Exchange rate policy and economic convergence in the European Union

This item was submitted to Loughborough University’s Institutional Repository by the/an author.

Additional Information:

• This paper forms part of the ESRC funded project (Award No. L1382511013) “Business Cycle Volatility and Economic Growth: A Comparative Time Series Study”, which itself is part of the Understanding the Evolving Macroeconomy Research programme.

Metadata Record: [https://dspace.lboro.ac.uk/2134/729](https://dspace.lboro.ac.uk/2134/729)

Publisher: © Loughborough University

Please cite the published version.
This item was submitted to Loughborough's Institutional Repository by the author and is made available under the following Creative Commons Licence conditions.

For the full text of this licence, please go to: http://creativecommons.org/licenses/by-nc-nd/2.5/
Department of Economics

Business Cycle Volatility and Economic Growth
Research Paper No. 2000/3

Exchange Rate Policy and Economic Convergence in the European Union

Mark J. Holmes

January 2000

This paper forms part of the ESRC funded project (Award No. L1382511013) "Business Cycle Volatility and Economic Growth: A Comparative Time Series Study", which itself is part of the Understanding the Evolving Macroeconomy Research programme.
Abstract This paper tests for long-run macroeconomic convergence among European Union countries according to the various exchange rate regimes that have prevailed over the last forty years. Applying a recently developed test to monthly index of industrial production data, output convergence is confirmed or rejected depending on whether or not the first largest principal component based on benchmark deviations with respect to Germany is stationary or not. It is argued that this methodology has key advantages over existing cointegrating and common trends procedures. For most European Union countries, there is evidence of increased macroeconomic convergence during the 1990s where evidence is particularly strong for Belgium, France and the Netherlands. The evidence also indicates that the Snake era of the 1970s was more conducive towards convergence than the initial ERM period of 1979-92. Evidence of convergence is lacking for Austria, Finland and Sweden who joined the EU in 1995 and for a sample of non-EU countries.

JEL Codes E0, F0, F4.

1. Introduction

The issue of macroeconomic convergence has figured prominently as European Union (EU) members have debated the desirability and plausibility of participating in a monetary union. A relevant consideration here is the role played by macroeconomic policy in influencing output co-movements. In recent decades EU members have participated in a number of exchange rate regimes- Bretton Woods, the Snake and Exchange Rate Mechanism (ERM)- which have aimed to promote nominal exchange rate stability. Furthermore, capital controls have been relaxed, a single market has been created for labour and goods, and the majority of EU members have embarked on measures aimed at achieving the Maastricht convergence criteria for a single currency. These factors might be expected to facilitate increased output convergence. However, the EU exchange rate arrangements have been conducted against a background of significant symmetric and asymmetric shocks- oil price crises and German unification- and have been noted for their periods of turbulence where members have at times exhibited some degree of policy autonomy. Using index of industrial production (IIP) data for a sample of twelve EU members along with Canada, Japan and the US, this study offers an empirical assessment of how long-run output convergence in the EU has been affected by the dramatic changes in policy environment over the last forty years.

There are several reasons of interest attached to this study. First, a key contribution is in terms of the methodology employed. Following Snell (1996), the tests for output convergence are on the basis of whether the largest principal component, based on benchmark deviations from German output, is stationary or not. As argued below, this methodology offers a number of advantages over alternative common trends methods based on Johansen (1988) and Stock and Watson (1988), which can suffer from low test power on account of data limitations, as well as principal components analyses that search for integration using arbitrary methods to determine the ‘significance’ of given components. Second, while numerous studies have tested for nominal convergence using interest rate, monetary aggregates and inflation data [see, inter alia, Koedijk and Kool (1992), Caporale and Pittis (1993), Hafer and Kutan (1994), Westbrook (1998)], this study addresses real convergence in the EU which is relatively less explored [Serletis and Krichel (1992), Mills and Holmes (1999)]. Third, convergence is investigated on the basis of defining sub-periods using key structural developments regarding exchange rate policy. This is preferable to examining full periods that do not acknowledge key structural breaks [see, for example, Serletis and Krichel (1992), Bernard and Durlauf (1995)]. Furthermore, the sample of
countries is divided into groups according to stance on EU membership and the associated exchange rate regime. This enables us to assess the possibility of convergence clubs [Quah (1996)] within the EU where common characteristics regarding exchange rate policy bind economies together. Finally, the extent to which national output movements exhibit convergence is of relevance to the literature on international business cycles [see, inter alia, Baxter and Stockman (1988), Ahmed et al. (1993), Artis and Zhang (1997)] and international growth convergence [see, inter alia, Barro and Sala-i-Martin (1995), Quah (1996), Sala-i-Martin (1996)].

