10/1992	I(1)
Greece	3/1998	I(1)	3/1998	I(1)
Ireland	2/1993	I(1)	10/1992	I(1)
Italy	9/1992	I(1)	9/1992	I(1)
Luxembourg	9/2003	I(1)	6/1993	I(1)
Netherlands	9/2003	I(1)	10/1992	I(1)
Portugal	7/1993	I(1)	7/1993	I(1)
Spain	7/1993	I(1)	7/1993	I(1)
Sweden	11/1992	I(1)	11/1992	I(1)
UK	10/1992	I(1)	2/2003	I(1)

Notes: I(1) denotes the integration order at 5% significance level.

PPP is accepted in 9 out of 15 countries, when the whole period is concerned, in 14 countries in the pre-euro period and in 11 countries in the post-euro period. With PPI used, PPP is accepted only in 5, 11 and 10 countries, respectively.

In particular, Denmark and Spain are the only countries for which there is evidence in favor of PPP for all periods under consideration and with both price indices. Moreover, Austria, Finland, France, Germany and Sweden, although reject PPP in the full sample period, show evidence of real exchange rate stationarity in the two subperiods, mostly when CPI is used. Espesially France rejects PPP both during the whole period and the pre-euro period, but presents evidence in favor of PPP after the adoption of the single currency, with both price indices. On the other hand, the UK shows evidence of PPP during the whole period and the pre-euro period, however rejects it after the introduction of the euro. Additionally, Ireland, Italy and Portugal show evidence of PPP in all specifications, except for the full sample period with PPI used. Similarly, in the case of Luxembourg and the Netherlands, PPP is rejected with PPI used, for the former during the pre-euro and the latter during the post-euro period. Finally, Belgium shows more evidence of PPP when PPI is used, in all periods, while Greece shows evidence in favor of PPP only in the full sample period and in the pre-euro period, mostly with CPI used.

However, when allowing for a structural break in the real exchange rates, the unit root cannot be rejected in any country, as it is shown in Table 4.2. Similar results are provided by the KSS nonlinear unit root test; with the exception of the UK in the post-Maastricht and pre-euro period, all series are found to be I(1), as can be seen in Table 4.3. This holds for the case of the raw, the de-meaned and the de-trended data. The panel unit root tests also reject the PPP condition, except for the BR test in the period 1992-1998, as shown in Table 4.4.

Table 4.3: Summary results of KSS nonlinear unit root test on real exchange rates

Sample	1992-2007		1992-1998		1999-2007	
Country	CPI	PPI	CPI	PPI	CPI	PPI
Austria	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Belgium	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Denmark	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Finland	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
France	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Germany	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Greece	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Ireland	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Italy	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Luxembourg	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Netherlands	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Portugal	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Spain	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Sweden	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
UK	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)

Notes: I(0) and I(1) denote the integration order in, at least, one specification at 5% significance level.

More supportive results are given by cointegration analysis, shown in Tables 8.6 to 8.8. Table 4.5 summarizes the cointegration rank between the nominal exchange rates and the relative prices, i.e. the price ratio.[2] Only in Austria and Belgium cointegrating relations are rejected in all periods. In all other countries one cointegrating relation is found in, at least, one specification (namely with one, two or without structural breaks), with the most supportive results concerning the full period, with CPI used, where in 13 out of 15 countries $r = 1$. For the pre-euro period, only in 8 countries PPP is accepted, while for the post-euro period the number of countries accepting PPP is 10. When it comes to PPI, the number of countries accepting PPP decreases dramatically; 3, 4 and 6 for the full, pre and post-euro periods, respectively. In other

[2] Although some variables may be integrated of different orders, it is still possible for these variables to interact in such a way as to produce an I(0) series (*MacDonald, 1993*).

Table 4.4: Summary results of panel unit root tests on real exchange rates

Sample	1992-2007		1992-1998		1999-2007	
	CPI	PPI	CPI	PPI	CPI	PPI
LLC	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
BR	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)
IPS	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
MW	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
CH	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
HAD	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Notes: LLC denotes the Levin, Lin and Chu (2002) test, BR denotes the Breitung (2000) test, IPS denotes the Im, Pesaran and Shin (2003) test, MW denotes the Maddala and Wu (1999) test, CH denotes the Choi (2001) test, HAD denotes the Hadri (2000) test, the panel has been tested at 5% significance level.

words, cointegration analysis gives more favorable results of PPP after the advent of the single currency than before, mainly when CPI is used.

Especially in the case of Denmark and Sweden, which do not participate in the Euro area, we see that the PPP condition has changed during the pre and the post-euro period, with both price indices. In Denmark PPP is rejected in the post-euro period; in Sweden, contrariwise, PPP is accepted after the advent of the euro. In the UK, on the other hand, PPP is accepted in all sample periods, when CPI is used.

Moreover, Finland, France, Portugal and Spain accept the PPP hypothesis in all periods when CPI is used; in particular, Portugal and Spain accept it also with PPI used, the former during the post-euro and the latter during both the whole and the post-euro periods. In Germany, Ireland and Italy the PPP condition has changed during the two subperiods. However, only in Ireland the change is consistent with both price indices; in the other two countries such changes are opposite, according to the price index used. Additionally, in the Netherlands the condition changes in favor of PPP during the post-euro period only with CPI used, while in Luxembourg PPP is accepted only in the whole period, with CPI used. Finally, Greece is the only country where PPP holds in all periods, both with CPI and PPI.

Table 4.6 shows the estimates of the cointegrating vectors, for the cases that cointegrating relations are found, and tests strong form PPP - the proportionality condition. In most cases only the weak form of PPP - the symmetry condition - is accepted. It can be easily seen that the most cases in which the strong form of PPP is accepted refer to the full sample period (8 out of 13 countries), with Ireland and the Netherlands accepting strong form PPP in the post-euro period. Denmark, Luxembourg and Sweden accept the strong form of PPP only in the full sample period, while Finland, France, Germany and the UK accept it for the pre-euro period, as well. Finally, Greece, Italy, Portugal and Spain accept only the weak form of PPP, in all periods. It should also be mentioned that, with the exception of Germany before and Ireland after the introduction of the euro, strong form PPP is accepted only when CPI is used.

Summing up, unit root tests, both univariate and panel, reject the PPP hypothesis, except for the KPSS test, which mostly supports PPP before the introduction of the euro with CPI used. On the other hand, cointegration analysis provides much more evidence in favor of PPP, showing more supportive results after the advent of the single currency and with CPI used, as well. It is then clear that the *Balassa-Samuelson effect* is not confirmed, neither with unit root tests, nor with cointegration analysis.

Table 4.5: Summary results of Johansen cointegration test on exchange rates and relative prices

Sample	1992-2007		1992-1998		1999-2007	
Country	CPI	PPI	CPI	PPI	CPI	PPI
Austria	$r=0$	$r=0$	$r=0$	$r=0$	$r=0$	$r=0$
Belgium	$r=0$	$r=0$	$r=0$	$r=0$	$r=0$	$r=0$
Denmark	$r=1$	$r=0$	$r=1$	$r=1$	$r=0$	$r=0$
Finland	$r=1$	$r=0$	$r=1$	$r=0$	$r=1$	$r=0$
France	$r=1$	$r=0$	$r=1$	$r=0$	$r=1$	$r=0$
Germany	$r=1$	$r=0$	$r=0$	$r=1$	$r=1$	$r=0$
Greece	$r=1$	$r=1$	$r=1$	$r=1$	$r=1$	$r=1$
Ireland	$r=1$	$r=0$	$r=0$	$r=0$	$r=1$	$r=1$
Italy	$r=1$	$r=1$	$r=1$	$r=0$	$r=0$	$r=1$
Luxembourg	$r=1$	$r=0$	$r=0$	$r=0$	$r=0$	$r=0$
Netherlands	$r=1$	$r=0$	$r=0$	$r=0$	$r=1$	$r=0$
Portugal	$r=1$	$r=0$	$r=1$	$r=0$	$r=1$	$r=1$
Spain	$r=1$	$r=1$	$r=1$	$r=0$	$r=1$	$r=1$
Sweden	$r=1$	$r=0$	$r=0$	$r=0$	$r=1$	$r=1$
UK	$r=1$	$r=0$	$r=1$	$r=1$	$r=1$	$r=0$

Notes: r denotes the cointegration rank in, at least, one specification at 5% significance level.

Table 4.6: Estimation of cointegrating vector [1, b] and test of Ho: b = -1 for s and p/p*

Sample	1992-2007		1992-1998		1999-2007	
Country	CPI	PPI	CPI	PPI	CPI	PPI
Denmark	-1.60		-3.29	-6.90*		
	(0.75)		(0.02)*	(0.00)*		
Finland	-0.91		-0.81		-3.42*	
	(0.97)		(0.91)		(0.00)*	
France	-1.31		2.37		-7.77*	
	(0.59)		(0.055)		(0.00)*	
Germany	-3.53			-0.36	-6.92*	
	(0.08)			(0.78)	(0.00)*	
Greece	9.89*	-10.78*	-0.78*	-2.64*	11.07*	10.94*
	(0.00)*	(0.00)*	(0.00)*	(0.00)*	(0.00)*	(0.00)*
Ireland	2.18*				4.70*	-1.12*
	(0.00)*				(0.00)*	(0.48)
Italy	-8.02*	-5.18*	-4.46*			-14.98*
	(0.00)*	(0.00)*	(0.00)*			(0.00)*
Luxembourg	-0.57					
	(0.86)					
Netherlands	1.09				-1.51	
	(0.26)				(0.81)	
Portugal	-11.02*		6.72*		7.95*	-6.54*
	(0.00)*		(0.00)*		(0.00)*	(0.00)*
Spain	-1.26	-7.19*	-4.99*		13.13*	-39.70*
	(0.00)*	(0.00)*	(0.00)*		(0.00)*	(0.00)*
Sweden	-0.20				-3.47*	-3.62*
	(0.68)				(0.00)*	(0.00)*
UK	-2.18*		-3.12	-0.34	-5.14*	
	(0.11)		(0.36)	(0.04)*	(0.00)*	

*Notes: p-values in parentheses, * on coefficients indicates statistical significance at 5% significance level, * on p-values indicates rejection of the restriction at 5% significance level.*

Chapter 5

Conclusions

This paper examined whether PPP between the European Union and the USA holds better in the more recent years, after the adoption of the euro. Towards this end, the empirical study is conducted for the full post-Maastricht period (1992-2007), including the pre-euro period (1992-1998), as well as the post-euro period (1999-2007). The investigation is carried out by using three main approaches: univariate and panel unit root tests and cointegration analysis.

As far as unit root methodology is concerned, several tests were applied to a set of bilateral real exchange rates between the EU-15 and the US. Such tests include univariate linear, nonlinear and with structural break as well as panel unit root tests. The results provided by those tests are not very supportive in favor of PPP, since in most cases PPP is rejected, regardless of the period concerned or the price index used. The only exception is the KPSS stationarity test, which, compared to all other unit root tests, gives more supportive results, especially before the introduction of the euro.

Given the second approach, the PPP hypothesis is accepted in many cases, with some evidence that PPP holds better after the introduction of the euro. On the other hand, there is no evidence of the *Balassa-Samuelson effect*, since using CPI gives more supportive results in favor of PPP than using PPI, in both methods.

Overall, we may not conclude that the PPP condition holds strongly between Europe and the USA, nor can we say that the introduction of the euro has played an essential role for better performance of the PPP hypothesis. However, there is still much research to be done and further econometric tools to be used, in order to examine deeper the PPP hypothesis and the impact of the EMU in price convergence.

