Eurozone's leader and its followers: Are their markets integrated enough?

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Abstract: This paper investigates whether commodity and capital markets integration has strengthened after the EMU formation. Focusing on the dominant role of Germany as the leading economy in the EMU, we test the progress of markets integration between Germany and selected EMU countries. For comparison reasons, we examine the same research question between Germany and selected non-EMU countries. Our research was based on the analysis of the PPP and UIP conditions and whether these two conditions hold jointly or individually. Our evidence implies that after the launch of the euro, there is stronger integration between Germany and non-EMU countries, such as Japan and the USA, rather than between Germany and EMU countries. These results can be explained by the fact that even though there is increased heterogeneity across EMU countries, these countries cannot adjust their exchange rates in order to respond to shocks and restore equilibrium in commodity and capital markets.

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1. Introduction

European Economic and Monetary Union (EMU) was admittedly a remarkable step in the direction of enhancing economic integration among European countries. The launch of the common currency was expected to lead to price stability, lower transaction costs, stronger intra-euro trade relationships and thus, higher growth for member-countries. However, a fundamental weakness of the EMU, such as the lack of homogeneity across member-countries, should not be ignored. Divergent factors, such as dissimilar national policies (apart from the monetary policy) and different national regulations on goods and labour markets, may increase the possibility of emergence of asymmetric shocks in the Eurozone.

Based on the aforementioned heterogeneity and the resulting asymmetries across countries, academics and policy makers focus on answering the question of whether the EMU achieved its goals. Their main reservation arises from the presence of asymmetries and the lack of autonomous monetary policy for member-countries. In a monetary union, like the EMU, an asymmetric shock cannot be managed by an exchange rate adjustment. Thus, the main question is whether the common monetary policy (including the exchange rate policy) can achieve higher growth rates and higher economic and financial integration in the Eurozone.

De Grauwe (2009) argues that in the first decade of euro's life and before the debt crisis arises, there is little evidence that the euro caused higher growth rates in the Eurozone. On the other hand, nobody can argue that the euro had negative impacts on growth. However, it is also true that the EMU suffers from significant design weaknesses (De Grauwe 2002, 2009), which became more evident and stronger during the sovereign debt crisis (see, De Grauwe and Ji 2013, 2014). What may be indicative of the progress of economic integration among EMU members is that real effective exchange rates deviate among them, thereby implying divergence in their competitive positions (De Grauwe, 2009, 2010). Northern European countries, namely Germany, Austria and The Netherlands, gained in terms of international competitiveness, while competiveness in international trade for Southern European countries, namely Greece, Italy and Spain, has deteriorated.

In this context, the present paper aims to find whether economic and financial integration has increased among countries after the EMU establishment.[1] Analytically, we investigate whether EMU countries as well as selected non-EMU countries are financially integrated with Germany, which is the leading country in the EMU as it has the highest influence on the common monetary policy. We initially expect that the euro has led to integrated commodity and capital markets in the Eurozone because of stronger trade linkages among its member-countries. On the other hand, given the high degree of heterogeneity across countries and the absence of (intra-euro) exchange rate fluctuations, it is doubtful that higher economic integration can be achieved among EMU countries (especially for those that are structurally different from Germany).

The existence of economic and financial integration between Germany and the rest of the Eurozone's countries (and the non-EMU countries) is tested through two well-known international parity relationships, *i.e.* the Purchasing Power Parity (PPP) and the Uncovered Interest Parity (UIP). The empirical validity of the PPP condition implies goods markets integration, while the validity of the UIP condition implies capital markets integration.

Empirical literature implies that the introduction of the euro may have failed to increase commodity and financial markets integration among EMU countries. (Koedijk *et al.*, 2004; Kim *et al.*, 2006; Christidou and Panagiotidis, 2010; Wu and Lin, 2011; Huang and Yang, 2015). However, these studies have tested the PPP and UIP hypotheses only as independent

[1] The full sample (1991:01 to 2015:01) is split into two sub-periods: pre-EMU (1991:01 – 1998:12) and post-EMU (1999:01 – 2015:01). To find whether integration has increased due to the EMU, we first test our hypotheses on the pre-EMU period and then to the whole period (which includes both sub- periods).

parity conditions. This implies that the possibility that deviations from the PPP equilibrium are utilized by investors when forming expectations has been overlooked. Motivated by the seminal papers of Johansen and Juselius (1992) and Juselius (1995), we expect that PPP deviations may interact with UIP deviations. In the present paper, we extend the empirical literature on economic and financial integration in the Eurozone by testing the PPP and the UIP jointly. To the best of our knowledge, we argue that the present paper is the first that tests jointly the PPP and UIP conditions between Germany (as the leading economy of the EMU) and the remaining EMU countries.[2]

Another contribution of this paper is that, compared to the majority of the empirical studies in the literature, it uses more accurate price indices. Specifically, we utilize constructed Traded-goods Price Indices (TPI) instead of Consumer Price Indices (CPI), in order to avoid the presence of non-traded goods prices that biases negatively the empirical validation of the PPP hypothesis. Moreover, we use state-of-the-art time series econometric techniques, which allow the presence of structural breaks in cointegration analysis. Admittedly, the launch of the euro in 1999 and the global financial crisis of 2007 have altered the behaviour of variables under consideration. Hence, these two facts have probably caused an equal number of structural breaks, which should not be ignored by our analysis. Finally, the use of Germany as a benchmark country allows us to shed more light on Germany's leading role in the Eurozone. Does the degree of economic integration among Germany and

[2] Canarella *et al.* (2014) and Czudaj and Pruser (2015) have already tested jointly the two conditions, but not within the Eurozone. They test the international relationships of Germany against the UK and the USA, respectively. On the other hand, an indirect combination between the PPP and UIP conditions in the Eurozone is performed by Arghyrou *et al.* (2009). These authors examine the international Fisher effect within Europe (for EMU and non-EMU countries against the EMU average real interest rate). Similarly, Dreger (2010) tests the real interest parity in a set of 15 countries (including selected European countries, Japan and the USA), using however the USA as the base country.

the rest of the Eurozone's countries allow the characterization of Germany as the representative EMU country? Given Germany's domination in the Eurozone, a number of policy-related issues arise for the future of the EMU.

The structure of the paper is as follows. The next section describes the theoretical framework and section 3 illustrates the econometric methodology. Section 4 reports the dataset and the empirical findings, while a final section discusses the results and concludes.

2. Theoretical Framework

2.1 Purchasing Power Parity

PPP is based on the Law of One Price (LOP), which states that identical goods across countries should have the same price once they are converted to a common currency. Thus, the absolute version of PPP can be written as follows:

$$P_t = S_t P_t^*, \tag{1}$$

where P_t is the domestic price level, P_t^* corresponds to the foreign price level and S_t is the nominal exchange rate measured as units of domestic currency per unit of foreign currency. Using natural logarithms in equation (1) and rearranging it properly, we get:[3]

$$p_t - p_t^* - s_t = 0. \tag{2}$$

Equation (2) reflects the basic idea of the relative PPP form. It implies that the nominal exchange rate adjusts in the long-run so that to offset price differentials and restore equilibrium in international goods markets. Thus, the exchange rate and relative prices form a long-run equilibrium relationship. Equivalently, relative PPP holds if the real exchange rate is stationary, *i.e.*:

$$p_t - p_t^* - s_t \sim I(0). \tag{3}$$

[3] Lower-case letters correspond to natural logarithms of the variables of equation 1.