The paper is organised as follows. The following section considers the literature on economic integration and some theoretical issues. Section 3 discusses the econometric methodology. This leads to a new categorisation of types of real convergence based on the stationarity of the first largest principal component and the nature of the attached factor loadings. Section 4 describes the data set employed and then reports and discusses the results. The evidence suggests that convergence with Germany is confirmed for most EU members during the 1990s though there is some more limited evidence of this during the 1960s and 1970s. Convergence is absent for those countries who have remained outside the EU for much of the study period. Section 5 concludes.

2. Economic Integration in the EU

In the short-run, output linkages are influenced by asymmetric shocks, such as German unification in July 1990, or symmetric shocks, such as the oil price rises in the 1970s. Structural and institutional factors are crucial in forming the background against which long-run linkages with Germany can exist. While Bretton Woods and the Snake during the 1960s and 1970s sought to stabilise nominal exchange rates with respect to the US dollar, the ERM which followed also sought to remove capital controls among its members. In this context, the standard Mundell-Fleming model can be used to argue that fixed exchange rates combined with perfect capital mobility and asset substitutability removes the scope for long-run autonomous monetary policy. Upto the early 1990s, the ERM had mixed success in achieving its aims. While Artis and Taylor (1988) find evidence of stabilised nominal exchange rates during its early years, the permitted fluctuations in nominal exchange rates were set at $\pm2.25\%$ around a central parity and there were several realignments within the ERM. Speculative crises in the early 1990s resulted in the exit of Italy and the UK in September 1992 and the subsequent widening of the permitted bands of exchange rate fluctuations to $\pm15\%$ for the remaining members in August 1993. Also, there has been a diversity of experience with regard to the use of capital controls. As documented by Ungerer et al. (1990), these controls have been gradually relaxed over the period of the ERM with the removal of all controls for most countries by May 1990.

Recent work on long-run output convergence in the EU includes Mills and Holmes (1999) who employ IIP data for Belgium, France, Germany, Italy, Netherlands and the UK during March 1979 to December 1994 and find the presence four (two) common stochastic trends when employing the Johansen (Stock and Watson) methodology thereby rejecting convergence. There is, however, evidence that convergence was greater during the ERM period than during Bretton Woods which features five (four) common trends using the Johansen (Stock and Watson) methodology. Serletis and Krichel (1992) use per capita IIP data over the period January 1962 to January 1990 and find eight common stochastic trends among a sample of ten EU countries while Bernard and Durlauf (1995) examine annual per capita real GDP data for eleven European economies over the period 1900-87. They conclude that there are 4-5 long-run processes driving European output. However, these latter studies are based on study periods that cut across different exchange rate regimes thereby increasing the likelihood of rejecting convergence. Further insight
is offered by Koedijk and Kool (1992), Katsimbris and Miller (1993) and Hafer and Kutan (1994) who test the somewhat looser hypothesis that regimes of relatively fixed exchange rates promote financial integration among the participating members. These studies examine interest rate covariation through principal component and cointegration techniques and conclude that while EU monetary policies are fairly interdependent, there is some limited scope for independent policy and that notions of German dominance can be rejected. Similar conclusions are drawn in the case of inflation convergence [Hall et al. (1992), Koedijk and Kool (1992), Caporale and Pittis (1993) and Thom (1995)] though Westbrook (1998) claims to find evidence of a single common trend among EU inflation rates during March 1979 to December 1992.