Chapter 6

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Chapter 7

Appendix A

Table 7.1: Summary statistics

	Country	Mean	Std.dev	Skweness	Kurtosis	J-B
	AUS	4.603	0.084	-0.068	2.067	7.108
	BEL	4.602	0.086	0.076	1.912	9.657
	DEN	4.589	0.097	-0.044	1.655	14.524
	FIN	4.595	0.065	0.031	1.619	15.281
	FRA	4.608	0.072	0.136	1.943	9.533
	GER	4.601	0.072	-0.194	2.315	4.959
	GR	4.544	0.223	-0.762	2.696	19.335
	IRE	4.611	0.142	0.279	1.705	15.916
CPI	IT	4.586	0.123	-0.364	2.118	10.471
	LUX	4.606	0.092	0.186	1.934	10.200
	NETH	4.601	0.106	-0.066	1.644	14.840
	POR	4.594	0.147	-0.226	2.046	8.912
	SP	4.595	0.143	-0.085	1.998	8.262
	SWE	4.615	0.059	-0.217	2.426	4.137
	UK	4.594	0.075	-0.175	2.162	6.591
	USA	4.592	0.116	0.053	1.920	9.407
	AUS	4.623	0.062	1.168	3.274	44.270
	BEL	4.570	0.085	0.608	2.402	14.692
	DEN	4.601	0.073	0.365	2.077	11.078
	FIN	4.556	0.047	0.455	2.738	7.182
	FRA	4.620	0.030	0.920	3.349	28.072
	GER	4.607	0.053	0.758	2.632	19.479
	GR	4.616	0.139	0.036	2.005	6.459
	IRE	4.517	0.053	0.706	2.881	16.067
PPI	IT	4.583	0.117	-0.045	2.409	2.850
	LUX	4.645	0.108	1.601	4.301	95.670
	NETH	4.576	0.108	0.636	2.292	16.982
	POR	4.534	0.154	-0.086	1.658	14.632
	SP	4.592	0.114	0.179	2.389	4.009
	SWE	4.582	0.081	-0.579	3.318	11.574
	UK	4.593	0.07	-0.192	2.868	1.322
	USA	4.603	0.094	0.727	2.621	18.094
	AUS	2.477	0.135	0.638	2.600	14.328
	BEL	3.553	0.136	0.604	2.560	13.249
	DEN	1.870	0.132	0.615	2.631	13.219
	FIN	1.645	0.141	0.368	2.294	8.330
	FRA	1.742	0.131	0.663	2.649	15.086
	GER	0.526	0.135	0.640	2.601	14.383
Exchange	GR	5.619	0.186	0.135	2.647	1.584
rates	IRE	-0.381	0.132	0.709	2.735	16.656
	IT	7.418	0.147	0.110	3.199	0.711
	LUX	3.553	0.136	0.604	2.560	13.249
	NETH	0.644	0.136	0.632	2.588	14.151
	POR	5.143	0.147	0.457	2.554	8.301
	SP	4.946	0.160	0.146	2.824	0.935
	SWE	2.048	0.145	0.214	3.274	2.079
	UK	-0.498	0.095	-0.527	2.427	11.511

Table 7.2: Unit root tests on prices

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Austria	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-1.35^{c} (0)	-12.79^{c} (0)		3.54^{c} (0)	-11.92^{c} (0)	
	$-2.96^{@}$ (0)	$-12.79^{@}$ (0)		$0.65^{@}$ (0)	$-12.67^{@}$ (0)	
PP	-1.14^{c}	-13.10^{c}		3.25^{c}	-12.04^{c}	
	$-2.97^{@}$	$-13.09^{@}$		$0.46^{@}$	$-12.70^{@}$	
KPSS	1.68^{c}	0.28^{c}		1.42^{c}	0.85^{c}	0.09^{c}
	$0.142^{@}$			$0.41^{@}$	$0.09^{@}$	
Belgium	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.34^{c} (0)	-12.06^{c} (0)		1.64^{c} (1)	-9.47^{c} (0)	
	$-1.78^{@}$ (0)	$-12.04^{@}$ (0)		$-1.80^{@}$ (3)	$-9.79^{@}$ (0)	
PP	0.35^{c}	-11.95^{c}		1.31^{c}	-10.16^{c}	
	$-1.80^{@}$	$-11.93^{@}$		$-1.38^{@}$	$-10.41^{@}$	
KPSS	1.68^{c}	0.12^{c}		1.56^{c}	0.31^{c}	
	$0.213^{@}$	$0.10^{@}$		$0.20^{@}$	$0.05^{@}$	
Denmark	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.01^{c} (0)	-13.37^{c} (0)		2.90^{c} (0)	-11.71^{c} (0)	
	$-1.79^{@}$ (0)	$-13.34^{@}$ (0)		$-0.95^{@}$ (0)	$-12.12^{@}$ (0)	
PP	0.02^{c}	-13.37^{c}		2.31^{c}	-11.95^{c}	
	$-1.82^{@}$	$-13.34^{@}$		$-1.32^{@}$	$-12.20^{@}$	
KPSS	1.70^{c}	0.11^{c}		1.64^{c}	0.49^{c}	0.19^{c}
	$0.22^{@}$	$0.11^{@}$		$0.19^{@}$	$0.08^{@}$	
Finland	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.22^{c} (0)	-13.17^{c} (0)		-0.65^{c} (1)	-7.94^{c} (0)	
	$-1.34^{@}$ (0)	$-13.14^{@}$ (0)		$-1.73^{@}$ (1)	$-7.94^{@}$ (0)	
PP	0.14^{c}	-13.29^{c}		-0.88^{c}	-8.38^{c}	
	$-1.60^{@}$	$-13.26^{@}$		$-2.02^{@}$	$-8.37^{@}$	
KPSS	1.70^{c}	0.10^{c}		1.19^{c}	0.09^{c}	
	$0.13^{@}$			$0.08^{@}$		
France	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.62^{c} (0)	-13.15^{c} (0)		-1.87^{c} (3)	-3.58^{c} (4)	
	$-0.90^{@}$ (0)	$-13.16^{@}$ (0)		$-3.42^{@}$ (3)	$-3.72^{@}$ (4)	
PP	0.63^{c}	-13.13^{c}		-0.10^{c}	-6.38^{c}	
	$-0.95^{@}$	$-13.14^{@}$		$-1.43^{@}$	$-6.68^{@}$	
KPSS	1.68^{c}	0.22^{c}		0.91^{c}	0.22^{c}	
	$0.26^{@}$	$0.16^{@}$	$0.08^{@}$	$0.24^{@}$	$0.05^{@}$	

Notes: superscripts c and @ denote respectively intercept and trend in test equation. Lag length in parentheses, based on SIC, critical values at 5% significance level ADF^{c} *and* PP^{c} *= -2.876,* $KPSS^{c}$ *= 0.463,* $ADF^{@}$ *and* $PP^{@}$ *= -3.433,* $KPSS^{@}$ *= 0.146.*

Table 7.3: Unit root tests on prices (continued)

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Germany	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-2.50^c (0)	-13.70^c (0)		2.82^c (1)	-10.22^c (0)	
	-4.14$^@$ (0)			0.43$^@$ (1)	-10.79$^@$ (0)	
PP	-2.27^c	-14.01^c		2.29^c	-11.02^c	
	-4.08$^@$			0.10$^@$	-11.25$^@$	
KPSS	1.67^c	0.53^c	0.17^c	1.56^c	0.50^c	0.20^c
	0.19$^@$	0.35$^@$	0.13$^@$	0.31$^@$	0.09$^@$	
Greece	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-10.80^c (0)			0.06^c (2)	-8.53^c (1)	
	-6.24$^@$ (0)			-2.57$^@$ (1)	-8.51$^@$ (1)	
PP	-9.48^c			0.16^c	-9.74^c	
	-6.18$^@$			-2.17$^@$	-9.71$^@$	
KPSS	1.60^c	1.21^c	0.21^c	1.50^c	0.09^c	
	0.36$^@$	0.39$^@$	0.21$^@$	0.09$^@$		
Ireland	CPI	CPI	CPI	PPI	PPI	PPI
ADF	2.98^c (1)	-10.70^c (0)		-1.74^c (1)	-11.07^c (0)	
	-1.27$^@$ (1)	-11.43$^@$ (0)		-1.10$^@$ (1)	-11.30$^@$ (0)	
PP	2.57^c	-11.72^c		-1.78^c	-11.13^c	
	-1.40$^@$	-12.14$^@$		-1.09$^@$	-11.30$^@$	
KPSS	1.68^c	0.63^c	0.06^c	0.53^c	0.41^c	
	0.33$^@$	0.10$^@$		0.30$^@$	0.07$^@$	
Italy	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-2.57^c (3)	-3.69^c (2)		-0.19^c (2)	-4.81^c (1)	
	-2.94$^@$ (3)	-4.23$^@$ (2)		-1.93$^@$ (2)	-4.80$^@$ (1)	
PP	-4.36^c			-0.08^c	-8.73^c	
	-2.91$^@$	-12.71$^@$		-1.66$^@$	-8.73$^@$	
KPSS	1.66^c	0.85^c	0.36^c	1.61^c	0.12^c	
	0.31$^@$	0.19$^@$	0.29$^@$	0.15$^@$	0.11$^@$	
Luxembourg	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.70^c (1)	-16.02^c (0)		1.56^c (2)	-4.78^c (2)	
	-0.57$^@$ (1)	-16.02$^@$ (0)		-0.23$^@$ (2)	-7.04$^@$ (1)	
PP	0.81^c	-15.94^c		1.71^c	-14.12^c	
	-0.62$^@$	-15.94$^@$		-0.27$^@$	-14.40$^@$	
KPSS	1.69^c	0.29^c		1.06^c	0.57^c	0.17^c
	0.29$^@$	0.18$^@$	0.03$^@$	0.34$^@$	0.07$^@$	
Netherlands	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-1.88^c (0)	-13.83^c (0)		1.64^c (1)	-9.43^c (0)	
	-0.42$^@$ (0)	-14.06$^@$ (0)		-1.20$^@$ (1)	-9.77$^@$ (0)	
PP	-1.81^c	-13.91^c		1.39^c	-9.99^c	
	-0.52$^@$	-14.07$^@$		-1.51$^@$	-10.15$^@$	
KPSS	1.70^c	0.40^c		1.55^c	0.36^c	
	0.17$^@$	0.18$^@$	0.38$^@$	0.25$^@$	0.04$^@$	

Notes: see notes in Table 7.2.

Table 7.4: Unit root tests on prices (continued)

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Portugal	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-6.01^{c} (0)			-0.10^{c} (1)	-8.53^{c} (0)	
	-7.21$^{@}$ (0)			-3.12$^{@}$ (3)	-8.52$^{@}$ (0)	
PP	-4.50^{c}			-0.21^{c}	-8.87^{c}	
	-6.57$^{@}$			-2.55$^{@}$	-8.87$^{@}$	
KPSS	1.69^{c}	0.88^{c}	0.27^{c}	1.64^{c}	0.04^{c}	
	0.23$^{@}$	0.28$^{@}$	0.15$^{@}$	0.06$^{@}$		
Spain	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.79^{c} (1)	-9.70^{c} (0)		0.79^{c} (1)	-7.17^{c} (0)	
	-2.10$^{@}$ (1)	-9.69$^{@}$ (0)		-0.75$^{@}$ (1)	-7.23$^{@}$ (0)	
PP	-1.50^{c}	-9.74^{c}		0.80^{c}	-7.11^{c}	
	-2.68$^{@}$	-9.72$^{@}$		-0.85$^{@}$	-7.17$^{@}$	
KPSS	1.69^{c}	0.38^{c}		1.61^{c}	0.22^{c}	
	0.16$^{@}$	0.26$^{@}$	0.33$^{@}$	0.17$^{@}$	0.143$^{@}$	
Sweden	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-1.25^{c} (0)	-11.82^{c} (0)		-1.38^{c} (1)	-7.95^{c} (0)	
	-2.27$^{@}$ (0)	-11.83$^{@}$ (0)		-2.07$^{@}$ (1)	-7.95$^{@}$ (0)	
PP	-1.15^{c}	-11.99^{c}		-1.33^{c}	-8.17^{c}	
	-2.40$^{@}$	-11.98$^{@}$		-2.06$^{@}$	-8.17$^{@}$	
KPSS	1.63^{c}	0.21^{c}		1.37^{c}	0.15^{c}	
	0.12$^{@}$			0.17$^{@}$	0.13$^{@}$	
UK	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-1.21^{c} (0)	-13.63^{c} (0)		-0.18^{c} (1)	-8.90^{c} (0)	
	-2.06$^{@}$ (0)	-13.65$^{@}$ (0)		-1.00$^{@}$ (1)	-8.86$^{@}$ (0)	
PP	-1.21^{c}	-13.63^{c}		-0.52^{c}	-8.96^{c}	
	-2.06$^{@}$	-13.65$^{@}$		-1.39$^{@}$	-8.92$^{@}$	
KPSS	1.66^{c}	0.47^{c}	0.09^{c}	1.53^{c}	0.41^{c}	
	0.26$^{@}$	0.38$^{@}$	0.05$^{@}$	0.211$^{@}$	0.41$^{@}$	0.09$^{@}$
USA	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.67^{c} (2)	-11.78^{c} (1)		2.15^{c} (0)	-13.05^{c} (0)	
	-1.27$^{@}$ (2)	-11.79$^{@}$ (1)		0.14$^{@}$ (0)	-11.06$^{@}$ (1)	
PP	0.69^{c}	-11.08^{c}		2.15^{c}	-13.03^{c}	
	-1.45$^{@}$	-11.07$^{@}$		0.11$^{@}$	-13.34$^{@}$	
KPSS	1.69^{c}	0.16^{c}		1.56^{c}	0.61^{c}	0.09^{c}
	0.17$^{@}$	0.118$^{@}$		0.30$^{@}$	0.13$^{@}$	

Notes: see notes in Table 7.2.