2.2 Uncovered Interest-rate Parity

On the other hand, the fundamental idea of the UIP condition is that if the expected returns on domestic and foreign equivalent assets are different, then economic agents will borrow at the low rate and invest the proceeds at the high rate. This procedure will stop when both rates are equalized plus the expected rate of change in the exchange rate. In a log-linear form, the UIP condition can be expressed as follows:

$$i_t = i_t^* + E_t \Delta s_{t+k}, \tag{4}$$

where i_t and i_t^* are the domestic and foreign interest rates, E_t is the conditional expectations operator at time t and $E_t \Delta s_{t+k}$ denotes the expected rate of change of the nominal exchange rate from period t to $t+k$. In other words, the UIP condition describes how assets arbitrage restores equilibrium in international capital markets. Further, under the assumption that agents form rational expectations, which implies that they do not make systematic forecast errors, UIP condition is empirically validated if the change of the nominal exchange rate and the interest rate differential form a stationary long-run relationship, i.e.:

$$i_t^* - i_t + \Delta s_{t+k} \sim I(0). \tag{5}$$

Having in mind that the first difference of the nominal exchange rate is usually nonstationary, the empirical evidence in favour of the UIP condition requires that:

$$i_t^* - i_t \sim I(0). \tag{6}$$

2.3 Interaction between PPP and UIP

Both international parity conditions may hold as independent long-run equilibrium relationships.[4] However, based on the seminal papers of Johansen and Juselius (1992) and

[4] On the other hand, we should not ignore a number of theoretical and empirical factors which prevent the empirical validation of the above international parities. For example, transportation costs, tariff and non-tariff

Juselius (1995) and the subsequent papers in literature (MacDonald and Marsh, 1997; Juselius and MacDonald, 2004), we expect a possible interaction among prices, interest rates and exchange rates. Hence, PPP and UIP conditions should not be examined independently. The central idea of the connection between commodity and capital markets is that deviations from PPP equilibrium are utilized by investors when formatting expectations for the future exchange rate. In this sense, if investors form rational expectations and the expected exchange rate is given by $E_t s_{t+k} = p_t - p_t^*$, the relation that combines the PPP and the UIP conditions is as follows:

$$s_t + p_t^* - p_t + i_t - i_t^* = 0. \tag{7}$$

Likewise, the interaction between PPP and UIP conditions forms stationary long-run relationships if:

$$s_t + p_t^* - p_t + i_t - i_t^* \sim I(0). \tag{8}$$

The condition expressed in equation (8) can be satisfied if PPP and UIP hold jointly, that is:

$$p_t - p_t^* - s_t \sim I(0) \text{ and } i_t^* - i_t \sim I(0) \tag{9}$$

Alternatively, the above condition can also be satisfied if:

$$p_t - p_t^* - s_t \sim I(1) \text{ and } i_t^* - i_t \sim I(1) \text{, but } s_t + p_t^* - p_t + i_t - i_t^* \sim I(0). \tag{10}$$

In terms of cointegration, equation (10) implies exploiting the following vector:

$$y_t' = [s_t, p_t, p_t^*, i_t, i_t^*] \ . \tag{11}$$

Expression (10) shows that PPP and UIP conditions are not identified as independent long-run relationships, but they form a stationary equilibrium relation when considered jointly. Consequently, PPP deviations interact with UIP deviations and generate a long-run equilibrium relationship. In other words, the nominal exchange rate adjusts to price level and

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barriers, pricing to market and the Balassa-Samuelson effect explain deviations from PPP. Similarly, UIP deviations may be explained by transaction costs, differences in taxation and risk, and capital controls.

interest rate differentials to restore simultaneous equilibrium in commodity and capital markets.

2.4 Theoretical Hypotheses

To test whether PPP and UIP conditions hold jointly or individually, we first define the theoretical hypotheses under investigation. The form of the theoretical restrictions is subject to the number of long-run relationships (*i.e.* cointegrating relations) found among the variables of interest. Initially, we expect two long-run relationships that may correspond to the PPP and UIP relations, respectively. These two long-run relationships may be either individual or interdependent. In this case, the theoretical restrictions, as suggested by Johansen and Juselius (1992), are formed as follows:

$\mathcal{H}_1$: PPP condition is identified with unrestricted interest rates, while UIP condition is identified with unrestricted price levels.

$\mathcal{H}_2$: PPP condition is identified as a strict individual relationship, while UIP condition is identified as a strict individual relationship.

$\mathcal{H}_3$: PPP condition is identified while interest rates have equal and opposite signs, while UIP condition is identified while price levels have equal and opposite signs.

$\mathcal{H}_1$ tests the hypothesis that PPP and UIP hold. If $\mathcal{H}_1$ cannot be rejected we proceed to $\mathcal{H}_2$, which tests the hypothesis that PPP and UIP hold only individually. Once the latter hypothesis is rejected, we test the hypothesis that PPP and UIP hold jointly ($\mathcal{H}_3$), thereby implying strong interaction between goods and capital markets.

The above representation of the theoretical hypotheses applies when two long-run relationships exist among variables. But, this is not the only possible case. We cannot exclude the possibility that the variables of interest may form only one long-run relationship. In this case, theoretical restrictions need to be slightly modified. Although the literature about the interaction between PPP and UIP conditions is rich, none of the previous studies has provided insights on how theoretical restrictions should be modified in the case of a unique long-run relationship. In this paper, we extend the literature by testing the joint identification of PPP and UIP conditions under a unique long-run relationship. Hence, theoretical hypotheses are modified as follows[5]:

$\mathcal{H}_4$: PPP condition is identified with unrestricted interest rates.

$\mathcal{H}_5$: UIP condition is identified with unrestricted price levels.

$\mathcal{H}_6$: PPP condition is identified as a strict individual relationship.

$\mathcal{H}_7$: UIP condition is identified as a strict individual relationship.

$\mathcal{H}_8$: PPP condition is identified, while interest rates have equal and opposite signs.

$\mathcal{H}_9$: UIP condition is identified, while price levels have equal and opposite signs.

$\mathcal{H}_{10}$: PPP and UIP conditions are fully identified jointly.

The testing procedure is the same as above. One can easily observe that $\mathcal{H}_4$ and $\mathcal{H}_5$ correspond to the joint hypothesis $\mathcal{H}_1$. Similarly, $\mathcal{H}_6$ and $\mathcal{H}_7$ refer to $\mathcal{H}_2$, while $\mathcal{H}_8$ and $\mathcal{H}_9$ correspond to $\mathcal{H}_3$. The reason that the initial hypotheses are split is the existence of a single long-run relationship. Hence, the unique long-run relationship may represent the PPP condition or the UIP condition. One the other hand, price level and interest rate differentials may form a single long-run relationship with the nominal exchange rate. In this case, the PPP and UIP conditions hold jointly under the same long-run relationship. This hypothesis is expressed by $\mathcal{H}_{10}$.

[5] The modification of the restrictions imposed in the cointegrated space and the revised design matrices are illustrated in the empirical results section.