In more recent years, the Maastricht convergence criteria for a single currency has set various limitations in terms of exchange rate flexibility, domestic interest rate setting and inflation rates as well as fiscal flexibility. With a tighter reign on macroeconomic policy, we might therefore expect evidence of convergence to be strongest over this period. Furthermore, 1992 saw the creation of the single market thereby promoting the free movement of goods and labour. Against this background, wage and price flexibility should, in theory, help facilitate increased convergence. However, the evidence suggests that labour mobility and price flexibility is restricted and the limited scope for fiscal transfers across the EU is likely to hinder member countries in dealing with an asymmetric shock [Tavlas (1993), De Grauwe (1994)].

3. Methodology

This study employs a new technique, developed by Snell (1996), which is an extension of the Principal Components methodology, based on testing for the stationarity of the first largest principal component (LPC) of benchmark deviations from German output. Suppose the benchmark deviations are defined as

\[(y_i^1 - y_i^G)_t = u_t^1\]  \hspace{1cm} (1)

where \(y_i^1\) and \(y_i^G\) respectively denote the natural logarithm of the IIP of country \(i\) and Germany, and \(i = 1, 2, \ldots, n\). Let \(X_t\) be an \((n \times 1)\) vector of random variables, namely the \(u_t^1\)’s for each of the \(n\) countries, which may be integrated up to order one. The principal components technique addresses the question of how much interdependence there is in the \(n\) variables contained in \(X_t\). We can construct \(n\) linearly independent principal components which collectively explain all of the variation in \(X_t\), where each component is itself a linear combination of the \(u_t^1\)’s. Since I(1) variables have infinite variances, whereas stationary, I(0), variables have constant variances, it follows that the first LPC, which explains the largest share of the variation in \(X_t\), is the most likely to be I(1) and so corresponds to the notion of a common trend [Stock and Watson (1988)]. However, if the first LPC is I(0) then all the remaining principal components will also be stationary and there are no common trends which suggests that the \(u_t^1\)’s contained in \(X_t\) are themselves stationary. This will confirm real convergence with Germany across the sample of \(n\) benchmark deviations.

More formally, following Stock and Watson (1988) we can argue that each element of \(X_t\) may be written as a linear combination of \(k \leq n\) independent common trends which are I(1), and \((n - k)\) stationary components which correspond to the set of \((n - k)\) cointegrating vectors among
The vector of common trends and $(n-k)\times 1$ vector of stationary components may respectively be written as

\[ \tau_t = \alpha^X_t \]

\[ \xi_t = \beta^X_t \]  

where $\alpha^X$ is an $(n-k)$ matrix of full column rank, $\beta$ is an $n\times(n-k)$ matrix that forms the $(n-k)$ cointegrating vectors, $\alpha^\prime \alpha = I$ and $\alpha^\prime \beta = 0$. If there are $k$ common trends, it can be shown that the $k$ LPCs of $X_t$ may be written as

\[ \xi_t^S = X_t^\prime \alpha^* \]  

where $X_t^\prime$ is a vector of observations on the $u_t^i$'s in mean deviation form, $\alpha^*$ represents the $k$ eigenvectors corresponding to the largest eigenvalues of $X_t$ and is defined as $\alpha R$ where $R$ is an arbitrary, orthogonal $(k\times k)$ matrix of full rank. This relationship guarantees that under the null hypothesis of $k$ common trends, each of the $k$ LPCs will be I(1). Similarly, for the $(n-k)$ remaining principal components, it can be shown that

\[ \xi_t^S = X_t^\prime \beta^* \]

where $\beta^*$ corresponds to the $(n-k)$ eigenvectors that provide the $(n-k)$ smallest principal components and is defined as $\beta S$ where $S$ is an arbitrary orthogonal $(n-k)\times(n-k)$ matrix.