Table 7.5: Unit root tests on exchange rates

Country	Level	1st diff.	Country	Level	1st diff.	2nd diff.
Austria			Germany			
ADF	-0.70^{c} (0)	-11.63^{c} (0)	ADF	-0.71^{c} (0)	-11.72^{c} (0)	
	-0.61$^{@}$ (0)	-11.71$^{@}$ (0)		-0.62$^{@}$ (0)	-11.80$^{@}$ (0)	
PP	-0.70^{c}	-11.59^{c}	PP	-0.71^{c}	-11.66^{c}	
	-0.78$^{@}$	-11.62$^{@}$		-0.78$^{@}$	-11.71$^{@}$	
KPSS	0.31^{c}		KPSS	0.31^{c}		
	0.30$^{@}$	0.10$^{@}$		0.30$^{@}$	0.10$^{@}$	
Belgium			Greece			
ADF	-0.71^{c} (0)	-11.54^{c} (0)	ADF	-2.02^{c} (0)	-12.34^{c} (0)	
	-0.63$^{@}$ (0)	-11.62$^{@}$ (0)		-0.74$^{@}$ (0)	-12.81$^{@}$ (0)	
PP	-0.86^{c}	-11.51^{c}	PP	-2.02^{c}	-12.34^{c}	
	-0.78$^{@}$	-11.56$^{@}$		-0.79$^{@}$	-12.80$^{@}$	
KPSS	0.30^{c}		KPSS	0.68^{c}	0.76^{c}	0.50^{c}
	0.29$^{@}$	0.10$^{@}$		0.36$^{@}$	0.06$^{@}$	
Denmark			Ireland			
ADF	-0.68^{c} (0)	-11.60^{c} (0)	ADF	-0.84^{c} (0)	-12.06^{c} (0)	
	-0.69$^{@}$ (0)	-11.67$^{@}$ (0)		-0.75$^{@}$ (0)	-12.21$^{@}$ (0)	
PP	-0.68^{c}	-11.55^{c}	PP	-0.99^{c}	-12.06^{c}	
	-0.87$^{@}$	-11.59$^{@}$		-0.86$^{@}$	-12.18$^{@}$	
KPSS	0.29^{c}		KPSS	0.31^{c}		
	0.29$^{@}$	0.09$^{@}$		0.30$^{@}$	0.09$^{@}$	
Finland			Italy			
ADF	-0.68^{c} (0)	-12.10^{c} (0)	ADF	-1.80^{c} (0)	-11.69^{c} (0)	
	-0.67$^{@}$ (0)	-12.19$^{@}$ (0)		-1.41$^{@}$ (0)	-12.07$^{@}$ (0)	
PP	-0.80^{c}	-12.08^{c}	PP	-1.80^{c}	-11.63^{c}	
	-0.80$^{@}$	-12.13$^{@}$		-1.44$^{@}$	-11.96$^{@}$	
KPSS	0.30^{c}		KPSS	0.40^{c}		
	0.30$^{@}$	0.09$^{@}$		0.36$^{@}$	0.05$^{@}$	
France			Luxembourg			
ADF	-0.68^{c} (0)	-12.10^{c} (0)	ADF	-0.71^{c} (0)	-11.54^{c} (0)	
	-0.67$^{@}$ (0)	-12.19$^{@}$ (0)		-0.63$^{@}$ (0)	-11.62$^{@}$ (0)	
PP	-0.80^{c}	-12.08^{c}	PP	-0.86^{c}	-11.51^{c}	
	-0.80$^{@}$	-12.13$^{@}$		-0.78$^{@}$	-11.56$^{@}$	
KPSS	0.30^{c}		KPSS	0.30^{c}		
	0.30$^{@}$	0.09$^{@}$		0.29$^{@}$	0.10$^{@}$	

Notes: see notes in Table 7.2. Exchange rate is defined as domestic currency per US dollars.

Table 7.6: Unit root tests on exchange rates (continued)

Country	Level	1st diff.
Netherlands		
ADF	-0.70^{c} (0)	-11.70^{c} (0)
	$-0.60^{@}$ (0)	$-11.78^{@}$ (0)
PP	-0.84^{c}	-11.66^{c}
	$-0.73^{@}$	$-11.72^{@}$
KPSS	0.31^{c}	
	$0.30^{@}$	$0.10^{@}$
Portugal		
ADF	-1.19^{c} (0)	-12.02^{c} (0)
	$-0.80^{@}$ (0)	$-12.24^{@}$ (0)
PP	-1.31^{c}	-12.02^{c}
	$-0.89^{@}$	$-12.22^{@}$
KPSS	0.39^{c}	
	$0.33^{@}$	$0.06^{@}$
Spain		
ADF	-1.79^{c} (0)	-12.33^{c} (0)
	$-1.14^{@}$ (0)	$-12.67^{@}$ (0)
PP	-1.84^{c}	-12.31^{c}
	$-1.14^{@}$	$-12.63^{@}$
KPSS	0.462^{c}	
	$0.34^{@}$	$0.05^{@}$
Sweden		
ADF	-1.86^{c} (0)	-11.65^{c} (0)
	$-1.46^{@}$ (0)	$-11.83^{@}$ (0)
PP	-2.03^{c}	-11.64^{c}
	$-1.63^{@}$	$-11.81^{@}$
KPSS	0.39^{c}	
	$0.29^{@}$	$0.05^{@}$
UK		
ADF	-1.18^{c} (0)	-12.21^{c} (0)
	$-2.35^{@}$ (0)	$-12.31^{@}$ (0)
PP	-1.23^{c}	-12.12^{c}
	$-2.34^{@}$	$-12.32^{@}$
KPSS	0.72^{c}	0.27^{c}
	$0.27^{@}$	$0.03^{@}$

Notes: see notes in Table 7.5.

Table 7.7: Unit root tests on relative prices

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Austria	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.74^{c} (0)	-13.59^{c} (0)		-1.95^{c} (0)	-13.59^{c} (0)	
	$-3.26^{@}$ (0)	$-13.68^{@}$ (0)		$-2.93^{@}$ (0)	$-13.61^{@}$ (0)	
PP	0.88^{c}	-13.61^{c}		-1.95^{c}	-13.60^{c}	
	$-3.23^{@}$	$-13.73^{@}$		$-2.93^{@}$	$-13.64^{@}$	
KPSS	1.62^{c}	0.32^{c}		1.49^{c}	0.12^{c}	
	$0.13^{@}$			$0.17^{@}$	$0.04^{@}$	
Belgium	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.30^{c} (0)	-12.69^{c} (0)		-2.50^{c} (0)	-12.01^{c} (0)	
	$-3.24^{@}$ (0)	$-12.66^{@}$ (0)		$-2.43^{@}$ (0)	$-12.00^{@}$ (0)	
PP	-0.10^{c}	-13.51^{c}		-2.65^{c}	-12.02^{c}	
	$-3.24^{@}$	$-13.49^{@}$		$-2.63^{@}$	$-12.01^{@}$	
KPSS	1.66^{c}	0.05^{c}		0.41^{c}		
	$0.13^{@}$			$0.15^{@}$	$0.06^{@}$	
Denmark	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.20^{c} (0)	-12.83^{c} (0)		-0.83^{c} (0)	-11.23^{c} (1)	
	$-0.71^{@}$ (0)	$-12.82^{@}$ (0)		$-1.37^{@}$ (0)	$-11.21^{@}$ (1)	
PP	0.20^{c}	-12.80^{c}		-0.75^{c}	-13.75^{c}	
	$-0.76^{@}$	$-12.79^{@}$		$-1.38^{@}$	$-13.73^{@}$	
KPSS	1.31^{c}	0.30^{c}		0.79^{c}	0.18^{c}	
	$0.22^{@}$	$0.25^{@}$	$0.12^{@}$	$0.24^{@}$	$0.15^{@}$	$0.17^{@}$
Finland	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.05^{c} (0)	-12.69^{c} (0)		0.55^{c} (0)	-11.76^{c} (0)	
	$-1.311^{@}$ (0)	$-12.66^{@}$ (0)		$-1.65^{@}$ (0)	$-11.85^{@}$ (0)	
PP	-0.05^{c}	-12.69^{c}		0.02^{c}	-12.23^{c}	
	$-1.35^{@}$	$-12.66^{@}$		$-2.02^{@}$	$-12.21^{@}$	
KPSS	1.58^{c}	0.14^{c}		1.35^{c}	0.18^{c}	
	$0.17^{@}$	$0.141^{@}$		$0.22^{@}$	$0.05^{@}$	
France	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.12^{c} (0)	-11.39^{c} (1)		0.15^{c} (0)	-12.76^{c} (0)	
	$-2.03^{@}$ (0)	$-11.36^{@}$ (1)		$-1.82^{@}$ (0)	$-12.75^{@}$ (0)	
PP	-0.07^{c}	-13.61^{c}		0.08^{c}	-12.76^{c}	
	$-1.97^{@}$	$-13.57^{@}$		$-2.16^{@}$	$-12.75^{@}$	
KPSS	1.67^{c}	0.07^{c}		1.63^{c}	0.09^{c}	
	$0.15^{@}$	$0.07^{@}$		$0.144^{@}$	$0.05^{@}$	

Notes: see notes in Table 7.2.

Table 7.8: Unit root tests on relative prices (continued)

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Germany	CPI	CPI	CPI	PPI	PPI	PPI
ADF	1.45^{c} (0)	-14.10^{c} (0)		0.40^{c} (0)	-11.87^{c} (1)	
	-3.65$^{@}$ (0)	-14.45$^{@}$ (0)		-1.50$^{@}$ (0)	-11.92$^{@}$ (1)	
PP	1.51^{c}	-14.10^{c}		0.71^{c}	-14.93^{c}	
	-3.72$^{@}$	-14.45$^{@}$		-1.41$^{@}$	-14.97$^{@}$	
KPSS	1.65^{c}	0.59^{c}	0.18^{c}	1.50^{c}	0.20^{c}	
	0.22$^{@}$	0.13$^{@}$		0.25$^{@}$	0.08$^{@}$	
Greece	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-10.80^{c} (0)			-2.28^{c} (0)	-10.60^{c} (0)	
	-4.98$^{@}$ (0)			-2.03$^{@}$ (1)	-10.79$^{@}$ (0)	
PP	-10.82^{c}			-2.21^{c}	-10.57^{c}	
	-5.00$^{@}$			-1.73$^{@}$	-10.70$^{@}$	
KPSS	1.34^{c}	1.29^{c}	0.15^{c}	1.32^{c}	0.31^{c}	
	0.37$^{@}$	0.33$^{@}$	0.15$^{@}$	0.35$^{@}$	0.04$^{@}$	
Ireland	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.35^{c} (1)	-11.23^{c} (0)		2.03^{c} (0)	-12.14^{c} (0)	
	-2.08$^{@}$ (1)	-11.58$^{@}$ (0)		-0.01$^{@}$ (0)	-11.08$^{@}$ (1)	
PP	0.15^{c}	-11.65^{c}		1.96^{c}	-12.15^{c}	
	-2.12$^{@}$	-11.74$^{@}$		-0.02$^{@}$	-12.57$^{@}$	
KPSS	1.18^{c}	0.55^{c}	0.07^{c}	0.99^{c}	0.77^{c}	0.12^{c}
	0.30$^{@}$	0.16$^{@}$	0.06$^{@}$	0.35$^{@}$	0.117$^{@}$	
Italy	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-2.23^{c} (1)	-11.22^{c} (0)		-2.56^{c} (0)	-13.25^{c} (0)	
	-1.24$^{@}$ (0)	-11.15$^{@}$ (1)		-1.44$^{@}$ (0)	-13.54$^{@}$ (0)	
PP	-2.29^{c}	-11.25^{c}		-2.49^{c}	-13.40^{c}	
	-1.26$^{@}$	-12.15$^{@}$		-1.54$^{@}$	-13.58$^{@}$	
KPSS	0.43^{c}			0.98^{c}	0.41^{c}	
	0.33$^{@}$	0.07$^{@}$		0.33$^{@}$	0.04$^{@}$	
Luxembourg	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.50^{c} (1)	-17.86^{c} (0)		-1.73^{c} (0)	-14.02^{c} (0)	
	-1.64$^{@}$ (1)	-17.81$^{@}$ (0)		-1.34$^{@}$ (0)	-14.35$^{@}$ (0)	
PP	-0.71^{c}	-17.86^{c}		-2.06^{c}	-14.62^{c}	
	-1.74$^{@}$	-17.89$^{@}$		-1.67$^{@}$	-14.73$^{@}$	
KPSS	1.67^{c}	0.07^{c}		1.63^{c}	0.09^{c}	
	0.15$^{@}$	0.07$^{@}$		0.144$^{@}$	0.05$^{@}$	

Notes: see notes in Table 7.2.