3. Cointegration Models

The current analysis is mainly based on cointegration tests. We perform two types of tests: those without structural breaks in the data and those that include structural breaks. For the cases with no structural breaks, we implement the multivariate approach of Johansen along with the methodology developed by Lütkepohl and Saikkonen (2000), Saikkonen and Lütkepohl (2000a,c) [SL]. Concerning cointegration tests with structural breaks in the data, there is a large literature on different approaches and techniques.[6] For reasons of comparison and consistency with the cases with no structural breaks, we employ the approach of Johansen *et al.* (2000) [JMN] as well as the approach developed by Saikkonen and Lütkepohl (2000b), Trenkler *et al.* (2008) [SLT].

The JMN approach extends the Johansen methodology by adding in the VECM several dummy variables, in order to account for q possible exogenous breaks in the deterministic components of a vector-valued stochastic process. Using the response surface method, this approach derives the asymptotic distribution of the trace statistic for cointegration and obtains critical values or p-values.

Similarly, the SLT approach extends the SL methodology. Again it is assumed that in the data generating process (DGP) for a vector-valued process y_t, its deterministic part (μ_t) does not affect its stochastic part (x_t).[7] Thus, the deterministic part is removed in the first stage, and the likelihood ratio (LR) cointegration test is applied in the second stage using the detrended stochastic part of y_t. Briefly, for a single exogenous break at time T_B in μ_t, in both the level and the trend of y_t, the DGP for y_t is:

$$y_t = \mu_t + x_t = \mu_0 + \mu_1 t + \delta_0 b_t + \delta_1 d_t + x_t, \quad t = 1, ..., T, \tag{12}$$

[6] Perron (2006) provides a comprehensive literature review.

[7] Structural breaks along with deterministic components are included in the deterministic part of y_t.

where t is a linear time trend, $\mu_i\ (i=0,1)$ and $\delta_i\ (i=0,1)$ are unknown $(v\times 1)$ parameter vectors, b_t and d_t are dummy variables defined as $b_t = d_t = 0$ for $t < T_B$, and $b_t = 1$ and $d_t = t - T_B + 1$ for $t \geq T_B$. The unobserved stochastic error x_t has the following VECM representation:

$$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \varepsilon_t \ , \quad \varepsilon_t \sim iidN(0,\Omega), \quad t = 1,...,T \ . \tag{13}$$

It is also assumed that the components of x_t are at most $I(1)$ and cointegrated (*i.e.*, $\Pi = \alpha\beta^{/}$) with cointegrating rank r_0. Based on equations (12) and (13), estimates of μ_0, μ_1, δ_0 and δ_1 are obtained using a feasible GLS procedure under the null hypothesis $H_0(r_0): rank(\Pi) = r_0$: vs. $H_1(r_0): rank(\Pi) > r_0$. Using these estimates, the detrended series $\hat{x}_t = y_t - \hat{\mu}_0 - \hat{\mu}_1 t - \hat{\delta}_0 d_t - \hat{\delta}_1 b_t$ are computed. Finally, x_t is replaced by $\hat{x}_t$ in the VECM of equation (13) and the following trace statistic is computed:

$$LST_{Trace} = -T \sum_{i=r_0+1}^{p} \ln\left(1 - \tilde{\lambda}_i\right), \tag{14}$$

where the eigenvalues $\tilde{\lambda}_i$'s can be obtained by solving a generalized eigenvalue problem. *P*-values are derived using response surface techniques (Trenkler *et al.*, 2008).

4. Data and Empirical Results

4.1 Data

The dataset consists of monthly observations from 1991:01 to 2015:01 on nominal exchange rates, interest rates and traded-goods price indices (based on export and import price indices and total exports and imports) for nine core EMU countries, three EU (but non-EMU) countries and two non-EU countries. The cluster of the EMU countries includes Belgium, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands and Spain, while the whole sample is filled with Denmark, Sweden, UK (EU – but non-EMU – countries) and Japan, USA (non-EU countries).[8] Throughout the paper, the benchmark country is Germany. Therefore, all nominal exchange rates correspond to national currencies against the Deutsche mark. For the pre-EMU period, Deutsche mark exchange rates were retrieved from the statistical databases of Eurostat and Bundesbank.[9] Obviously, there is no official exchange rate between Germany and any EMU member country for the post-EMU period. However, there was an exchange rate relationship between EMU countries at the time of the adoption of the single currency, which remained fixed since then. This could imply that there is a hypothetical and constant exchange rate between Germany and EMU countries. To derive this hypothetical exchange rate (for the post-EMU period), we calculate cross exchange rates based on the fixed euro conversion rates of EMU countries. For example, the post-EMU exchange rate between Germany and France is calculated as 6.5597/1.95583 = 3.353855 and remains unchanged until the end of the estimation period. All nominal exchange rates are transformed into a logarithmic form.

Moreover, interest rates correspond to the yield of 10-year government bond and are collected from the statistical database of the Eurostat. We have preferred the use of long-run interest rate instead of short-run interest rate for various reasons. Firstly, because of the common monetary policy, short-run interest rates do not fully reflect members' individual characteristics. For example, money market rates mostly reflect European Central Bank's policy decisions. Secondly, long-run interest rates reflect the long-run process of the economy and thus, are more appropriate when the long-run exchange rate is examined. Finally, the

[8] Traded-goods price indices could not be calculated for Austria, Luxembourg and Portugal due to data unavailability. Hence, these countries have been excluded from our dataset. Moreover, the sample period for Belgium is 1993:01 – 2015:01, while the starting date for Denmark is 1995:01.

[9] For non-EMU members (Denmark, Sweden, Japan, UK and USA) Deutsche mark exchange rates have been retrieved by Eurostat and Bundesbank for the whole period of estimation.

yield of government bonds is able to capture the impact of the EMU sovereign debt crisis on capital markets and financial integration within the Eurozone.

For national price levels, we have used constructed traded-goods price indices (TPI) instead of consumer price indices (CPI) so that to avoid the presence of non-traded goods prices, which biases negatively the empirical validation of the PPP hypothesis. Following Xu (2003) and Giannellis and Papadopoulos (2010), we construct the traded goods price index (TPI) as a weighted average of the log of export price index (p^x) and the log of import price index (p^m). The weights are the shares of total exports and total imports in total trade. The formula of the TPI is the following:

$$TPI = \left(\alpha \cdot p^x\right) + \left(\beta \cdot p^m\right), \tag{15}$$

where $\alpha = \dfrac{exports}{exports + imports}$ and $\beta = \dfrac{imports}{exports + imports}$. The above international trade data were retrieved from the *International Financial Statistics* of the International Monetary Fund database. Concerning prices and depending on data availability, we have used either export and import price indices or export and import unit value indices. The base year for all indices is 2010. Also, the value of exports and imports is expressed in US dollars.