The first LPC will be I(1) provided there is at least one common trend among the $u_t^i$'s contained in $X_t$. We can therefore test the null hypothesis that the first LPC is non-stationary against the alternative hypothesis that the first LPC is I(0). Rejection of the null means that all principal components are stationary and so there are no common trends among the $u_t^i$'s contained in $X_t$. This confirms convergence with respect to Germany across the sample. To test the stationarity of the LPC we can use the familiar Augmented Dickey-Fuller (ADF) test based on

\[ \Delta z_t = \alpha^\prime z_{t-1} + \sum_{i=1}^k \beta_i z_{t-i} + \epsilon_t \]

where $z = \alpha^\prime X_t$ using $\alpha^\prime$ as the first column of $\alpha^*$, and $\epsilon_t$ is a white noise error term. This notion of convergence can be seen in the context of the Bernard and Durlauf (1995) definition of convergence in a stochastic environment where the long-run forecasts of the benchmark deviations tend to zero as the forecast horizon tends to infinity. If each $y$ is I(1), then each $y_t^i$ is a stationary process (since the IIP series are indices having different bases, we may allow the benchmark deviations to have different means) where each $y_t^i$ and $y_t^S$ is cointegrated with a cointegrating vector $[1, -1]$.

An alternative way forward is to test for a single common trend among a series of I(1) variables
(\(y_1^G, y_2^G, \ldots, y_n^G\)) where convergence is confirmed through the presence of \(n\) cointegrating vectors among the \(n+1\) countries. The advantage of examining the stationarity of the first LPC is that, unlike the Johansen (1988) maximum likelihood procedure (and the Stock and Watson (1988) common trend framework), it does not require the estimation of a complete vector autoregression system (VAR). The size and power of this test is not affected by the VAR being constrained to an unreasonably low order on account of data limitations. This method also avoids the need for an entire sequence of tests for the stationarity of a multivariate system. As indicated by Snell, even if each test in the sequence had a reasonable chance of rejecting the false null, the procedure as a whole is likely to have low power. The downside of this methodology concerns a standard criticism of principal component estimation and indeed of common stochastic trends. They are linear combination of economic variables and so the economic interpretation of a given component can be problematic. Also, testing the null of non-stationarity of the first LPC leaves one vulnerable to the standard criticisms concerning the low power attached to unit root tests making it difficult to reject the null of non-stationarity.

In this investigation, a number of definitions of convergence are proposed. While the stationarity of the first LPC indicates convergence between each \(y_i^G\) and \(y_i^G\), convergence should also be judged in terms of the relationships among non-German outputs, i.e. \(y_1^G\) and \(y_i^G\). The factor loadings attached to the first LPC, i.e. the elements of \(\alpha_k\), indicate the degree of integration among these countries and range from -1 (perfect negative correlation with the first LPC) to 1 (perfect positive correlation) while a value of zero indicates a degree of independence from the other countries included in \(X_i\). Since the eigenvalue attached to the first LPC is the sum of its squared factor loadings, if each factor loading equals 1 then the eigenvalue will equal the number of countries \(n\) and so the first LPC explains all the variation in \(X_i\). This will confirm convergence among the non-German economies. If, on the other hand, at least one factor loading of the first LPC is not equal to 1 then the first LPC does not explain all the variation in the data set where there is at least one other principal component that also offers a ‘significant’ explanation of the variation in \(X_i\). In this case, convergence among the non-German economies is not present. On the basis of this discussion, consider the following convergence categorisation.

<table>
<thead>
<tr>
<th>All elements of (\alpha_k) are unity</th>
<th>First LPC is I(0)</th>
<th>Case 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>All elements of (\alpha_k) are not unity</td>
<td>First LPC is not I(0)</td>
<td>Case 3</td>
</tr>
</tbody>
</table>

Cases 1 and 2 both indicate convergence with Germany. However, Case 1 constitutes strong convergence among the sample of countries because the stationarity of the first LPC is accompanied by factor loadings that are insignificantly different from unity suggesting that the real outputs of the non-German economies also move together in tandem. Since the factor loadings are, in effect, correlation coefficients, critical values are those employed for Pearson product-moment correlation coefficients. Case 2, however, has at least one factor loading on the first LPC that is not equal to unity suggesting that there is some degree of macroeconomic independence among the non-German economies. We can define this as a case of weak convergence. Cases 3 and 4 are characterised by a non-stationary first LPC which indicates some degree of independence from Germany. Case 3 occurs when the real output among the non-German economies still move together because the elements of \(\alpha_k\) are nonetheless insignificantly different from unity. Linkages among the non-German economies is stronger than with Germany.
itself. Case 4 highlights independence from both the base country and other non-German economies.