Table 7.9: Unit root tests on relative prices (continued)

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Netherlands	CPI	CPI	CPI	PPI	PPI	PPI
ADF	1.41^{c} (0)	-12.54^{c} (0)		-1.46^{c} (0)	-12.55^{c} (0)	
	$0.33^{@}$ (0)	$-12.74^{@}$ (0)		$-2.58^{@}$ (0)	$-12.68^{@}$ (0)	
PP	1.04^{c}	-12.68^{c}		-2.07^{c}	-13.10^{c}	
	$0.03^{@}$	$-12.82^{@}$		$-2.91^{@}$	$-13.17^{@}$	
KPSS	0.66^{c}	0.40^{c}		0.66^{c}	0.17^{c}	
	$0.19^{@}$	$0.214^{@}$	$0.48^{@}$	$0.13^{@}$	$0.06^{@}$	
Portugal	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-5.17^{c} (2)			-1.28^{c} (1)	-11.34^{c} (0)	
	$-3.36^{@}$ (2)	$-10.74^{@}$ (1)		$-1.11^{@}$ (1)	$-11.36^{@}$ (0)	
PP	-6.03^{c}			-1.38^{c}	-11.79^{c}	
	$-3.94^{@}$	$-12.06^{@}$		$-1.39^{@}$	$-11.78^{@}$	
KPSS	1.40^{c}	1.01^{c}	0.10^{c}	1.32^{c}	0.14^{c}	
	$0.25^{@}$	$0.19^{@}$	$0.06^{@}$	$0.24^{@}$	$0.08^{@}$	
Spain	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-2.86^{c} (0)	-11.21^{c} (1)		-2.33^{c} (1)	-15.54^{c} (0)	
	$-2.50^{@}$ (0)	$-11.54^{@}$ (1)		$-1.84^{@}$ (0)	$-15.70^{@}$ (0)	
PP	-3.08^{c}	-12.58^{c}		-2.21^{c}	-15.53^{c}	
	$-2.47^{@}$	$-12.78^{@}$		$-1.69^{@}$	$-15.74^{@}$	
KPSS	1.51^{c}	0.54^{c}	0.50^{c}	1.12^{c}	0.28^{c}	
	$0.19^{@}$	$0.13^{@}$		$0.29^{@}$	$0.04^{@}$	
Sweden	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.62^{c} (0)	-12.28^{c} (0)		-1.29^{c} (3)	-5.76^{c} (2)	
	$-2.34^{@}$ (0)	$-12.34^{@}$ (0)		$-1.77^{@}$ (0)	$-6.09^{@}$ (2)	
PP	0.46^{c}	-12.34^{c}		-1.13^{c}	-11.79^{c}	
	$-2.45^{@}$	$-12.34^{@}$		$-1.92^{@}$	$-11.92^{@}$	
KPSS	1.62^{c}	0.19^{c}		0.58^{c}	0.40^{c}	
	$0.10^{@}$			$0.31^{@}$	$0.05^{@}$	
UK	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.84^{c} (0)	-12.98^{c} (0)		0.09^{c} (0)	-15.63^{c} (0)	
	$-1.99^{@}$ (0)	$-13.05^{@}$ (0)		$-1.90^{@}$ (2)	$-12.49^{@}$ (1)	
PP	0.80^{c}	-12.98^{c}		0.41^{c}	-15.68^{c}	
	$-2.03^{@}$	$-13.04^{@}$		$-2.03^{@}$	$-16.29^{@}$	
KPSS	1.65^{c}	0.24^{c}		0.99^{c}	0.93^{c}	0.13^{c}
	$0.30^{@}$	$0.05^{@}$		$0.38^{@}$	$0.05^{@}$	

Notes: see notes in Table 7.2.

Table 7.10: Unit root tests on real exchange rates for the period 1/1992-12/2007

Country	Level	1st dif.	Level	1st dif.
Austria	CPI	CPI	PPI	PPI
ADF	-1.001^{c} (0)	-11.59^{c} (0)	-1.05^{c} (0)	-11.64^{c} (0)
	$-0.62^{@}$ (0)	$-11.62^{@}$ (0)	$-0.55^{@}$ (0)	$-11.77^{@}$ (0)
PP	-1.11^{c}	-11.53^{c}	-1.20^{c}	-11.64^{c}
	$-0.77^{@}$	$-11.57^{@}$	$-0.69^{@}$	$-11.75^{@}$
KPSS	0.51^{c}	0.27^{c}	0.53^{c}	0.35^{c}
	$0.34^{@}$	$0.10^{@}$	$0.36^{@}$	$0.09^{@}$
Belgium	CPI	CPI	PPI	PPI
ADF	-0.98^{c} (0)	-11.68^{c} (0)	-0.88^{c} (0)	-11.94^{c} (0)
	$-0.60^{@}$ (0)	$-11.76^{@}$ (0)	$-0.67^{@}$ (0)	$-12.05^{@}$ (0)
PP	-1.13^{c}	-11.66^{c}	-1.04^{c}	-11.94^{c}
	$-0.74^{@}$	$-11.73^{@}$	$-0.67^{@}$	$-12.02^{@}$
KPSS	0.49^{c}	0.31^{c}	0.39^{c}	0.33^{c}
	$0.34^{@}$	$0.10^{@}$	$0.35^{@}$	$0.08^{@}$
Denmark	CPI	CPI	PPI	PPI
ADF	-1.05^{c} (0)	-11.67^{c} (0)	-1.16^{c} (0)	-11.93^{c} (0)
	$-0.85^{@}$ (0)	$-11.74^{@}$ (0)	$-0.96^{@}$ (0)	$-12.001^{@}$ (0)
PP	-1.05^{c}	-11.62^{c}	-1.16^{c}	-11.88^{c}
	$-0.99^{@}$	$-11.68^{@}$	$-1.13^{@}$	$-11.93^{@}$
KPSS	0.37^{c}	0.25^{c}	0.36^{c}	0.25^{c}
	$0.33^{@}$	$0.08^{@}$	$0.32^{@}$	$0.08^{@}$
Finland	CPI	CPI	PPI	PPI
ADF	-1.86^{c} (0)	-11.57^{c} (0)	-1.82^{c} (0)	-11.91^{c} (0)
	$-1.32^{@}$ (0)	$-11.69^{@}$ (0)	$-1.33^{@}$ (0)	$-12.00^{@}$ (0)
PP	-1.97^{c}	-11.55^{c}	-1.93^{c}	-11.88^{c}
	$-1.45^{@}$	$-11.63^{@}$	$-1.46^{@}$	$-11.94^{@}$
KPSS	0.54^{c}	0.30^{c}	0.58^{c}	0.25^{c}
	$0.30^{@}$	$0.06^{@}$	$0.28^{@}$	$0.06^{@}$
France	CPI	CPI	PPI	PPI
ADF	-1.10^{c} (0)	-12.13^{c} (0)	-1.42^{c} (0)	-11.92^{c} (0)
	$-0.66^{@}$ (0)	$-12.21^{@}$ (0)	$-0.89^{@}$ (0)	$-11.98^{@}$ (0)
PP	-1.18^{c}	-12.11^{c}	-1.51^{c}	-11.92^{c}
	$-0.77^{@}$	$-12.18^{@}$	$-1.01^{@}$	$-11.96^{@}$
KPSS	0.54^{c}	0.30^{c}	0.74^{c}	0.25^{c}
	$0.34^{@}$	$0.10^{@}$	$0.32^{@}$	$0.08^{@}$

Notes: see notes in Table 7.2.

Table 7.11: Unit root tests on real exchange rates for the period 1/1992-12/2007 (continued)

Country	Level	1st dif.	Level	1st dif.
Germany	CPI	CPI	PPI	PPI
ADF	-1.06^{c} (0)	-11.80^{c} (0)	-1.25^{c} (0)	-11.91^{c} (0)
	$-0.62^{@}$ (0)	$-11.85^{@}$ (0)	$-0.83^{@}$ (0)	$-11.97^{@}$ (0)
PP	-1.06^{c}	-11.76^{c}	-1.34^{c}	-11.88^{c}
	$-0.75^{@}$	$-11.79^{@}$	$-0.83^{@}$	$-11.92^{@}$
KPSS	0.59^{c}	0.27^{c}	0.57^{c}	0.26^{c}
	$0.33^{@}$	$0.1191^{@}$	$0.33^{@}$	$0.08^{@}$
Greece	CPI	CPI	PPI	PPI
ADF	-0.58^{c} (0)	-12.86^{c} (0)	-0.03^{c} (0)	-12.42^{c} (0)
	$-0.72^{@}$ (0)	$-12.99^{@}$ (0)	$-0.74^{@}$ (0)	$-12.83^{@}$ (0)
PP	-0.69^{c}	-12.86^{c}	-0.06^{c}	-12.42^{c}
	$-0.77^{@}$	$-12.99^{@}$	$-0.72^{@}$	$-12.83^{@}$
KPSS	0.32^{c}		0.52^{c}	0.59^{c}
	$0.32^{@}$	$0.10^{@}$	$0.37^{@}$	$0.08^{@}$
Ireland	CPI	CPI	PPI	PPI
ADF	-0.49^{c} (0)	-11.97^{c} (0)	-1.92^{c} (0)	-14.48^{c} (0)
	$-0.76^{@}$ (0)	$-12.18^{@}$ (0)	$-2.08^{@}$ (0)	$-14.48^{@}$ (0)
PP	-0.69^{c}	-11.97^{c}	-1.83^{c}	-14.59^{c}
	$-0.85^{@}$	$-12.17^{@}$	$-2.00^{@}$	$-14.64^{@}$
KPSS	0.40^{c}	0.41^{c}	1.24^{c}	0.12^{c}
	$0.37^{@}$	$0.07^{@}$	$0.24^{@}$	$0.06^{@}$
Italy	CPI	CPI	PPI	PPI
ADF	-1.73^{c} (0)	-11.77^{c} (0)	-1.48^{c} (0)	-12.03^{c} (0)
	$-1.45^{@}$ (0)	$-12.04^{@}$ (0)	$-1.52^{@}$ (0)	$-12.31^{@}$ (0)
PP	-1.80^{c}	-11.71^{c}	-1.48^{c}	-11.96^{c}
	$-1.53^{@}$	$-11.95^{@}$	$-1.55^{@}$	$-12.23^{@}$
KPSS	0.38^{c}		0.35^{c}	
	$0.35^{@}$	$0.06^{@}$	$0.35^{@}$	$0.06^{@}$
Luxembourg	CPI	CPI	PPI	PPI
ADF	-0.90^{c} (0)	-11.65^{c} (0)	-0.86^{c} (1)	-11.20^{c} (0)
	$-0.58^{@}$ (0)	$-11.72^{@}$ (0)	$-0.26^{@}$ (0)	$-11.40^{@}$ (0)
PP	-1.02^{c}	-11.63^{c}	-0.77^{c}	-11.18^{c}
	$-0.58^{@}$	$-11.69^{@}$	$-0.45^{@}$	$-11.41^{@}$
KPSS	0.45^{c}	0.30^{c}	0.42^{c}	
	$0.35^{@}$	$0.10^{@}$	$0.38^{@}$	$0.10^{@}$

Notes: see notes in Table 7.2.

Table 7.12: Unit root tests on real exchange rates for the period 1/1992-12/2007 (continued)

Country	Level	1st dif.	Level	1st dif.
Netherlands	CPI	CPI	PPI	PPI
ADF	-1.00^c (0)	-11.71^c (0)	-0.50^c (0)	-12.19^c (0)
	-0.81$^@$ (0)	-11.77$^@$ (0)	-0.54$^@$ (0)	-12.37$^@$ (0)
PP	-1.12^c	-11.67^c	-0.62^c	-12.19^c
	-0.81$^@$	-11.72$^@$	-0.64$^@$	-12.33$^@$
KPSS	0.38^c	0.26^c	0.38^c	0.44^c
	0.33$^@$	0.09$^@$	0.38$^@$	0.08$^@$
Portugal	CPI	CPI	PPI	PPI
ADF	-0.82^c (0)	-11.91^c (0)	-0.76^c (0)	-12.29^c (0)
	-0.84$^@$ (0)	-12.02$^@$ (0)	-1.32$^@$ (0)	-12.46$^@$ (0)
PP	-1.00^c	-11.91^c	-0.88^c	-12.25^c
	-0.95$^@$	-12.01$^@$	-1.41$^@$	-12.40$^@$
KPSS	0.35^c	0.31^c	0.48^c	0.35^c
	0.35$^@$	0.07$^@$	0.35$^@$	0.05$^@$
Spain	CPI	CPI	PPI	PPI
ADF	-1.35^c (0)	-12.27^c (0)	-1.54^c (0)	-12.53^c (0)
	-1.09$^@$ (0)	-12.56$^@$ (0)	-1.20$^@$ (0)	-12.82$^@$ (0)
PP	-1.42^c	-12.23^c	-1.54^c	-12.51^c
	-1.12$^@$	-12.52$^@$	-1.21$^@$	-12.78$^@$
KPSS	0.41^c		0.42^c	
	0.38$^@$	0.06$^@$	0.38$^@$	0.06$^@$
Sweden	CPI	CPI	PPI	PPI
ADF	-2.16^c (0)	-11.86^c (0)	-1.97^c (0)	-12.41^c (0)
	-1.36$^@$ (0)	-12.01$^@$ (0)	-1.54$^@$ (0)	-12.50$^@$ (0)
PP	-2.21^c	-11.87^c	-2.08^c	-12.39^c
	-1.53$^@$	-11.98$^@$	-1.68$^@$	-12.48$^@$
KPSS	0.86^c	0.32^c	0.54^c	0.23^c
	0.30$^@$	0.05$^@$	0.25$^@$	0.06$^@$
UK	CPI	CPI	PPI	PPI
ADF	-2.12^c (0)	-12.13^c (0)	-1.88^c (0)	-12.51^c (0)
	-2.28$^@$ (0)	-12.21$^@$ (0)	-2.40$^@$ (0)	-12.54$^@$ (0)
PP	-2.24^c	-12.04^c	-1.93^c	-12.47^c
	-2.33$^@$	-12.15$^@$	-2.43$^@$	-12.54$^@$
KPSS	0.25^c		0.39^c	0.15^c
	0.24$^@$	0.05$^@$	0.17$^@$	0.05$^@$

Notes: see notes in Table 7.2.