4.2 Unit Root Tests Results

The sample is split into two sub-periods: the pre-EMU (1991:01 – 1998:12) and the post-EMU (1999:01 – 2015:01), but the estimation period is focused on the pre-EMU period and the whole period (which includes both sub-periods).[10] As a preliminary analysis of the data, we have employed a number of unit root tests, such as the ADF; the DF-GLS; and the KPSS

[10] For Greece, the pre-EMU period is up to 2000:12. Moreover, the starting date for Denmark is 1995:01 due to restrictions on data availability. As the pre-EMU period (1995-1998) is too short in the case of Denmark, we do not present results for this sub-period, but only for the whole sample.

tests. For the ADF and the DF-GLS tests the null hypothesis is that a series contains a unit root. In contrast, for the KPSS test the null hypothesis is that a series is stationary.[11] The results imply that all series, apart from the pre-EMU exchange rate in the case of Belgium, are difference stationary, i.e. they are $I(1)$ in levels, but $I(0)$ in first differences. However, the Belgian exchange rate in the pre-EMU period is an unambiguous exception. All tests unanimously reveal that this series is integrated in levels, *i.e.* $I(0)$. Therefore, we consider this series as covariance stationary.[12]

4.3 Cointegration Space and its Structure

As noted above, the estimation period is focused in the pre-EMU period and the whole period. For the pre-EMU period estimation we do not include structural breaks in the VECMs, and thus we implement the Johansen and SL cointegration methodologies. In contrast, for the whole period estimation we include two structural breaks in the cointegration tests, which were detected exogenously as suggested by economic theory. Of course, this detection was based on specific economic events that took place during the sample period. For all sample countries except Greece, the first structural break is allowed to be at the formation of the EMU in January 1999. For Greece, the first break is placed in January 2001, when the country joined the EMU. Also, for all sample countries the second break is allowed to be at the beginning of the recent global financial crisis. According to the U.S. National Bureau of Economic Research this crisis began in December 2007. Thus, for the whole period estimation we implement the JMN and SLT cointegration approaches. For the SLT test, we extended equation (12) by adding a second step dummy and a second linear trend dummy. Then, for each country, the SLT trace statistic and the corresponding response surface p-

[11] None of the unit root tests could be applied on post-EMU exchange rates as they are strictly constant.

[12] For saving space, unit root tests results are not reported but are available upon request.

values were computed using GAUSS codes. Also, the lag length for each VECM was selected using the Akaike information criterion (AIC).

Concerning the structure of the cointegrating vectors, the theoretical hypotheses were analyzed in Section 2.4. For a $p-$dimensional system, restrictions on the cointegration structure can be tests by formulating $\beta=[H_1\phi_1,...,H_r\phi_r]$, where H_i are $(p\times q_i)$ design matrices and ϕ_i are $(q_i\times 1)$ vectors of q_i free parameters. When two long-run relationships exist among variables, the theoretical hypothesis $\mathcal{H}_1$ implies that the first cointegrating vector describes the PPP condition with unrestricted interest rates, while the second cointegrating vector describes the UIP condition with unrestricted prices. Thus, the cointegrating vectors are $\beta_1=[1, -1, 1, \phi_{11}, \phi_{12}]$ and $\beta_2=[1, \phi_{21}, \phi_{22}, -1, 1]$, while the respective design matrices are the following:

$$H_{1A}=\begin{bmatrix}1&0&0\\-1&0&0\\1&0&0\\0&1&0\\0&0&1\end{bmatrix} \text{ and } H_{1B}=\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\\-1&0&0\\1&0&0\end{bmatrix}.$$

This LR test, which captures the proportionality and symmetry conditions, is distributed asymptotically as χ^2 with 2 degrees of freedom. If $\mathcal{H}_1$ cannot be rejected we proceed to the theoretical hypothesis $\mathcal{H}_2$, which implies that PPP and UIP hold only individually. In this case, the cointegrating vectors are $\beta_1=[1, -1, 1, 0, 0]$ and $\beta_2=[1, 0, 0, -1, 1]$, the respective design matrices are

$$H_{2A}=\begin{bmatrix}1\\-1\\1\\0\\0\end{bmatrix} \text{ and } H_{2B}=\begin{bmatrix}1\\0\\0\\-1\\1\end{bmatrix},$$

while the LR test is distributed asymptotically as χ^2 with 6 degrees of freedom. If the latter hypothesis is rejected, we test the theoretical hypothesis $\mathcal{H}_3$, which implies that PPP and UIP conditions hold jointly and thus, there is strong interaction between goods and capital markets. In this case, the cointegrating vectors are $\beta_1 = [1, -1, 1, -\phi_{11}, \phi_{11}]$ and $\beta_2 = [1, -\phi_{21}, \phi_{21}, -1, 1]$, the respective design matrices are

$$H_{3A} = \begin{bmatrix} 1 & 0 \\ -1 & 0 \\ 1 & 0 \\ 0 & -1 \\ 0 & 1 \end{bmatrix} \text{ and } H_{3B} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \\ 0 & 1 \\ -1 & 0 \\ 1 & 0 \end{bmatrix},$$

while the LR test is distributed asymptotically as χ^2 with 4 degrees of freedom.

When a single long-run relationship exists among variables, the theoretical restrictions are slightly modified. Thus, for the theoretical hypotheses $\mathcal{H}_4$ and $\mathcal{H}_5$, which correspond to the joint hypothesis $\mathcal{H}_1$, the cointegrating vector is either $\beta = [1, -1, 1, \phi_1, \phi_2]$ or $\beta = [1, \phi_1, \phi_2, -1, 1]$, respectively. The design matrix is

$$\text{either } H_4 = \begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{ or } H_5 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix},$$

respectively, while for both cases the LR test is distributed asymptotically as χ^2 with 2 degrees of freedom. Similarly, for the theoretical hypotheses $\mathcal{H}_6$ and $\mathcal{H}_7$, which correspond to the joint hypothesis $\mathcal{H}_2$, the cointegrating vector is either $\beta = [1, -1, 1, 0, 0]$ or $\beta = [1, 0, 0, -1, 1]$, respectively. The design matrix is

$$\text{either } H_6 = \begin{bmatrix} 1 \\ -1 \\ 1 \\ 0 \\ 0 \end{bmatrix} \text{ or } H_7 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ -1 \\ 1 \end{bmatrix},$$

respectively, while for both cases the LR test is distributed asymptotically as χ^2 with 4 degrees of freedom. Also, for the theoretical hypotheses $\mathcal{H}_8$ and $\mathcal{H}_9$, which correspond to the joint hypothesis $\mathcal{H}_3$, the cointegrating vector is either $\beta = [1, -1, 1, -\phi_1, \phi_1]$ or $\beta = [1, -\phi_1, \phi_1, -1, 1]$, respectively. The design matrix is

$$\text{either } H_8 = \begin{bmatrix} 1 & 0 \\ -1 & 0 \\ 1 & 0 \\ 0 & -1 \\ 0 & 1 \end{bmatrix} \text{ or } H_9 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \\ 0 & 1 \\ -1 & 0 \\ 1 & 0 \end{bmatrix},$$

while for both cases the LR test is distributed asymptotically as χ^2 with 3 degrees of freedom. Finally, for the theoretical hypothesis $\mathcal{H}_{10}$, which implies that the PPP and UIP conditions hold jointly under the same long-run relationship, the cointegrating vector is $\beta = [1, -1, 1, -1, 1]$, the respective design matrix is

$$H_{10} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \end{bmatrix},$$

while the LR test is distributed asymptotically as χ^2 with 4 degrees of freedom.