This categorisation can be compared with the use of principal components in earlier studies of financial integration [see, \textit{inter alia}, Logue \textit{et al.} (1976), White and Woodbury (1980) and Nellis (1982)] whereby \textit{increased} financial integration occurs if interest rate covariation is captured by fewer ‘significant’ principal components. Integration is confirmed if there is one ‘significant’ principal component explaining the variation of interest rates in the sample. In this context, ‘significance’ is determined by whether or not a principal component has an eigenvalue of greater than one. While this arbitrary procedure enables one to comment on the extent to which the benchmark output deviations move together over time, it does not address the issue of (long-run) relationships with Germany.

4. Data and Results

This study employs monthly IIP data for Austria, Belgium, Canada, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, UK and the US for the period January 1960 to May 1999. The data are obtained from the \textit{International Financial Statistics} database and are expressed in natural logarithm form with benchmark deviations calculated with respect to Germany.

The sample of countries is divided according to stance regarding membership of the EU and the associated exchange rate regime. Moreover, four sub-groups are defined. \textit{Group 1} constitutes the core EU group of Belgium, France and the Netherlands who have been members of the EU from the outset and have the strongest record of ERM membership. \textit{Group 2} consists of Greece, Italy, Spain, Portugal and the UK who joined the EU during the 1970s and 1980s and whose currencies have had varied experiences of ERM membership. As described earlier, Italy and the UK were ejected from the ERM in September 1992 while Portugal and Spain took part at the wider $\pm 6\%$ bands of exchange rate fluctuations having respectively joined the ERM in 1992 and 1989. Greece, on the other hand, has remained outside the ERM. \textit{Group 3} comprises Austria, Finland and Sweden who are the most recent new entrants to the EU having joined in January 1995. Of the full sample of EU economies, Greece, Sweden and the UK are currently not proceeding towards membership of the single currency. \textit{Group 4} comprises the three non-EU countries that is Canada, US and Japan. This enables us to judge whether EU or ERM membership \textit{per se} may have facilitated macroeconomic convergence.

The sample period is divided into four sub-periods that are defined according major policy changes in the EU. \textit{Period 1} covers the initial period of fixed exchange rates under the Bretton Woods regime from January 1960 to August 1971 which corresponds to the ending of dollar-gold convertibility. While the Bretton Woods period allowed currencies to fluctuate within a 1 per cent par value in terms of gold, the UK devalued Sterling in 1967. \textit{Period 2} covers April 1972 to February 1979 which is characterised by floating exchange rates with respect to the US dollar following the breakdown of Bretton Woods and the creation of the European Snake that sought to stabilise bilateral exchange rates between any two European countries through the use of declared fluctuation margins vis-à-vis the US dollar. \textit{Period 3} covers March 1979 to August 1992. This is the initial ERM period ending with the turbulence in 1992. This period also witnessed the relaxation of capital controls for most EU members and moves to establish the single European market during 1992. \textit{Period 4} covers September 1992 to May 1999 which is partly characterised by the absence of Greece, Italy, Sweden and the UK from the ERM, and by the use of the wide exchange rate fluctuation bands for the remaining members. This period encompasses the enlargement of the EU in 1995 and includes the preparatory period for the
single currency as the majority of EU members adhered to the Maastricht convergence criteria.

The ADF tests on the first LPC are reported in Table 1. Stationarity and therefore convergence with Germany is confirmed for Group 1 during April 1972 to February 1979, Group 2 during January 1962 to August 1971, and Groups 1 and 2 during September 1992 to May 1999. Although the final sub-period was largely characterised by the wider bands of permitted exchange rate fluctuation (which, in practice, were never fully used), increased capital mobility, the completion of the single European market and adherence to the Maastricht convergence criteria served to facilitate integration with Germany. The stationarity of first LPC also occurs during the Snake era for the Group 1 economies. Of all the EU countries, only Belgium, Germany and the Netherlands were ever-present members. These results suggest that the French flirting with the snake arrangements, but not fully committing themselves to exchange rate management, was nonetheless sufficient to facilitate convergence with Germany in the 1970s. During the Bretton Woods sub-period, convergence with Germany is confirmed for the Group 2 (who, with the exception of Italy, were then non-EU economies). This result is in contrast to Group 1 who were EU members from the start of the study period.