Table 7.13: Unit root tests on real exchange rates for the period 1/1992-12/1998

Country	Level	1st dif.	Level	1st dif.
Austria	CPI	CPI	PPI	PPI
ADF	-1.17^{c} (0)	-7.58^{c} (0)	-1.16^{c} (0)	-7.79^{c} (0)
	$-1.54^{@}$ (0)	$-7.57^{@}$ (0)	$-1.60^{@}$ (0)	$-7.75^{@}$ (0)
PP	-1.30^{c}	-7.50^{c}	-1.25^{c}	-7.73^{c}
	$-1.64^{@}$	$-7.48^{@}$	$-1.70^{@}$	$-7.68^{@}$
KPSS	0.41^{c}	0.12^{c}	0.58^{c}	0.10^{c}
	$0.219^{@}$	$0.08^{@}$	$0.19^{@}$	$0.09^{@}$
Belgium	CPI	CPI	PPI	PPI
ADF	-1.13^{c} (0)	-7.58^{c} (0)	-1.20^{c} (0)	-7.81^{c} (0)
	$-1.50^{@}$ (0)	$-7.56^{@}$ (0)	$-1.48^{@}$ (0)	$-7.77^{@}$ (0)
PP	-1.25^{c}	-7.54^{c}	-1.31^{c}	-7.81^{c}
	$-1.62^{@}$	$-7.51^{@}$	$-1.60^{@}$	$-7.78^{@}$
KPSS	0.42^{c}	0.11^{c}	0.37^{c}	0.11^{c}
	$0.20^{@}$	$0.08^{@}$	$0.18^{@}$	$0.09^{@}$
Denmark	CPI	CPI	PPI	PPI
ADF	-1.40^{c} (0)	-7.53^{c} (0)	-1.51^{c} (0)	-7.57^{c} (0)
	$-1.60^{@}$ (0)	$-7.49^{@}$ (0)	$-1.62^{@}$ (0)	$-7.52^{@}$ (0)
PP	-1.40^{c}	-7.48^{c}	-1.51^{c}	-7.48^{c}
	$-1.75^{@}$	$-7.43^{@}$	$-1.62^{@}$	$-7.43^{@}$
KPSS	0.33^{c}		0.27^{c}	
	$0.16^{@}$	$0.07^{@}$	$0.15^{@}$	$0.08^{@}$
Finland	CPI	CPI	PPI	PPI
ADF	-1.77^{c} (0)	-7.59^{c} (0)	-1.57^{c} (0)	-7.54^{c} (0)
	$-1.68^{@}$ (0)	$-7.56^{@}$ (0)	$-1.57^{@}$ (0)	$-7.49^{@}$ (0)
PP	-1.85^{c}	-7.54^{c}	-1.57^{c}	-7.47^{c}
	$-1.80^{@}$	$-7.50^{@}$	$-1.57^{@}$	$-7.42^{@}$
KPSS	0.28^{c}		0.22^{c}	
	$0.13^{@}$	$0.112^{@}$	$0.147^{@}$	$0.115^{@}$
France	CPI	CPI	PPI	PPI
ADF	-1.25^{c} (0)	-8.35^{c} (0)	-1.20^{c} (0)	-8.14^{c} (0)
	$-1.70^{@}$ (0)	$-8.31^{@}$ (0)	$-1.53^{@}$ (0)	$-8.10^{@}$ (0)
PP	-1.32^{c}	-8.32^{c}	-1.20^{c}	-8.11^{c}
	$-1.78^{@}$	$-8.28^{@}$	$-1.62^{@}$	$-8.06^{@}$
KPSS	0.48^{c}	0.10^{c}	0.465^{c}	0.10^{c}
	$0.18^{@}$	$0.08^{@}$	$0.16^{@}$	$0.09^{@}$

Notes: see notes in Table 7.2.

Table 7.14: Unit root tests on real exchange rates for the period 1/1992-12/1998 (continued)

Country	Level	1st dif.	Level	1st dif.
Germany	CPI	CPI	PPI	PPI
ADF	-1.16^{c} (0)	-7.96^{c} (0)	-1.27^{c} (0)	-7.87^{c} (0)
	$-1.58^{@}$ (0)	$-7.95^{@}$ (0)	$-1.64^{@}$ (0)	$-7.83^{@}$ (0)
PP	-1.26^{c}	-7.90^{c}	-1.37^{c}	-7.80^{c}
	$-1.65^{@}$	$-7.89^{@}$	$-1.75^{@}$	$-7.77^{@}$
KPSS	0.43^{c}	0.13^{c}	0.48^{c}	0.10^{c}
	$0.22^{@}$	$0.08^{@}$	$0.18^{@}$	$0.08^{@}$
Greece	CPI	CPI	PPI	PPI
ADF	-1.83^{c} (0)	-9.39^{c} (0)	-1.09^{c} (0)	-8.65^{c} (0)
	$-1.82^{@}$ (0)	$-9.33^{@}$ (0)	$-2.73^{@}$ (0)	$-8.55^{@}$ (0)
PP	-1.83^{c}	-9.41^{c}	-0.94^{c}	-8.79^{c}
	$-1.82^{@}$	$-9.35^{@}$	$-2.70^{@}$	$-8.68^{@}$
KPSS	0.17^{c}		0.74^{c}	0.08^{c}
	$0.18^{@}$	$0.09^{@}$	$0.115^{@}$	
Ireland	CPI	CPI	PPI	PPI
ADF	-1.68^{c} (0)	-8.25^{c} (0)	-1.96^{c} (0)	-9.35^{c} (0)
	$-1.90^{@}$ (0)	$-8.20^{@}$ (0)	$-2.38^{@}$ (0)	$-9.25^{@}$ (0)
PP	-1.76^{c}	-8.23^{c}	-1.88^{c}	-9.41^{c}
	$-2.00^{@}$	$-8.18^{@}$	$-2.38^{@}$	$-9.35^{@}$
KPSS	0.43^{c}		0.50^{c}	0.05^{c}
	$0.110^{@}$		$0.112^{@}$	
Italy	CPI	CPI	PPI	PPI
ADF	-2.43^{c} (0)	-7.89^{c} (0)	-2.56^{c} (0)	-8.03^{c} (0)
	$-2.09^{@}$ (0)	$-7.98^{@}$ (0)	$-2.22^{@}$ (0)	$-8.12^{@}$ (0)
PP	-2.43^{c}	-7.82^{c}	-2.56^{c}	-7.97^{c}
	$-2.11^{@}$	$-7.92^{@}$	$-2.20^{@}$	$-8.08^{@}$
KPSS	0.54^{c}	0.21^{c}	0.40^{c}	0.23^{c}
	$0.145^{@}$	$0.08^{@}$	$0.143^{@}$	$0.10^{@}$
Luxembourg	CPI	CPI	PPI	PPI
ADF	-1.06^{c} (0)	-7.54^{c} (0)	-1.20^{c} (0)	-7.48^{c} (0)
	$-1.48^{@}$ (0)	$-7.53^{@}$ (0)	$-1.57^{@}$ (0)	$-7.44^{@}$ (0)
PP	-1.19^{c}	-7.49^{c}	-1.20^{c}	-7.40^{c}
	$-1.60^{@}$	$-7.48^{@}$	$-1.73^{@}$	$-7.35^{@}$
KPSS	0.44^{c}	0.12^{c}	0.53^{c}	0.08^{c}
	$0.210^{@}$	$0.08^{@}$	$0.16^{@}$	$0.08^{@}$

Notes: see notes in Table 7.2.

Table 7.15: Unit root tests on real exchange rates for the period 1/1992-12/1998 (continued)

Country	Level	1st dif.	Level	1st dif.
Netherlands	CPI	CPI	PPI	PPI
ADF	-1.25^c (0)	-7.83^c (0)	-1.25^c (0)	-8.19^c (0)
	-1.55$^@$ (0)	-7.80$^@$ (0)	-1.57$^@$ (0)	-8.16$^@$ (0)
PP	-1.36^c	-7.76^c	-1.25^c	-8.16^c
	-1.66$^@$	-7.72$^@$	-1.57$^@$	-8.12$^@$
KPSS	0.40^c	0.11^c	0.42^c	0.10^c
	0.20$^@$	0.09$^@$	0.18$^@$	0.08$^@$
Portugal	CPI	CPI	PPI	PPI
ADF	-1.50^c (0)	8.21^c (0)	-1.50^c (0)	-8.70^c (0)
	-1.73$^@$ (0)	-8.16$^@$ (0)	-1.62$^@$ (0)	-8.65$^@$ (0)
PP	-1.57^c	-8.21^c	-1.50^c	-8.70^c
	-1.83$^@$	-8.16$^@$	-1.62$^@$	-8.64$^@$
KPSS	0.39^c	0.07^c	0.29^c	
	0.11$^@$	0.07$^@$	0.13$^@$	0.11$^@$
Spain	CPI	CPI	PPI	PPI
ADF	-1.87^c (0)	-8.61^c (0)	-1.97^c (0)	-8.64^c (0)
	-1.92$^@$ (0)	-8.61$^@$ (0)	-1.94$^@$ (0)	-8.63$^@$ (0)
PP	-1.86^c	-8.60^c	-1.95^c	-8.63^c
	-1.96$^@$	-8.60$^@$	-1.96$^@$	-8.62$^@$
KPSS	0.66^c	0.14^c	0.59^c	0.15^c
	0.116$^@$		0.116$^@$	
Sweden	CPI	CPI	PPI	PPI
ADF	-1.60^c (0)	-6.61^c (0)	-1.64^c (0)	-6.30^c (1)
	-1.70$^@$ (0)	-6.58$^@$ (0)	-1.60$^@$ (0)	-6.27$^@$ (1)
PP	-1.72^c	-6.52^c	-1.83^c	-6.62^c
	-1.93$^@$	-6.48$^@$	-1.80$^@$	-6.58$^@$
KPSS	0.52^c	0.11^c	0.15^c	
	0.13$^@$	0.10$^@$	0.13$^@$	
UK	CPI	CPI	PPI	PPI
ADF	-2.54^c (2)	-7.71^c (1)	-1.92^c (2)	-7.91^c (1)
	-2.60$^@$ (0)	-7.79$^@$ (1)	-2.72$^@$ (0)	-7.95$^@$ (1)
PP	-2.71^c	-7.33^c	-2.25^c	-7.49^c
	-2.51$^@$	-7.59$^@$	-2.71$^@$	-7.65$^@$
KPSS	0.18^c		0.41^c	0.18^c
	0.18$^@$	0.08$^@$	0.16$^@$	0.08$^@$

Notes: see notes in Table 7.2.

Table 7.16: Unit root tests on real exchange rates for the period 1/1999-12/2007

Country	Level	1st dif.	Level	1st dif.
Austria	CPI	CPI	PPI	PPI
ADF	-0.17^{c} (0)	-8.71^{c} (0)	-0.04^{c} (0)	-8.64^{c} (0)
	$-2.73^{@}$ (0)	$-9.00^{@}$ (0)	$-2.67^{@}$ (0)	$-8.94^{@}$ (0)
PP	-0.17^{c}	-8.72^{c}	-0.26^{c}	-8.64^{c}
	$-2.73^{@}$	$-8.94^{@}$	$-2.68^{@}$	$-8.94^{@}$
KPSS	0.92^{c}	0.40^{c}	0.93^{c}	0.44^{c}
	$0.143^{@}$		$0.13^{@}$	
Belgium	CPI	CPI	PPI	PPI
ADF	-0.08^{c} (0)	-8.86^{c} (0)	0.13^{c} (0)	-9.03^{c} (0)
	$-2.65^{@}$ (0)	$-9.15^{@}$ (0)	$-2.50^{@}$ (0)	$-9.28^{@}$ (0)
PP	-0.08^{c}	-8.87^{c}	-0.04^{c}	-9.03^{c}
	$-2.65^{@}$	$-9.10^{@}$	$-2.55^{@}$	$-9.23^{@}$
KPSS	0.93^{c}	0.41^{c}	1.02^{c}	0.340^{c}
	$0.147^{@}$	$0.18^{@}$	$0.13^{@}$	
Denmark	CPI	CPI	PPI	PPI
ADF	-0.19^{c} (0)	-8.88^{c} (0)	-0.27^{c} (0)	-9.20^{c} (0)
	$-2.52^{@}$ (0)	$-9.10^{@}$ (0)	$-2.65^{@}$ (0)	$-9.43^{@}$ (0)
PP	-0.19^{c}	-8.89^{c}	-0.27^{c}	-9.22^{c}
	$-2.53^{@}$	$-9.07^{@}$	$-2.67^{@}$	$-9.39^{@}$
KPSS	0.91^{c}	0.35^{c}	0.93^{c}	0.344^{c}
	$0.13^{@}$		$0.12^{@}$	
Finland	CPI	CPI	PPI	PPI
ADF	-0.37^{c} (0)	-8.70^{c} (0)	-0.46^{c} (0)	-9.45^{c} (0)
	$-2.59^{@}$ (0)	$-8.95^{@}$ (0)	$-2.55^{@}$ (0)	$-9.67^{@}$ (0)
PP	-0.37^{c}	-8.71^{c}	-0.61^{c}	-9.45^{c}
	$-2.61^{@}$	$-8.88^{@}$	$-2.58^{@}$	$-9.66^{@}$
KPSS	0.86^{c}	0.35^{c}	0.86^{c}	0.344^{c}
	$0.13^{@}$		$0.13^{@}$	
France	CPI	CPI	PPI	PPI
ADF	-0.23^{c} (0)	-8.77^{c} (0)	-0.75^{c} (0)	-8.64^{c} (0)
	$-2.61^{@}$ (0)	$-9.05^{@}$ (0)	$-2.75^{@}$ (0)	$-8.86^{@}$ (0)
PP	-0.35^{c}	-8.79^{c}	-0.75^{c}	-8.65^{c}
	$-2.62^{@}$	$-9.03^{@}$	$-2.75^{@}$	$-8.77^{@}$
KPSS	0.88^{c}	0.40^{c}	0.78^{c}	0.35^{c}
	$0.145^{@}$		$0.13^{@}$	

Notes: see notes in Table 7.2.