4.4 Results for the Pre-EMU Period

Table 1 reports the Johansen and SL trace statistics and the respective *p*-values for each of the sample countries. For the pre-EMU period (columns 3-4), the results indicate two cointegrating vectors for the cases of Greece, Italy, Spain, The Netherlands and the USA, at the 5 per cent level of significance.[13] In the case of Belgium, both tests indicate three cointegrating vectors. However, the third vector may be attributed to the stationarity of the Belgian exchange rate in the pre-EMU period. To make it clear, we test the hypothesis that one of the three cointegrating vectors is determined only by the stationary exchange rate. This test's result (χ^2 = 2.50 and p-value = 0.29) indicates that the above hypothesis cannot be rejected. Finally, both tests provide evidence of a single cointegrating vector for the cases of Finland, France, Ireland, Japan, Sweden and the UK.

Panel A of Table 2 reports the test results regarding the structure of the cointegrating vectors for the six countries that there is evidence of two cointegrating vectors. As shown in the second column of panel A, the theoretical hypothesis $\mathcal{H}_1$, which implies that the first vector describes the PPP condition with unrestricted interest rates and the second vector describes the UIP condition with unrestricted prices, cannot be rejected for Belgium, The Netherlands and Spain, at the 5 per cent level of significance. This hypothesis is marginally rejected for Greece (*p*-value = 0.04) and strongly rejected for Italy and the USA, at the same level of significance. Column 3 of panel A indicates that the theoretical hypothesis $\mathcal{H}_2$, which implies that PPP and UIP hold only individually, is strongly rejected for all countries. Finally, as shown in column 4 of panel A, the theoretical hypothesis $\mathcal{H}_3$ that implies strong interaction between goods and capital markets, cannot be rejected only for the case of Greece. As the hypothesis $\mathcal{H}_1$ is marginally rejected for Greece, we can conclude that for this country the PPP and UIP conditions hold jointly. The latter result seems reasonable as the country

[13] In the case of The Netherlands, the SL trace statistic indicates two cointegrating vectors, while the Johansen test indicates three vectors. However, Lütkepohl *et al.* (2003) found that their test has better size and power properties in finite samples. For this reason, we consider two cointegrating vectors also for The Netherlands.

performed significant economic adjustment in the second half of the 1990s, in order to fulfil the convergence criteria for joining the EMU.

Panel B of table 2 reports the respective test results for the six countries that there is evidence of a single cointegrating vector. As shown in columns 2 and 3 of panel B, the theoretical hypothesis $\mathcal{H}_4$ is rejected for all cases, while the theoretical hypothesis $\mathcal{H}_5$ cannot be rejected only for the cases of Finland and France, at the 5 per cent significance level. This implies absence of commodity market integration, but instead there is indication of capital markets integration in the cases of France and Finland. Columns 4 and 5 indicate that both the theoretical hypotheses $\mathcal{H}_6$ and $\mathcal{H}_7$ are rejected for all cases. Following the testing procedure, columns 6 and 7 indicate that the theoretical hypothesis $\mathcal{H}_8$ is rejected for all cases, while the theoretical hypothesis $\mathcal{H}_9$ cannot be rejected only for Finland. Namely, when hypotheses become more restrictive (i.e.$\mathcal{H}_8$ compared to $\mathcal{H}_4$ and $\mathcal{H}_9$ compared to $\mathcal{H}_5$), there is evidence of capital market integration only between Germany and Finland, while the evidence of commodity market integration is still absent. Similarly, as shown in the last column, the theoretical hypothesis $\mathcal{H}_{10}$, which implies that the PPP and UIP conditions hold jointly under the same long-run relationship, cannot be rejected only between Germany and Finland.

4.5 Results for the Whole Period

Moving to the whole period estimation, the JMN and SLT trace statistics for all sample countries are reported in columns 5-6 of Table 1. As shown in this table, both tests indicate two cointegrating vectors only for the case of Belgium. For the cases of Finland, France, Spain, Denmark, Japan and Sweden, the JMN test indicates different number of cointegrating relations than the SLT test. As noted above, the SLT test has better size and power properties than the JMN test in finite samples, and thus we can conclude that for the above six countries there is a single cointegrating vector. Finally, both tests also provide evidence of a single cointegrating vector for the cases of The Netherlands, the UK and the USA, and no evidence of cointegration for the cases of Greece, Ireland and Italy.

Table 3 reports the test results regarding the structure of the cointegrating vectors for the whole period. The case of Belgium, for which there is evidence of two cointegrating vectors, is illustrated in Panel A of this table. As shown in the second column of panel A, the theoretical hypothesis $\mathcal{H}_1$, which implies that the first vector describes the PPP condition with unrestricted interest rates and the second vector describes the UIP condition with unrestricted prices, cannot be rejected, at the 5 per cent significance. In contrast, as shown in columns 3-4 both theoretical hypotheses $\mathcal{H}_2$ and $\mathcal{H}_3$ are strongly rejected.

The respective test results for the nine countries with a single cointegrating vector are reported in panel B of table 3. As shown in columns 2 and 3, the theoretical hypothesis $\mathcal{H}_4$ cannot be rejected for the cases of Finland, The Netherlands, Denmark, Japan and marginally for the USA, while the theoretical hypothesis $\mathcal{H}_5$ cannot be rejected only for the cases of Sweden and the USA, at the 5 per cent significance level. To this point, there is evidence of partial commodity markets integration in the cases of Finland, The Netherlands, Denmark and Japan; evidence of partial capital markets integration in the case of Sweden and indications of joint commodity and capital markets integration in the case of the USA. Columns 4 and 5 indicate that both the theoretical hypotheses $\mathcal{H}_6$ and $\mathcal{H}_7$ are rejected for all cases, thereby implying that PPP and UIP conditions do not hold strictly as independent relationships. Following the same testing procedure as in the previous subsection, columns 6 and 7 indicate that the theoretical hypothesis $\mathcal{H}_8$ cannot be rejected only for the case of Finland, while the theoretical hypothesis $\mathcal{H}_9$ is rejected for all cases but marginally for Sweden, at the 5 per cent level of significance. Finally, as shown in the last column of panel B, the theoretical hypothesis $\mathcal{H}_{10}$ is rejected for all cases. Likewise, when hypotheses become more restrictive, the evidence in favour of economic and financial integration is weakened.

5. Discussion and Concluding Remarks

Surprisingly or not, our results imply stronger evidence of financial integration between Germany and the selected EMU countries before the launch of the euro. For the pre-EMU period, Germany was found to be integrated with most of the EMU countries, while stronger evidence of commodity and capital markets integration was found in the cases of Finland and Greece. The latter result reflects the traditionally high cultural and trade linkages between Finland and Germany and the adjustment of the Greek economy towards the requirements of the Maastricht treaty, respectively. On the other hand, economic and financial integration could not be established between Germany and each of Italy and Ireland.

When the whole sample is examined, there is weaker evidence of economic and financial integration between Germany and the rest of the EMU countries. Our results indicate evidence of simultaneous commodity and capital markets integration only between Germany and Belgium, while there is evidence of only commodity market integration between Germany and each of Finland and The Netherlands. In contrast, we found no evidence of either commodity or capital market integration between Germany and each of France, Greece, Italy, Ireland and Spain.