The first LPC is non-stationary in all the remaining cases. Thus there is no evidence of convergence with Germany in the case of the Group 3 countries who all joined the EU in 1995 with Austria and Finland proceeding towards monetary union. Neither is there evidence of convergence with Germany in the case of the three non-European economies: Canada, Japan and the US. In all cases, the first LPC is non-stationary during the initial ERM-period of March 1979 to August 1992. For the Group 1 and 2 economies one can point to the earlier discussion on currency realignments, the use of capital controls, German reunification and the exchange rate crisis in the early 1990s. During this period large interest rate increases were occasionally required by ERM members to keep their exchange rates within the band in order to prevent any expectations of a depreciation leading to speculative attacks. These results are consistent with Mills and Holmes (1999), who find more than a single common stochastic trend among EU real outputs during 1979-94, and Caporale and Pittis (1993), Hafer and Kutan (1994) and Thom (1995), who reach the same conclusion regarding EU inflation and interest rate levels.

Table 2 reports the factor loadings attached to the first LPC which can provide information on the extent of convergence among the non-German economies. At the 5% significance level, the factor loadings are different from zero in all but seven cases and they are different from unity in all but five cases. On no occasion is it possible to confirm strong (Case 1) convergence among the samples of countries because a stationary first LPC features at least one factor loading that is significantly different from unity. At best, weak (Case 2) convergence is present among these countries. This is particularly the case for the Group 1 countries who nonetheless feature high factor loadings during the 1970s and 1990s. In the case of the Group 2 countries, the final sub-period features Greece and the UK (who are not currently proceeding with monetary union) with noticeably low factor loadings on the first LPC.

In the remaining cases where the first LPC is non-stationary, there is always at least one factor loading that is significantly different from unity. Thus Case 3 convergence among the non-German samples is ruled out. However, it is possible to comment on the instances where the null of unity is accepted. In particular, the factor loadings are insignificantly different from unity in the cases of Finland and Sweden during the 1990s and reflects the strong economic linkages between these economies. The Group 4 non-European economies always feature a non-stationary first LPC thereby suggesting that there is no convergence with Germany. However, the factor loadings for Canada and the US are insignificantly different from unity during the 1990s. Japan, however, features a non-positive factor loading during this period which probably reflects the severe recession experienced.
Table 3 reports the eigenvalues and cumulative R-squared associated with the LPCs. The traditional principal component test of integration among the non-German economies is whether or not there is a single ‘significant’ principal component with an eigenvalue of greater than unity that explains the variation in benchmark deviations. According to this criteria, integration is confirmed for Group 1 during Periods 2, 3, and 4, Group 3 throughout and Group 4 throughout. There is no evidence of integration for the Group 2 economies. Overall, these results are more favourable than the previous tests towards integration. However, this is an arbitrary rule for judging significance. Rather than formally testing against a formal sampling distribution, any principal component is simply deemed ‘significant’ if the cumulative R-squared associated with its eigenvalue is greater than $1/n$.

5. Summary and Conclusion

This study has investigated the impact of the exchange rate regime on output convergence among EU economies. It is argued that use of a new methodology based on testing for the stationarity of the largest principal component for benchmark output deviations confers key advantages over existing alternative methods of examining common trends. Convergence with Germany is confirmed for Belgium, France and the Netherlands during the 1970s and 1990s, and Greece, Italy, Portugal, Spain and the UK during the 1960s and 1990s. Most recently, these results point towards the role of the single market, the easing of capital controls and (for the majority of EU members) measures to satisfy the Maastricht convergence as bringing macroeconomic policy into line thereby facilitating the convergence of output. Where stationarity is confirmed, the attached factor loadings are generally less than unity suggesting that convergence with Germany is often stronger than convergence between the non-German economies. This can be contrasted with the results obtained for the non-EU sample of Canada, Japan and the US for whom the largest principal component is always non-stationary.