Table 7.17: Unit root tests on real exchange rates for the period 1/1999-12/2007 (continued)

Country	Level	1st dif.	2nd dif.	Level	1st dif.	2nd dif.
Germany	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.28^{c} (0)	-8.65^{c} (0)		-0.45^{c} (0)	-8.88^{c} (0)	
	-2.70$^{@}$ (0)	-8.95$^{@}$ (0)		-2.76$^{@}$ (0)	-9.12$^{@}$ (0)	
PP	-0.41^{c}	-8.67^{c}		-0.45^{c}	-8.90^{c}	
	-2.70$^{@}$	-8.88$^{@}$		-2.76$^{@}$	-9.07$^{@}$	
KPSS	0.87^{c}	0.41^{c}		0.87^{c}	0.36^{c}	
	0.147$^{@}$	0.18$^{@}$		0.13$^{@}$		
Greece	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.21^{c} (0)	-8.84^{c} (0)		0.47^{c} (0)	-9.50^{c} (0)	
	-2.48$^{@}$ (0)	-9.16$^{@}$ (0)		-2.47$^{@}$ (0)	-9.85$^{@}$ (0)	
PP	-0.04^{c}	-8.88^{c}		0.40^{c}	-9.50^{c}	
	-2.47$^{@}$	-9.16$^{@}$		-2.48$^{@}$	-9.85$^{@}$	
KPSS	0.96^{c}	0.43^{c}		1.06^{c}	0.460^{c}	
	0.15$^{@}$	0.15$^{@}$	0.33$^{@}$	0.1462$^{@}$	0.148$^{@}$	0.05$^{@}$
Ireland	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.39^{c} (0)	-8.71^{c} (0)		-2.36^{c} (0)	-10.99^{c} (0)	
	-2.67$^{@}$ (0)	-8.96$^{@}$ (0)		-2.72$^{@}$ (0)	-11.08$^{@}$ (0)	
PP	0.25^{c}	-8.73^{c}		-2.36^{c}	-11.09^{c}	
	-2.68$^{@}$	-8.89$^{@}$		-2.66$^{@}$	-11.21$^{@}$	
KPSS	1.08^{c}	0.36^{c}		0.25^{c}		
	0.13$^{@}$			0.115$^{@}$		
Italy	CPI	CPI	CPI	PPI	PPI	PPI
ADF	-0.09^{c} (0)	-8.74^{c} (0)		0.05^{c} (0)	-8.97^{c} (0)	
	-2.66$^{@}$ (0)	-9.00$^{@}$ (0)		-2.87$^{@}$ (0)	-9.24$^{@}$ (0)	
PP	-0.09^{c}	-8.76^{c}		-0.06^{c}	-8.99^{c}	
	-2.66$^{@}$	-8.94$^{@}$		-2.87$^{@}$	-9.19$^{@}$	
KPSS	0.95^{c}	0.38^{c}		1.03^{c}	0.37^{c}	
	0.141$^{@}$			0.13$^{@}$		
Luxembourg	CPI	CPI	CPI	PPI	PPI	PPI
ADF	0.003^{c} (0)	-8.85^{c} (0)		0.54^{c} (0)	-8.37^{c} (0)	
	-2.65$^{@}$ (0)	-9.13$^{@}$ (0)		-3.00$^{@}$ (0)	-8.77$^{@}$ (0)	
PP	0.003^{c}	-8.86^{c}		0.37^{c}	-8.37^{c}	
	-2.65$^{@}$	-9.07$^{@}$		-2.98$^{@}$	-8.72$^{@}$	
KPSS	0.97^{c}	0.39^{c}		1.06^{c}	0.58^{c}	0.16^{c}
	0.144$^{@}$			0.18$^{@}$	0.149$^{@}$	0.16$^{@}$

Notes: see notes in Table 7.2.

Table 7.18: Unit root tests on real exchange rates for the period 1/1999-12/2007 (continued)

Country	Level	1st dif.	Level	1st dif.
Netherlands	CPI	CPI	PPI	PPI
ADF	-0.18^{c} (0)	-8.67^{c} (0)	0.47^{c} (0)	-9.07^{c} (0)
	$-2.59^{@}$ (0)	$-8.87^{@}$ (0)	$-2.60^{@}$ (0)	$-9.35^{@}$ (0)
PP	-0.18^{c}	-8.68^{c}	0.29^{c}	-9.09^{c}
	$-2.61^{@}$	$-8.80^{@}$	$-2.62^{@}$	$-9.30^{@}$
KPSS	0.94^{c}	0.33^{c}	1.11^{c}	0.36^{c}
	$0.13^{@}$		$0.148^{@}$	$0.142^{@}$
Portugal	CPI	CPI	PPI	PPI
ADF	0.08^{c} (0)	-8.54^{c} (0)	-0.02^{c} (0)	-8.73^{c} (0)
	$-2.70^{@}$ (0)	$-8.77^{@}$ (0)	$-2.30^{@}$ (0)	$-8.77^{@}$ (0)
PP	-0.05^{c}	-8.52^{c}	0.04^{c}	-8.60^{c}
	$-2.70^{@}$	$-8.67^{@}$	$-2.34^{@}$	$-8.65^{@}$
KPSS	1.01^{c}	0.37^{c}	1.14^{c}	0.19^{c}
	$0.13^{@}$		$0.117^{@}$	
Spain	CPI	CPI	PPI	PPI
ADF	0.26^{c} (0)	-8.61^{c} (0)	0.18^{c} (0)	-8.98^{c} (0)
	$-2.63^{@}$ (0)	$-8.88^{@}$ (0)	$-2.75^{@}$ (0)	$-9.26^{@}$ (0)
PP	0.04^{c}	-8.62^{c}	0.0008^{c}	-9.00^{c}
	$-2.63^{@}$	$-8.78^{@}$	$-2.75^{@}$	$-9.21^{@}$
KPSS	1.03^{c}	0.39^{c}	1.04^{c}	0.39^{c}
	$0.145^{@}$		$0.143^{@}$	
Sweden	CPI	CPI	PPI	PPI
ADF	-0.80^{c} (0)	-10.41^{c} (0)	-0.89^{c} (0)	-11.14^{c} (0)
	$-1.96^{@}$ (0)	$-10.56^{@}$ (0)	$-2.22^{@}$ (0)	$-11.29^{@}$ (0)
PP	-0.90^{c}	-10.43^{c}	-0.82^{c}	-11.14^{c}
	$-1.96^{@}$	$-10.56^{@}$	$-2.18^{@}$	$-11.29^{@}$
KPSS	0.62^{c}	0.27^{c}	0.70^{c}	0.30^{c}
	$0.13^{@}$		$0.146^{@}$	$0.10^{@}$
UK	CPI	CPI	PPI	PPI
ADF	-0.64^{c} (0)	-10.12^{c} (0)	-0.81^{c} (0)	-10.58^{c} (0)
	$-2.23^{@}$ (0)	$-10.29^{@}$ (0)	$-2.28^{@}$ (0)	$-10.72^{@}$ (0)
PP	-0.86^{c}	-10.23^{c}	-0.97^{c}	-10.59^{c}
	$-2.29^{@}$	$-10.34^{@}$	$-2.30^{@}$	$-10.71^{@}$
KPSS	0.77^{c}	0.26^{c}	0.75^{c}	0.25^{c}
	$0.16^{@}$	$0.10^{@}$	$0.146^{@}$	$0.112^{@}$

Notes: see notes in Table 7.2.

Chapter 8

Appendix B

Table 8.1: Unit root test with structural break on real exchange rates

	CPI		PPI	
Country	Break date	Test statistic	Break date	Test statistic
Austria	7/1997	-1.22 (1)	9/2003	-1.43 (1)
Belgium	7/1997	-1.16 (1)	6/1993	-0.69 (0)
Denmark	7/1997	-1.28 (1)	7/1997	-0.97 (0)
Finland	5/2003	-2.22 (9)	7/1997	-2.53 (10)
France	10/1992	-1.07 (1)	10/1992	-1.31 (1)
Germany	10/1992	-1.12 (1)	10/1992	-1.25 (1)
Greece	3/1998	-1.62 (9)	3/1998	0.30 (0)
Ireland	2/1993	-0.23 (0)	10/1992	-1.50 (1)
Italy	9/1992	-1.02 (1)	9/1992	-0.33 (0)
Luxembourg	9/2003	-1.36 (1)	6/1993	-0.63 (1)
Netherlands	9/2003	-1.48 (1)	10/1992	-0.29 (0)
Portugal	7/1993	-0.95 (1)	7/1993	-0.41 (0)
Spain	7/1993	-0.82 (0)	7/1993	-0.95 (0)
Sweden	11/1992	-1.53 (0)	11/1992	-1.56 (0)
UK	10/1992	-1.22 (4)	2/2003	-1.80 (9)

Notes: lag length in parentheses, based on AIC, critical value at 5% significance level -2.88.

Table 8.2: KSS nonlinear unit root test on real exchange rates for the period 1/1992-12/2007

	CPI			PPI		
Country	t_{NL}	t_{NL1}	t_{NL2}	t_{NL}	t_{NL1}	t_{NL2}
Austria	-0.39	-1.46	-1.16	-0.27	-1.49	-1.07
Belgium	-0.32	-1.43	-1.13	-0.43	-1.25	-1.02
Denmark	-0.47	-1.53	-1.38	-0.43	-1.58	-1.43
Finland	-0.13	-2.70	-2.17	-0.16	-2.60	-2.18
France	-0.36	-1.47	-1.14	-0.10	-1.71	-1.35
Germany	-0.75	-1.48	-1.13	-0.73	-1.60	-1.29
Greece	-0.61	-0.85	-0.99	-0.74	-0.29	-0.98
Ireland	0.24	-0.84	-1.22	-1.71	-2.46	-2.27
Italy	0.12	-2.59	-2.37	-0.04	-2.4	-2.47
Luxembourg	-0.38	-1.39	-1.12	-0.51	-0.89	-0.63
Netherlands	-0.77	-1.44	-1.31	-0.77	-0.80	-0.91
Portugal	-0.46	-1.26	-1.29	-0.48	-1.09	-1.80
Spain	-0.06	-1.91	-1.65	-0.003	-2.08	-1.75
Sweden	0.19	-2.09	-1.43	-0.02	-1.94	-1.67
UK	-1.10	-2.88	-2.99	-0.67	-2.62	-3.13

*Notes: t_{NL}, t_{NL1} and t_{NL2} refer to the model with the raw data, the de-meaned data and the de-trended data, respectively, * indicates rejection of the null hypothesis at 5% significance level, 5% critical values t_{NL} = -2.22, t_{NL1} = -2.93 and t_{NL2} = -3.40.*

Table 8.3: KSS nonlinear unit root test on real exchange rates for the period 1/1992-12/1998

	CPI			PPI		
Country	t_{NL}	t_{NL1}	t_{NL2}	t_{NL}	t_{NL1}	t_{NL2}
Austria	0.28	-1.17	-1.11	0.59	-1.49	-1.42
Belgium	0.42	-1.23	-1.21	0.54	-1.35	-1.37
Denmark	0.22	-1.71	-1.76	0.24	-1.64	-1.66
Finland	0.48	-2.50	-2.89	0.44	-2.18	-2.42
France	0.36	-1.53	-1.55	0.47	-1.38	-1.25
Germany	-0.19	-1.17	-1.06	-0.13	-1.35	-1.28
Greece	0.19	-1.61	-1.58	0.64	-1.71	-0.86
Ireland	-1.41	-1.77	-1.69	-1.04	-1.85	-2.42
Italy	0.97	-2.66	-2.73	0.86	-2.83	-2.81
Luxembourg	0.43	-1.23	-1.20	0.65	-1.35	-1.31
Netherlands	-0.10	-1.28	-1.27	0.24	-1.62	-1.62
Portugal	0.35	-1.62	-1.58	0.80	-2.34	-1.61
Spain	0.95	-2.10	-2.17	0.95	-2.15	-2.28
Sweden	1.12	-1.98	-1.92	0.63	-1.95	-2.26
UK	-1.43	-2.96*	-2.83	-0.90	-4.00*	-3.38

Notes: see notes in Table 8.2.