These results imply that despite the launch of the common currency, Germany has financially diverged from most of the EMU countries under investigation. But, at the same time, financial integration with non-EMU economies has been stronger. At the pre-EMU period, Germany was not financially integrated with any of the selected non-EMU countries. However, when the whole sample is the case, we found evidence of simultaneous commodity and capital markets integration with the USA. In addition, there was evidence of commodity market integration with Denmark and Japan and evidence of capital market integration with Sweden. Finally, the lack of integration with the UK remains.

Namely, our results imply stronger evidence of financial integration between Germany and the selected non-EMU countries rather than between Germany and the selected EMU countries. In contrast to the aim of the monetary union, this could mean that Germany seeks stronger economic and financial relationships outside the EMU. Certainly, this is not true. But, what is this that prevents the integration with some EMU countries? Moreover, what explains the fact that Germany is shown to be more integrated with non-EMU countries? Both questions have the same answer. This is the exchange rate! Normally, the nominal exchange rate adjusts in the long-run to offset any differentials and restore equilibrium. This is the case between Germany and the non-EMU countries. Obviously, the lack of exchange rate adjustment within the EMU prevents the PPP and UIP conditions to hold in the long-run. However, this does not mean that these conditions are not possible to hold in monetary unions. We just need to consider in which cases the exchange rate necessarily adjusts. Nominal exchange rates should change if permanent disequilibria exist, as a result of the heterogeneity across countries. Moreover, exchange rates are sensitive to monetary policy changes. In a monetary union, if member-countries respond symmetrically to shocks, equilibrium may be restored without any exchange rate adjustment. In our empirical exercise, this is shown in the cases of Belgium, Finland and The Netherlands. On the other hand, equilibrium could not be restored in the remaining selected EMU countries. As a consequence, this evidence implies that commodity and capital markets disequilibrium exist, which cannot be restored along the lines of the monetary union.

Intuitively, this evidence reveals that the common monetary policy cannot ensure higher financial integration in the Eurozone. It is apparent that the key prerequisite for a successful monetary union is homogeneity across country-members. Our empirical results confirm the above argument. In one hand, countries that share economic similarities with Germany, such as Finland, The Netherlands and Belgium, are shown to be financially integrated with it. On the other hand, there is no evidence of financial integration with countries that are structurally different from Germany. The cases of Greece, Italy, and Ireland attract special attention as no long-run relationship could be identified among the variables of interest. A number of deviations in national policies and market regulations (compared to Germany) may explain the above evidence. In other words, the existing heterogeneity causes permanent disequilibrium in markets, which cannot be handled without exchange rate adjustment.

To put it differently, our empirical investigation provides evidence against the well-known statement *"one size fits all"*. The above analysis implies that the unique monetary policy does not fit to all member-countries. This awareness raises serious concerns about the future of the Eurozone. Further, Germany's leading role in the Eurozone is in question. How satisfactory is the fact that the leading country in the Eurozone has financially diverged from most of the other country-members? Does the common monetary policy really reflect the needs and objectives of all country-members of the Eurozone? Is the fight against inflation able to solve the current problems in the Eurozone?

These concerns reveal that the EMU is, or will be soon, in trouble. Although, a generous modification of the applied monetary policy could make the differences among countries smoother, the EMU will have the opportunity to solve its problems if efficiently addresses its design weaknesses. Homogeneity across country-members can be achieved through the harmonization of national economic policies and market structures. EMU authorities are currently attempting to achieve market structure synchronization by promoting structural reforms in national economies. However, economic policy synchronization requires even stronger economic integration, which in turn cannot be achieved without political unification.

References

Arghyrou, M.G., Gregoriou, A. and Kontonikas, A. (2009) 'Do Real Interest Rates Converge? Evidence from the European Union'. *Journal of International Financial Markets, Institutions and Money*, Vol.19, No.3, pp. 447-460.

Canarella G., Miller, S.M. and Pollard, S.K. (2014) 'Purchasing Power Parity between the UK and Germany: The Euro Era'. *Open Economies Review*, Vol.25, No.4, pp. 677-699.

Christidou, M. and Panagiotidis, T. (2010) 'Purchasing Power Parity and the European Single Currency: Some New Evidence'. *Economic Modelling*, Vo.27, No.5, pp. 1116-1123.

Czudaj, R. and Pruser, J. (2015) 'International Parity Relationships between Germany and the USA Revisited: Evidence from the Post-DM Period'. *Applied Economics*, Vol.47, No. 26, pp. 2745-2767.

De Grauwe, P. (2002) 'Challenges for Monetary Policy in Euroland'. *Journal of Common Market Studies*, Vol.40, No.4, pp. 693-718.

De Grauwe, P. (2009) 'The Euro at Ten: Achievements and Challenges'. *Empirica*, Vol.36, No.1, pp. 5-20.

De Grauwe, P. (2010) 'The Fragility of the Eurozone's Institutions'. *Open Economies Review*, Vol.21, No.1, pp. 167-174.

De Grauwe, P. and Ji, Y. (2013) 'Self-fulfilling Crises in the Eurozone: An Empirical Test'. *Journal of International Money and Finance*, Vol.34, pp. 15-36.

De Grauwe, P. and Ji, Y. (2014) 'The Future of the Eurozone'. *The Manchester School*, Vol.82, Supplement S1, pp. 15-34.

Dreger, C. (2010) 'Does the Nominal Exchange Rate Regime Affect the Real Interest Parity Condition?' *North American Journal of Economics and Finance*, Vol.21, No.3, pp. 274-285.

Giannellis, N. and Papadopoulos, A.P. (2010) ‘Nonlinear Exchange Rate Adjustment in the Enlarged Euro zone. Evidence and Implications for Candidate Countries’. *Review of International Economics*, Vol.18, No.4, pp. 741-757.

Huang, C-H. and Yang, C-Y. (2015) ‘European Exchange Rate Regimes and Purchasing Power Parity: An Empirical Study on Eleven Eurozone Countries’. *International Review of Economics and Finance*, Vol.35, pp. 100-109.

Johansen, S. and Juselius, K. (1992) ‘Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and the UIP for the UK’. *Journal of Econometrics,* Vol.53, No.1-3, pp. 211–244.

Johansen, S., Mosconi, R. and Nielsen, B. (2000) ‘Cointegration Analysis in the Presence of Structural Breaks in the Deterministic Trend’. *Econometrics Journal*, Vol.3, No.2, pp. 216-249.

Juselius, K. (1995) ‘Do Purchasing Power Parity and Uncovered Interest Rate Parity Hold in the Long Run? An Example of Likelihood Inference in a Multivariate Time-series Model’. *Journal of Econometrics*, Vol.69, No.1, pp. 211–240.

Juselius, K., and MacDonald, R. (2004) ‘International Parity Relationships between the USA and Japan’. *Japan and the World Economy*, Vol.16, No.1, pp. 17-34.

Kim, S-J., Moshirian, F. and Wu, E. (2006) ‘Evolution of International Stock and Bond Market Integration: Influence of the European Monetary Union’. *Journal of Banking and Finance*, Vol.30, No.5, pp. 1507-1534.

Koedijk, K.G., Tims, B. and van Dijk, M.A. (2004) ‘Purchasing Power Parity and the Euro Area’. *Journal of International, Money and Finance,* Vol.23, No.7-8, pp. 1081-1107.