### Table 1. ADF Unit Root Tests on the First LPC

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>-2.288</td>
<td>-2.912**</td>
<td>-0.582</td>
<td>-3.043**</td>
</tr>
<tr>
<td>Group 2</td>
<td>-3.110**</td>
<td>-1.980</td>
<td>-1.244</td>
<td>-3.010**</td>
</tr>
<tr>
<td>Group 3</td>
<td>-1.280</td>
<td>-2.361</td>
<td>-2.341</td>
<td>-1.816</td>
</tr>
<tr>
<td>Group 4</td>
<td>-1.440</td>
<td>-1.739</td>
<td>-1.813</td>
<td>-2.006</td>
</tr>
</tbody>
</table>

Deviations in the natural logarithm of the IIP are with respect to Germany. Group 1 comprises Belgium, France and the Netherlands; Group 2 comprises Greece, Italy, Portugal, Spain and the UK; Group 3 comprises Austria, Finland and Sweden; Group 4 comprises Canada, Japan and the US. Due to Greek data limitations, the Bretton Woods period for Group 2 commences at January 1962. The lag lengths are chosen to ensure white noise residuals. Following the application of the Schwarz Information Criteria, all regressions exclude a time trend. Further tests based on Dickey and Fuller (1981), table VI revealed the time trend to be insignificant. ** indicates rejection of the null of non-stationarity at the 5 and 10% significance levels with critical values taken from Fuller (1976).
Table 2. Factor Loadings Attached to the First LPC

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.828***</td>
<td>0.785***</td>
<td>0.842***</td>
<td>0.841***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>0.816***</td>
<td>0.872***</td>
<td>0.957***</td>
<td>0.784***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>-0.025</td>
<td>0.822***</td>
<td>0.857***</td>
<td>0.860***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.893***</td>
<td>0.910***</td>
<td>0.829***</td>
<td>0.263**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>0.702***</td>
<td>0.758***</td>
<td>0.768***</td>
<td>0.844***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>0.039</td>
<td>0.854***</td>
<td>-0.044</td>
<td>0.787***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>0.835***</td>
<td>0.913***</td>
<td>0.899***</td>
<td>0.840***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>-0.721***</td>
<td>0.161</td>
<td>0.823***</td>
<td>0.431***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 3</td>
<td>0.764***</td>
<td>0.624***</td>
<td>0.072</td>
<td>0.929***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>0.888***</td>
<td>0.922***</td>
<td>0.441***</td>
<td>0.981***.#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>0.825***</td>
<td>0.694***</td>
<td>0.923***</td>
<td>0.959***.#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 4</td>
<td>0.903***</td>
<td>0.847***</td>
<td>0.969***.#</td>
<td>0.970***.#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.437***</td>
<td>0.898***</td>
<td>0.953***</td>
<td>0.986***.#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>0.087</td>
<td>0.879***</td>
<td>0.207</td>
<td>-0.259**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See notes for Table 1. *** and ** indicates significance of the factor loadings at the 1 and 5% levels based on Pearson correlation coefficients (see Child (1970)). # denotes a factor loading that is insignificantly different from unity at the 5% level.

Table 3. Principal Components based on IIP Differentials wrt Germany

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960.1-1971.8</td>
<td>1.352</td>
<td>0.451</td>
<td>2.510</td>
<td>0.502</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>1972.4-</td>
<td>2.053</td>
<td>0.684</td>
<td>2.992</td>
<td>0.598</td>
</tr>
<tr>
<td>1979.2</td>
<td>0.572</td>
<td>1.019</td>
<td>0.549</td>
<td>0.802</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979.3-</td>
<td>2.359</td>
<td>0.786</td>
<td>2.765</td>
<td>0.553</td>
</tr>
<tr>
<td>1992.8</td>
<td>0.502</td>
<td>1.210</td>
<td>0.551</td>
<td>0.795</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992.9-</td>
<td>2.061</td>
<td>0.687</td>
<td>2.294</td>
<td>0.459</td>
</tr>
<tr>
<td>1999.5</td>
<td>0.553</td>
<td>1.330</td>
<td>0.980</td>
<td>0.725</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See notes for Table 1. Cum R sq. is the cumulative R squared associated with eigenvalues of greater than unity.

References