Table 8.4: KSS nonlinear unit root test on real exchange rates for the period 1/1999-12/2007

	CPI			PPI		
Country	t_{NL}	t_{NL1}	t_{NL2}	t_{NL}	t_{NL1}	t_{NL2}
Austria	-0.68	-1.11	-0.93	-0.75	-1.03	-0.80
Belgium	-0.74	-1.08	-0.90	-1.01	-0.85	-0.68
Denmark	-0.75	-1.13	-1.06	-0.72	-1.16	-1.10
Finland	-0.63	-1.15	-0.97	-0.66	-1.20	-0.94
France	-0.66	-1.08	-0.93	-0.42	-1.17	-1.10
Germany	-0.73	-1.12	-0.93	-0.73	-1.16	-1.04
Greece	-0.98	-0.74	-0.84	-1.28	-0.20	-0.77
Ireland	1.35	-0.53	-0.79	-1.77	-1.56	-1.68
Italy	-0.76	-1.08	-0.99	-0.90	-0.93	-0.96
Luxembourg	-0.83	-1.05	-0.87	-1.14	-0.57	-0.37
Netherlands	-0.80	-1.13	-1.07	-1.02	-0.47	-0.55
Portugal	-0.96	-0.95	-0.98	-1.47	-0.55	-1.17
Spain	-1.08	-0.88	-0.73	-1.01	-0.91	-0.71
Sweden	-0.52	-0.74	-0.65	-0.52	-0.85	-0.84
UK	0.09	-0.89	-0.91	-0.03	-1.13	-1.11

Notes: see notes in Table 8.2.

Table 8.5: Panel unit root tests on real exchange rates

Sample	1992-2007		1992-1998		1999-2007	
	CPI	PPI	CPI	PPI	CPI	PPI
LLC	t^*	t^*	t^*	t^*	t^*	t^*
	1.285	1.344	-0.31	-0.351	4.798	4.611
	(0.900)	(0.910)	(0.378)	(0.362)	(1.000)	(1.000)
BR	t	t	t	t	t	t
	3.69	3.659	-2.283*	-2.891*	2.314	1.984
	(0.999)	(0.999)	(0.012)	(0.001)	(0.989)	(0.976)
IPS	w_t	w_t	w_t	w_t	w_t	w_t
	1.418	1.353	-0.246	-0.056	6.286	5.679
	(0.922)	(0.912)	(0.402)	(0.477)	(1.000)	(1.000)
MW	p	p	p	p	p	p
	15.845	16.391	24.626	22.841	2.143	6.122
	(0.984)	(0.979)	(0.743)	(0.821)	(1.000)	(1.000)
CH	z	z	z	z	z	z
	1.556	1.453	-0.128	0.074	6.056	5.432
	(0.940)	(0.926)	(0.448)	(0.529)	(1.000)	(1.000)
HAD	z	z	z	z	z	z
	8.266*	9.197*	7.049*	6.539*	20.164*	21.228*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

*Notes: The optimal lag length is based on SIC with 12 maximum lags. LLC denotes the Levin, Lin and Chu (2002) test, BR denotes the Breitung (2000) test, IPS denotes the Im, Pesaran and Shin (2003) test, MW denotes the Maddala and Wu (1999) test, CH denotes the Choi (2001) test, HAD denotes the Hadri (2000) test. Corresponding p-values in parentheses, * indicates rejection of the null hypothesis at 5% significance level.*

Table 8.6: Johansen cointegration test on exchange rates and relative prices for the period 1/1992-12/2007

Country	H_0	CPI	CPI_1	CPI_2	PPI	PPI_1	PPI_2
Austria	$r = 0$	0.44	0.41	0.70	0.69	0.60	0.73
	$r \leq 1$	0.83	0.94	0.93	0.96	0.91	0.92
Belgium	$r = 0$	0.35	0.51	0.73	0.20	0.13	0.31
	$r \leq 1$	0.80	0.76	0.81	0.89	0.43	0.57
Denmark	$r = 0$	0.02*	0.053	0.10	0.30	0.06	0.06
	$r \leq 1$	0.86	0.96	0.87	0.95	0.96	0.77
Finland	$r = 0$	0.00*	0.00*	0.00*	0.67	0.80	0.58
	$r \leq 1$	0.56	0.43	0.66	0.72	0.46	0.41
France	$r = 0$	0.00*	0.00*	0.00*	0.10	0.17	0.06
	$r \leq 1$	0.78	0.54	0.25	0.85	0.64	0.63
Germany	$r = 0$	0.06	0.06	0.03*	0.41	0.48	0.30
	$r \leq 1$	0.82	0.63	0.72	0.89	0.76	0.65
Greece	$r = 0$	0.00*	0.00*	0.00*	0.04*	0.09	
	$r \leq 1$	0.88	0.94	0.96	0.11	0.29	
Ireland	$r = 0$	0.00*	0.00*		0.26	0.50	0.39
	$r \leq 1$	0.13	0.22		0.45	0.68	0.85
Italy	$r = 0$	0.31	0.39	0.00*	0.00*	0.00*	0.00*
	$r \leq 1$	0.54	0.42	0.47	0.31	0.56	0.52
Luxembourg	$r = 0$	0.43	0.04*	0.29	0.81	0.16	0.26
	$r \leq 1$	0.90	0.18	0.39	0.98	0.44	0.36
Netherlands	$r = 0$	0.01*	0.00*	0.00*	0.49	0.66	0.63
	$r \leq 1$	0.94	0.86	0.14	0.77	0.75	0.80
Portugal	$r = 0$	0.00*	0.00*	0.00*	0.36	0.44	0.45
	$r \leq 1$	0.69	0.83	0.75	0.43	0.58	0.41
Spain	$r = 0$	0.00*	0.01*	0.01*	0.01*	0.01*	0.01*
	$r \leq 1$	0.27	0.40	0.31	0.34	0.20	0.17
Sweden	$r = 0$	0.01*	0.10		0.97	0.99	0.97
	$r \leq 1$	0.41	0.78		0.96	0.98	0.99
UK	$r = 0$	0.00*	0.01*	0.04*	0.86	0.84	0.77
	$r \leq 1$	0.14	0.14	0.17	0.98	0.90	0.85

*Notes: p-values are given. CPI_1, PPI_1 and CPI_2, PPI_2 refer to cointegration test with one and two structural breaks, respectively. * indicates rejection of the null hypothesis at 5% significance level.*

Table 8.7: Johansen cointegration test on exchange rates and relative prices for the period 1/1992-12/1998

Country	H_0	CPI	CPI_1	CPI_2	PPI	PPI_1	PPI_2
Austria	$r=0$	0.84	0.71	0.11	0.29	0.39	0.17
	$r\leq 1$	0.94	0.44	0.61	0.37	0.52	0.80
Belgium	$r=0$	0.41	0.51	0.55	0.45	0.18	0.55
	$r\leq 1$	0.70	0.67	0.74	0.42	0.59	0.71
Denmark	$r=0$	0.03*	0.09	0.05	0.04*	0.12	0.18
	$r\leq 1$	0.57	0.73	0.79	0.63	0.71	0.80
Finland	$r=0$	0.00*	0.00*	0.00*	0.51	0.29	0.31
	$r\leq 1$	0.79	0.87	0.76	0.98	0.70	0.57
France	$r=0$	0.00*	0.00*	0.00*	0.29	0.42	0.71
	$r\leq 1$	0.54	0.63	0.68	0.20	0.25	0.65
Germany	$r=0$	0.63	0.35	0.11	0.02*	0.03*	0.01*
	$r\leq 1$	0.97	0.48	0.72	0.51	0.69	0.58
Greece	$r=0$	0.00*	0.00*	0.00*	0.05	0.04*	
	$r\leq 1$	0.52	0.37	0.58	0.60	0.17	
Ireland	$r=0$	0.16	0.43	0.35	0.70	0.71	
	$r\leq 1$	0.40	0.68	0.72	0.51	0.57	
Italy	$r=0$	0.00*	0.00*	0.00*	0.16	0.30	0.62
	$r\leq 1$	0.20	0.30	0.59	0.21	0.44	0.70
Luxembourg	$r=0$	0.09	0.15	0.21	0.16	0.24	0.18
	$r\leq 1$	0.82	0.60	0.75	0.28	0.52	0.72
Netherlands	$r=0$	0.07	0.14	0.058	0.49	0.75	0.94
	$r\leq 1$	0.17	0.17	0.07	0.70	0.81	0.88
Portugal	$r=0$	0.00*	0.00*	0.00*	0.97	0.42	0.32
	$r\leq 1$	0.65	0.20	0.24	0.94	0.48	0.31
Spain	$r=0$	0.00*	0.00*	0.00*	0.51	0.70	
	$r\leq 1$	0.56	0.07	0.12	0.41	0.52	
Sweden	$r=0$	0.10	0.30		0.65	0.48	0.56
	$r\leq 1$	0.31	0.89		0.50	0.71	0.81
UK	$r=0$	0.43	0.00*	0.00*	0.01*	0.00*	0.00*
	$r\leq 1$	0.61	0.64	0.89	0.10	0.02	0.15

Notes: see notes in Table 8.6.

Table 8.8: Johansen cointegration test on exchange rates and relative prices for the period 1/1999-12/2007

Country	H_0	CPI	CPI_1	CPI_2	PPI	PPI_1	PPI_2
Austria	$r = 0$	0.17	0.05	0.07	0.90	0.51	0.33
	$r \leq 1$	0.28	0.09	0.16	0.96	0.52	0.30
Belgium	$r = 0$	0.32	0.19	0.15	0.38	0.19	0.18
	$r \leq 1$	0.36	0.44	0.33	0.91	0.82	0.52
Denmark	$r = 0$	0.33	0.06	0.33	0.28	0.08	0.08
	$r \leq 1$	0.84	0.16	0.39	0.97	0.16	0.12
Finland	$r = 0$	0.01*	0.00*	0.02*	0.64	0.10	0.07
	$r \leq 1$	0.55	0.10	0.22	0.68	0.38	0.32
France	$r = 0$	0.06	0.01*	0.06	0.23	0.07	0.06
	$r \leq 1$	0.25	0.11	0.21	0.59	0.14	0.08
Germany	$r = 0$	0.00*	0.00*	0.03*	0.37	0.09	0.10
	$r \leq 1$	0.10	0.07	0.15	0.86	0.10	0.14
Greece	$r = 0$	0.01*	0.01*	0.00*	0.00*	0.03*	0.18
	$r \leq 1$	0.57	0.31	0.058	0.20	0.51	0.83
Ireland	$r = 0$	0.00*	0.02*	0.00*	0.11	0.01*	0.07
	$r \leq 1$	0.03*	0.13	0.17	0.45	0.11	0.16
Italy	$r = 0$	0.84	0.26	0.49	0.03*	0.03*	0.06
	$r \leq 1$	0.97	0.36	0.64	0.89	0.35	0.39
Luxembourg	$r = 0$	0.91	0.46	0.07	0.92	0.27	0.18
	$r \leq 1$	0.92	0.55	0.37	0.72	0.73	0.58
Netherlands	$r = 0$	0.10	0.01*	0.09	0.16	0.20	0.50
	$r \leq 1$	0.94	0.10	0.15	0.39	0.72	0.88
Portugal	$r = 0$	0.04*	0.08	0.04*	0.00*	0.00*	0.00*
	$r \leq 1$	0.13	0.13	0.19	0.52	0.62	0.77
Spain	$r = 0$	0.00*	0.01*	0.01*	0.00*	0.00*	0.02*
	$r \leq 1$	0.33	0.57	0.29	0.86	0.65	0.25
Sweden	$r = 0$	0.00*	0.00*	0.02*	0.11	0.00*	0.01*
	$r \leq 1$	0.74	0.65	0.59	0.95	0.41	0.43
UK	$r = 0$	0.01*	0.00*	0.05	0.57	0.42	0.44
	$r \leq 1$	0.41	0.38	0.51	0.74	0.43	0.43

Notes: see notes in Table 8.6.