Lütkepohl, H. and Saikkonen, P. (2000). ‘Testing for the Cointegrating Rank of a VAR Process with a Time Trend’. *Journal of Econometrics*, Vol.95, No.1, pp. 177-198.

Lütkepohl, H., Saikkonen, P. and Trenkler, C. (2003) 'Comparison of Tests for the Cointegrating Rank of a VAR Process with a Structural Shift'. *Journal of Econometrics*, Vol.113, No.2, pp. 201-229.

MacDonald, R. and Marsh, I.W. (1997) 'On Fundamentals and Exchange Rates: A Casselian Perspective'. *Review of Economics and Statistics*, Vol.79, No.4, pp. 655–664.

Saikkonen, P. and Lütkepohl, H. (2000a) 'Testing for the Cointegrating Rank of a VAR Process with an Intercept'. *Econometric Theory*, Vol.16, No.3, pp. 373-406.

Saikkonen, P. and Lütkepohl, H. (2000b) 'Testing for the Cointegrating Rank of a VAR Process with Structural Shifts'. *Journal of Business and Economic Statistics*, Vol.18, No. 4, pp. 451-464.

Saikkonen, P. and Lütkepohl, H. (2000c) 'Trend Adjustment Prior to Testing for the Cointegrating Rank of a Vector Autoregressive Process'. *Journal of Time Series Analysis*, Vol.21, No.4, pp. 435-456.

Trenkler, C., Saikkonen, P. and Lütkepohl, H. (2008) 'Testing for the Cointegrating Rank of a VAR Process with Level Shift and Trend Break'. *Journal of Time Series Analysis*, Vol.29, No.2, pp. 331-358.

Wu, Y-H. and Lin, E.S. (2011) 'Does Purchasing Power Parity Hold Following the Launch of the Euro? Evidence from the Panel Unit Root Test'. *Applied Economics Letters*, Vol.18, No.2, pp. 167-172.

Xu, Z. (2003) 'Purchasing Power Parity, Price Indices, and Exchange Rate Forcasts'. *Journal of International Money and Finance*, Vol.22, No.1, pp. 105-130.

Table 1: Cointegration tests

		Pre-EMU period		Whole period	
Country	$(p-r_0)$	J_{Trace}	SL_{Trace}	JMN_{Trace}	SLT_{Trace}
Belgium	5	143.58* (0.00)	106.86* (0.00)	209.03* (0.00)	97.10* (0.00)
	4	73.69* (0.00)	45.95* (0.01)	122.08* (0.00)	55.82* (0.04)
	3	33.70* (0.02)	28.42* (0.01)	50.47 (0.78)	23.27 (0.63)
	2	9.81 (0.30)	9.70 (0.13)	28.50 (0.80)	10.58 (0.76)
	1	0.13 (0.72)	0.39 (0.59)	13.68 (0.61)	3.53 (0.75)
Finland	5	70.19* (0.04)	61.55* (0.04)	233.07* (0.00)	92.19* (0.00)
	4	36.17 (0.39)	34.08 (0.18)	135.18* (0.00)	51.46 (0.10)
	3	14.74 (0.80)	12.61 (0.66)	86.03* (0.00)	33.41 (0.12)
	2	7.54 (0.52)	4.07 (0.70)	42.57 (0.17)	12.77 (0.58)
	1	3.50 (0.06)	0.08 (0.83)	18.37 (0.28)	0.01 (0.99)
France	5	80.58* (0.02)	70.97* (0.00)	208.79* (0.00)	92.88* (0.00)
	4	48.40 (0.15)	36.10 (0.12)	121.33* (0.00)	34.26 (0.78)
	3	23.46 (0.50)	18.68 (0.22)	74.72 (0.06)	25.19 (0.50)
	2	12.54 (0.40)	10.13 (0.11)	43.15 (0.15)	11.76 (0.67)
	1	4.68 (0.32)	3.05 (0.10)	14.77 (0.54)	0.33 (0.99)
Greece	5	77.63* (0.01)	79.01* (0.00)	115.55 (0.51)	52.33 (0.76)
	4	51.93* (0.02)	40.65* (0.04)	75.49 (0.80)	26.11 (0.98)
	3	27.75 (0.08)	15.41 (0.43)	45.69 (0.91)	15.11 (0.97)
	2	9.78 (0.30)	5.43 (0.51)	21.14 (0.98)	3.32 (0.99)
	1	2.55 (0.11)	0.07 (0.85)	8.32 (0.95)	1.94 (0.95)
Ireland	5	74.41* (0.02)	70.99* (0.00)	118.82 (0.41)	55.01 (0.66)
	4	37.26 (0.34)	32.64 (0.23)	75.32 (0.80)	26.99 (0.97)
	3	11.31 (0.95)	11.06 (0.78)	39.39 (0.98)	12.49 (0.99)
	2	3.35 (0.95)	2.06 (0.94)	23.03 (0.96)	5.37 (0.99)
	1	0.05 (0.82)	1.07 (0.35)	10.64 (0.85)	1.94 (0.95)
Italy	5	114.48* (0.00)	99.89* (0.00)	138.32 (0.06)	66.25 (0.23)
	4	65.06* (0.00)	58.01* (0.00)	83.45 (0.54)	40.52 (0.48)
	3	29.43 (0.06)	20.44 (0.36)	48.04 (0.86)	11.92 (0.99)
	2	14.54 (0.07)	14.60 (0.08)	23.38 (0.96)	4.17 (0.99)
	1	0.93 (0.34)	0.23 (0.98)	9.47 (0.91)	1.82 (0.96)
The Netherlands	5	116.87* (0.00)	109.85* (0.00)	172.21* (0.00)	96.14* (0.00)
	4	57.48* (0.00)	47.24* (0.03)	100.14 (0.10)	33.55 (0.81)
	3	31.77* (0.03)	26.67 (0.09)	60.48 (0.39)	15.44 (0.97)
	2	13.85 (0.09)	7.82 (0.57)	33.20 (0.58)	3.40 (0.99)
	1	0.01 (0.91)	0.01 (0.99)	14.26 (0.58)	0.79 (0.99)
Spain	5	101.67* (0.00)	100.39* (0.00)	128.75 (0.17)	84.91* (0.00)
	4	54.14* (0.01)	60.00* (0.00)	70.99 (0.89)	32.65 (0.85)
	3	28.01 (0.08)	21.72 (0.28)	45.82 (0.91)	19.29 (0.85)
	2	7.84 (0.48)	7.49 (0.61)	22.53 (0.97)	8.62 (0.90)
	1	0.52 (0.47)	0.00 (1.00)	10.31 (0.87)	4.64 (0.59)
Denmark	5	Non Applicable		174.24* (0.00)	91.72* (0.00)
	4			117.94* (0.00)	43.76 (0.33)
	3			65.41 (0.18)	19.84 (0.82)
	2			39.87 (0.21)	9.92 (0.80)
	1			16.85 (0.33)	0.61 (0.99)
Japan	5	70.96* (0.04)	77.84* (0.00)	163.25* (0.00)	85.10* (0.00)
	4	33.33 (0.54)	38.27 (0.08)	105.69* (0.05)	46.72 (0.22)
	3	10.35 (0.97)	12.86 (0.64)	60.03 (0.41)	29.43 (0.26)
	2	4.75 (0.83)	5.00 (0.57)	30.36 (0.73)	16.74 (0.26)
	1	1.11 (0.29)	2.65 (0.12)	10.61 (0.85)	3.09 (0.82)