Chapter 9

Appendix C

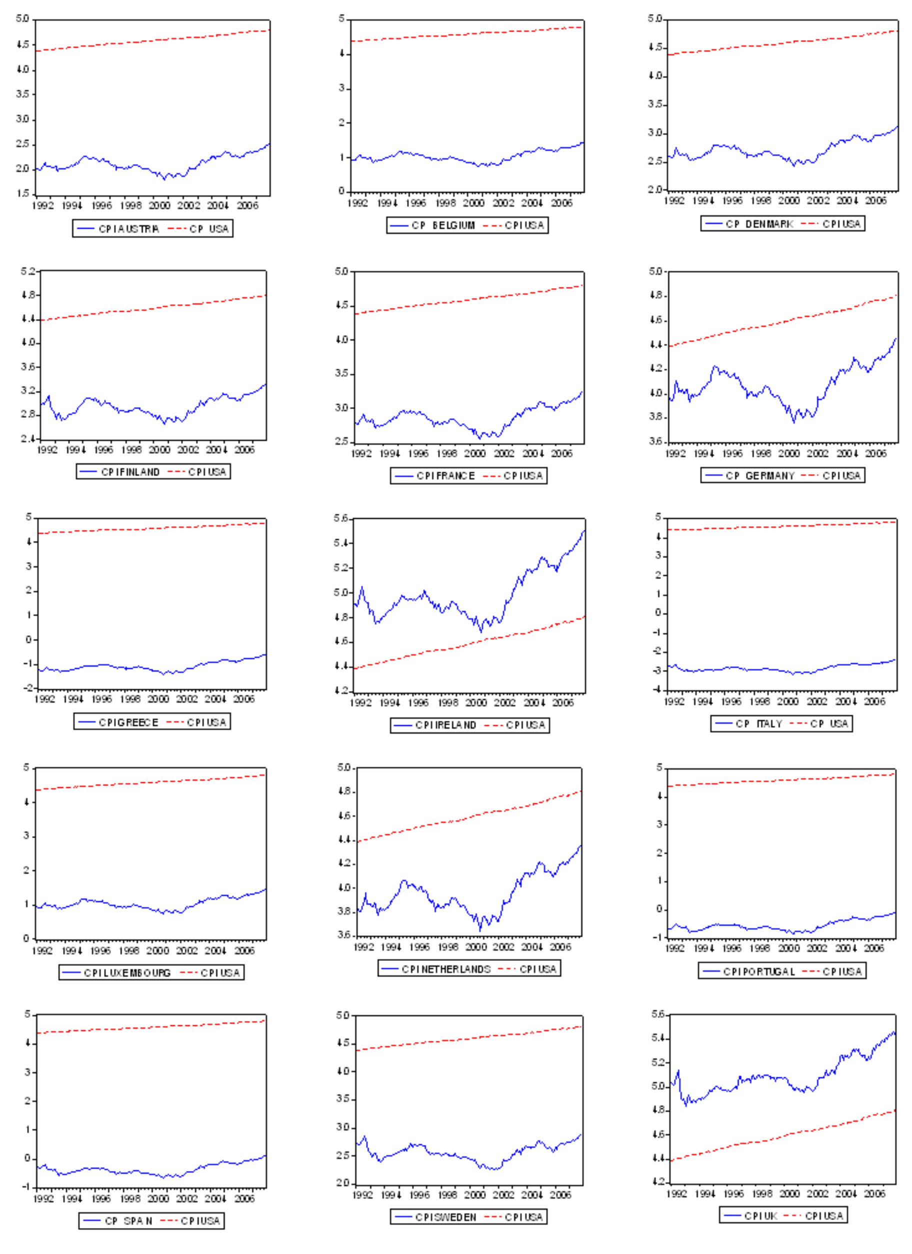

Figure 1a. CPI in US dollar terms.

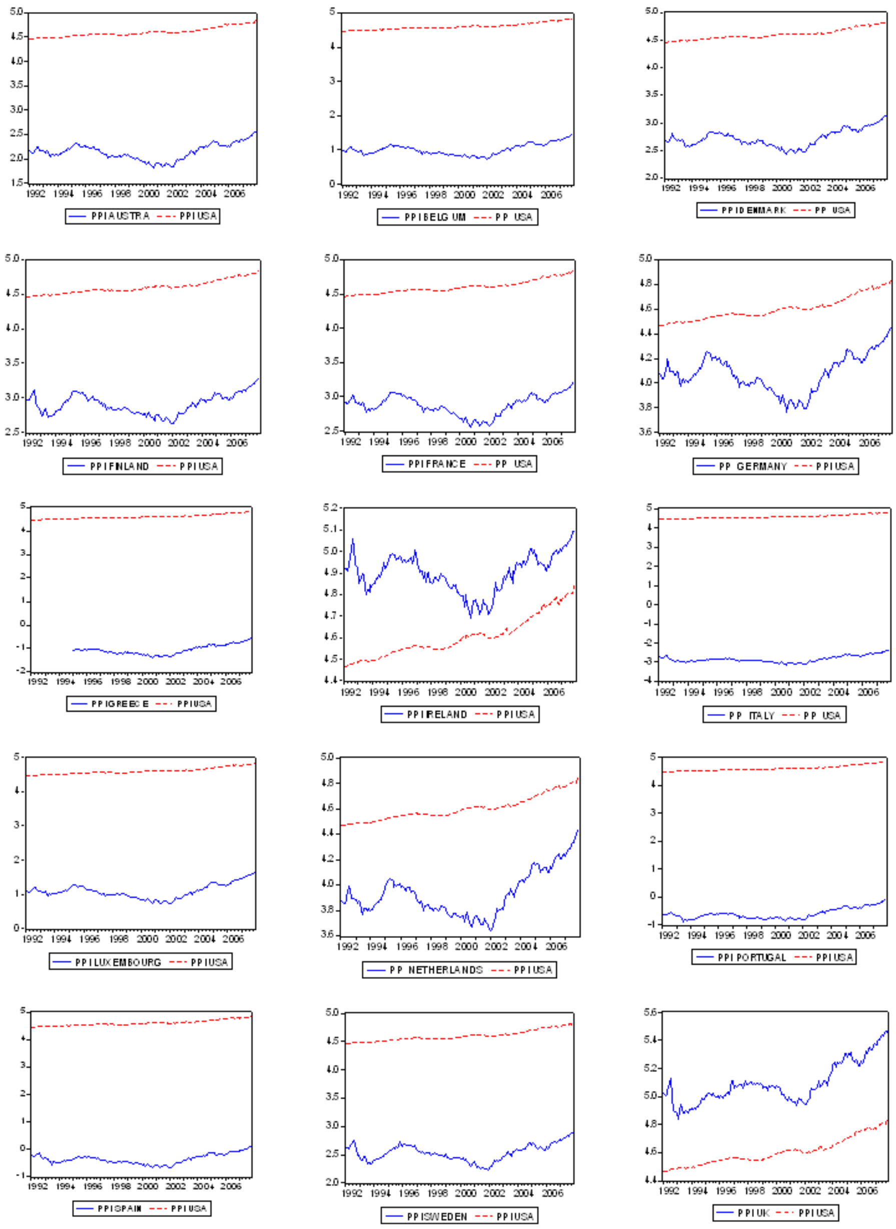

Figure 1b. PPI in US dollar terms.

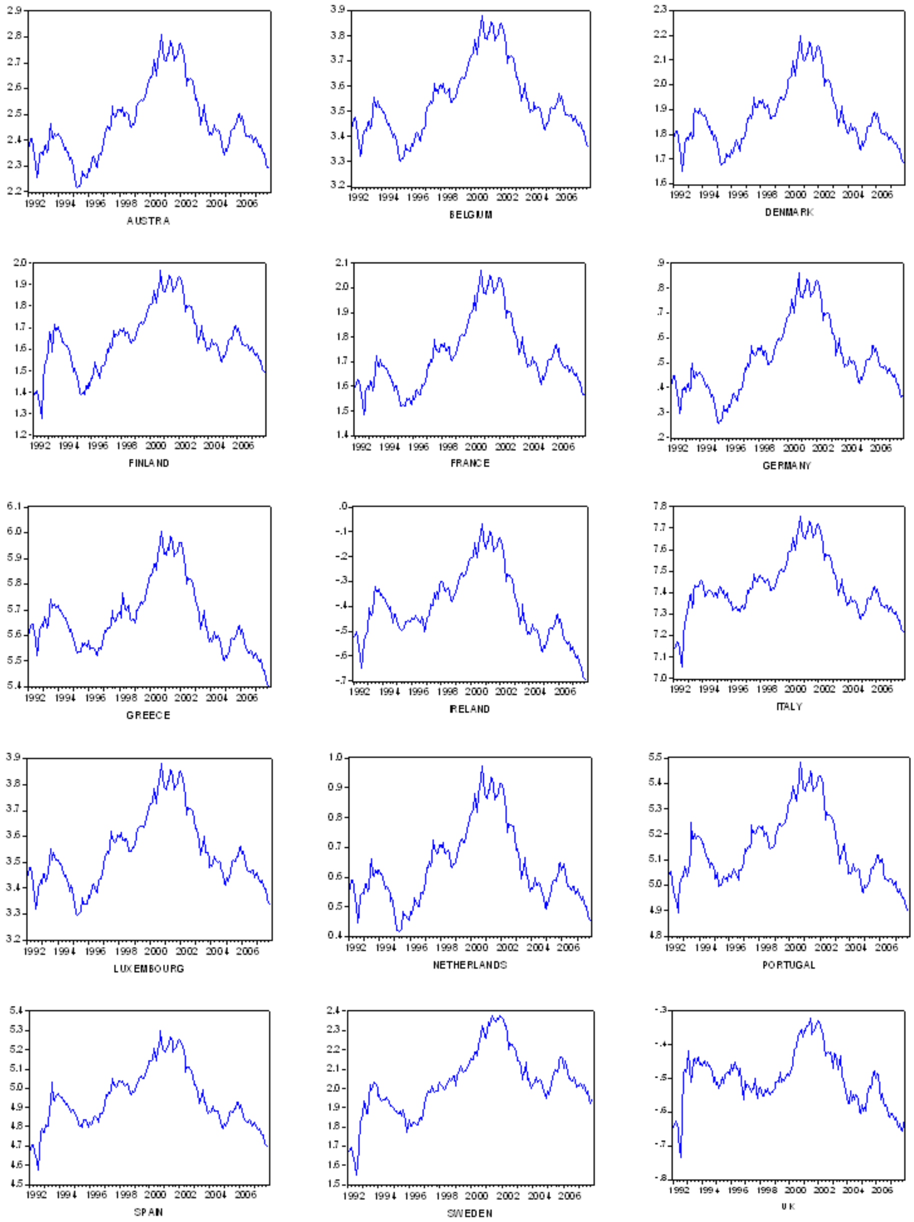

Figure 2a. Real exchange rates: CPI

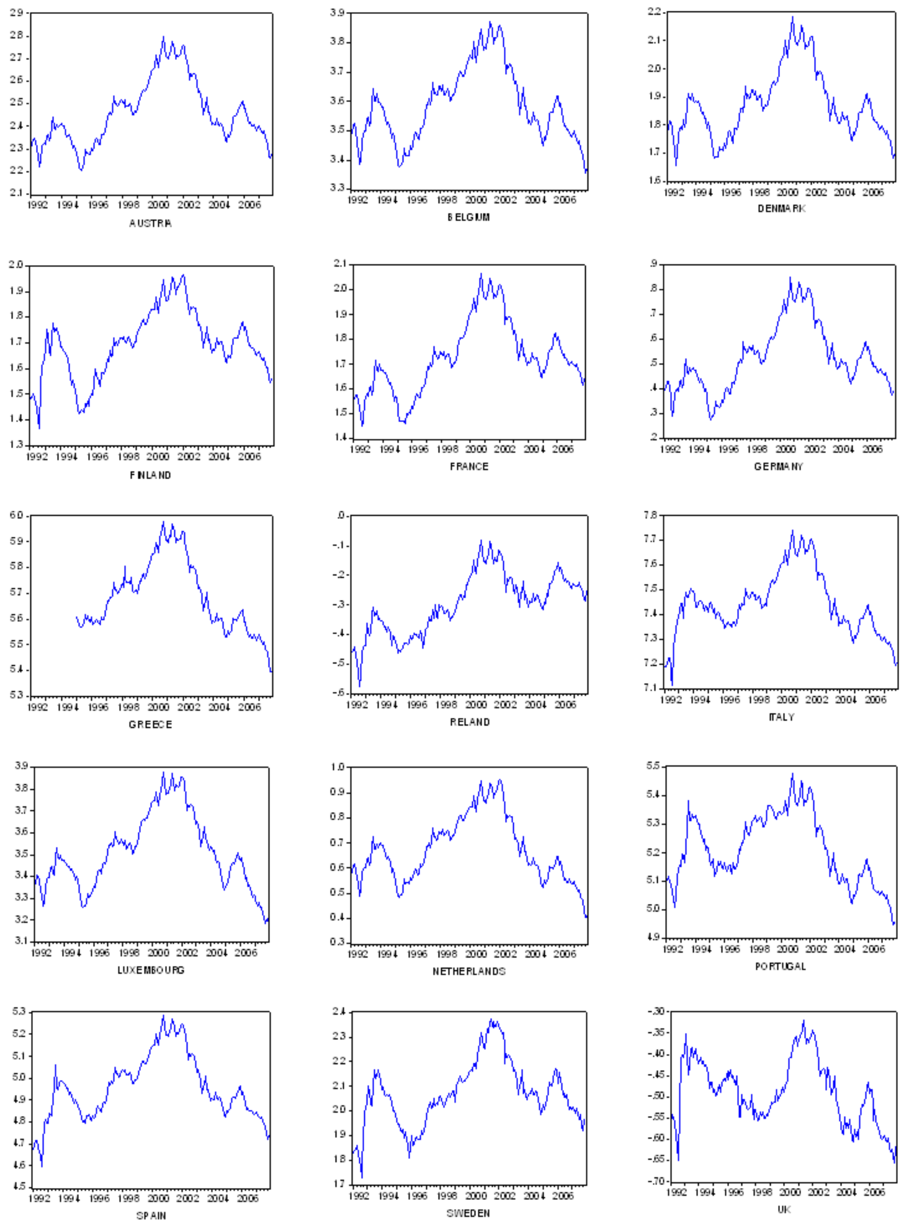

Figure 2b. Real exchange rates: PPI