Table 1 *(continued)*

		Pre-EMU period		Whole period	
Country	$(p-r_0)$	JMN_{Trace}	LST_{Trace}	JMN_{Trace}	LST_{Trace}
Sweden	5	74.14* (0.02)	72.55* (0.00)	164.20* (0.00)	83.69* (0.01)
	4	37.09 (0.34)	37.64 (0.09)	108.14* (0.03)	36.23 (0.70)
	3	10.73 (0.97)	12.41 (0.68)	60.82 (0.38)	18.01 (0.90)
	2	3.89 (0.91)	6.41 (0.39)	34.73 (0.50)	13.69 (0.49)
	1	0.27 (0.61)	2.01 (0.18)	10.32 (0.87)	1.55 (0.97)
UK	5	88.02* (0.00)	86.05* (0.00)	151.86* (0.00)	85.33* (0.00)
	4	39.08 (0.26)	36.22 (0.12)	85.66 (0.47)	39.25 (0.55)
	3	22.18 (0.29)	19.33 (0.19)	50.64 (0.78)	20.97 (0.76)
	2	10.44 (0.25)	7.99 (0.24)	28.97 (0.79)	8.02 (0.93)
	1	3.55 (0.06)	0.08 (0.83)	11.26 (0.81)	2.71 (0.87)
USA	5	101.85* (0.00)	72.52* (0.00)	181.57* (0.00)	102.95* (0.00)
	4	67.77* (0.02)	45.69* (0.04)	101.95 (0.08)	34.87 (0.76)
	3	36.71 (0.18)	23.34 (0.20)	56.24 (0.56)	22.21 (0.69)
	2	18.17 (0.33)	8.38 (0.50)	24.32 (0.94)	10.07 (0.81)
	1	6.28 (0.43)	3.51 (0.27)	11.00 (0.83)	1.27 (0.99)

Notes: The values reported is for $r_0 = 0$, so that $p - r_0 = p$ is the dimension of the VECM. Numbers in parentheses are *p*-values. * denotes rejection of the null hypothesis at the 0.05 level of significance.

Table 2: Likelihood ratio tests for the structure of cointegrating vectors for the pre-EMU period

Panel A: Two cointegrating vectors

Country	$\mathcal{H}_1$ (PPP with unrestricted interest rates, UIP with unrestricted prices)	$\mathcal{H}_2$ (Only PPP, only UIP)	$\mathcal{H}_3$ (PPP with interest rates with equal and opposite signs, UIP with prices with equal and opposite signs)
Belgium	2.02 (0.36)	38.09* (0.00)	10.59* (0.03)
Greece	6.59* (0.04)	18.27* (0.00)	8.29 (0.08)
Italy	18.42* (0.00)	63.58* (0.00)	23.78* (0.00)
The Netherlands	5.70 (0.06)	58.92* (0.00)	40.61* (0.00)
Spain	4.55 (0.10)	59.61* (0.00)	35.81* (0.00)
USA	7.69* (0.02)	20.78* (0.00)	11.72* (0.02)

Panel B: Single cointegrating vector

Country	$\mathcal{H}_4$ (PPP with unrestricted interest rates)	$\mathcal{H}_5$ (UIP with unrestricted prices)	$\mathcal{H}_6$ (only PPP)	$\mathcal{H}_7$ (only UIP)	$\mathcal{H}_8$ (PPP with interest rates with equal and opposite signs)	$\mathcal{H}_9$ (UIP with prices with equal and opposite signs)	$\mathcal{H}_{10}$ (PPP and UIP jointly)
Finland	8.42* (0.01)	2.80 (0.25)	27.76* (0.00)	11.61* (0.02)	8.41* (0.04)	7.33 (0.06)	8.36 (0.08)
France	11.23* (0.00)	4.96 (0.08)	21.96* (0.00)	24.94* (0.00)	19.75* (0.00)	20.34* (0.00)	24.79* (0.00)
Ireland	11.15* (0.00)	25.94* (0.00)	35.37* (0.00)	27.00* (0.00)	13.07* (0.00)	26.12* (0.00)	26.48* (0.00)
Japan	12.84* (0.00)	15.61* (0.00)	25.36* (0.00)	23.51* (0.00)	21.28* (0.00)	22.51* (0.00)	23.84* (0.00)
Sweden	8.03* (0.02)	19.80* (0.00)	11.92* (0.02)	24.41* (0.00)	8.54* (0.04)	19.98* (0.00)	23.42* (0.00)
UK	24.82* (0.00)	29.89* (0.00)	34.11* (0.00)	34.73* (0.00)	26.83* (0.00)	29.89* (0.00)	32.17* (0.00)

Notes: The LR tests are distributed asymptotically as χ^2, while the respective *p*-values are shown in parentheses. * denotes rejection of the null hypothesis at the 0.05 level of significance.

Table 3: Likelihood ratio tests for the structure of cointegrating vectors for the whole period

Panel A: Two cointegrating vectors

Country	$\mathcal{H}_1$ (PPP with unrestricted interest rates, UIP with unrestricted prices)	$\mathcal{H}_2$ (Only PPP, only UIP)	$\mathcal{H}_3$ (PPP with interest rates with equal and pposite signs, UIP with prices with equal and opposite signs)
Belgium	2.32 (0.31)	75.26* (0.00)	71.75* (0.00)

Panel B: Single cointegrating vector

Country	$\mathcal{H}_4$ (PPP with unrestricted interest rates)	$\mathcal{H}_5$ (UIP with unrestricted prices)	$\mathcal{H}_6$ (only PPP)	$\mathcal{H}_7$ (only UIP)	$\mathcal{H}_8$ (PPP with interest rates with equal and opposite signs)	$\mathcal{H}_9$ (UIP with prices with equal and opposite signs)	$\mathcal{H}_{10}$ (PPP and UIP jointly)
Finland	0.73	7.57*	81.90*	10.47*	1.11	9.96*	11.19*
	(0.69)	(0.02)	(0.00)	(0.03)	(0.77)	(0.02)	(0.02)
France	36.89*	7.02*	45.73*	40.09*	37.85*	35.76*	43.86*
	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
The Netherlands	0.84	13.27*	12.84*	37.45*	12.26*	13.73*	40.81*
	(0.66)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Spain	30.33*	17.39*	39.29*	45.71*	38.71*	17.42*	45.77*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Denmark	2.47	9.08*	23.66*	30.59*	19.71*	20.43*	29.50*
	(0.29)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Japan	1.02	17.90*	29.37*	25.81*	12.49*	18.51*	23.59*
	(0.60)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sweden	13.65*	4.56	31.52*	10.98*	10.19*	7.92*	11.76*
	(0.00)	(0.10)	(0.00)	(0.02)	(0.02)	(0.05)	(0.02)
UK	23.02*	34.16*	29.49*	39.27*	25.48*	35.93*	37.57*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
USA	5.85	2.43	29.44*	15.60*	11.50*	11.25*	12.81*
	(0.06)	(0.30)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)

Notes: The LR tests are distributed asymptotically as χ^2, while the respective *p*-values are shown in parentheses. * denotes rejection of the null hypothesis at the 0.05 level of significance.