Inflation Convergence Within the European Union: A Panel Data Analysis

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Abstract:

This paper investigates the question of whether there exists evidence in support of inflation convergence within the European Union. The analysis also focuses on whether the Exchange Rate Mechanism (ERM) helped to accelerate inflation convergence in its member countries. The results of this paper are supportive of convergence. The countries which continuously participated in the narrow ERM bands show a dramatically higher convergence rate during the period following establishment of the mechanism.

Abstrakt:

Tento článek se zabývá otázkou, zda existuje evidence o tom, že míry inflace v Evropské Unii konvergují. Analýza se rovněž soustřeďuje na otázku zda Mechanismus směnných kurzů (ERM) přispěl k urychlení konvergence inflace mezi jeho členskými zeměmi. Výsledky analýzy podporují hypotézu konvergence míry inflace jako takové. Navíc země, které kontinuálně udržovaly své směnné kurzy v úzkém fluktuačním pásmu Mechanismu, vykazují výrazně vyšší míru konvergence inflace během období fungování Mechanismu.

Keywords: inflation differential, convergence, panel data, stationarity, exchange rates.

JEL Classification: C15, C23, E31

1. Introduction

Do the inflation rates of countries within the European Union converge to a common level? Do convergence processes differ across particular groups of countries? This paper examines these questions and focuses on whether there exists convincing evidence in support of inflation convergence. Further, the paper elaborates on whether the Exchange Rate Mechanism (ERM) helped to accelerate the inflation convergence of its member countries. The objective that motivates these questions is to quantify degree of inflation convergence within the European Union. Finding and quantifying such convergence provides a solid indication of whether one of the conditions to enter the European Monetary Union in the near future is attainable in reality.

Inflation convergence within the European Union is a widely discussed topic. Convergence of inflation rates was incorporated in the Maastricht treaty as one of the requirements to admit a prospective country as a full member of the European Monetary Union (EMU). The convergence condition requires that a country can only join the Union if its inflation rate is no more than 1.5 percentage points higher than the average of the three lowest inflation rates in the European Monetary System (EMS). De Grauwe (1994) provides a full general explanation of the monetary integration. Bean (1992) provides a comprehensive descriptive overview of the economic and monetary union in Europe that is envisaged in the Treaty.

De Grauwe (1992) elaborates on the subject of convergence of inflation rates prior to the acceptance of a country into the monetary union. He argues that in 1991, the degree of inflation convergence among the countries participating in the EMS achieved its historically highest level and further narrowing of the differences among inflation rates is unrealistic. He concludes that the inflation convergence criterion is too tight to fulfill. In later research, De Grauwe (1995) finds that a further drop in inflation differentials occurred after 1991. However, he again cautions against tight nominal convergence criteria and argues that the transition to a monetary union should put less emphasis on such convergence requirements and more on strengthening the future monetary institutions of the union. Bayoumi and Masson (1995) argue that the Treaty convergence criteria are not only unnecessary but are also dangerous for the proper functioning of the future monetary union.

What might be a role of the ERM in promotion of inflation convergence? Within the EMS the nominal exchange rates of member countries that participate in the ERM are allowed to fluctuate within a narrow band. This arrangement can be considered a fixed nominal exchange rate regime. An exchange rate peg within such a type of regime allows a high inflation country to import monetary stability from a low inflation country. Giavazzi and Giovanninni (1989) argue that inflation control costs through an exchange rate peg are also lower because they are partially shifted abroad. They summarize that the equilibrium inflation rate in a fixed exchange rate regime is lower than that observed in a regime of flexible rates. However, the anchoring country endures a higher inflation rate than it would endure under the flexible rate regime.

Not all economic theories support the idea that change in a nominal exchange rate regime would have a real effect. It should be stressed that Baxter and Stockman (1989) found that the real exchange rate is the only macroeconomic aggregate which depends systematically on the exchange rate system. They found no strong evidence that the business cycle behavior of real output, consumption, trade flows, and government spending depends systematically on the type of the nominal exchange rate regime. Therefore it is not clear whether an exchange rate peg should both help bring down inflation within the group of countries participating in the ERM and result in a convergence of inflation over time.

Inflation convergence will be analyzed by using the concept of the σ-convergence outlined by Barro and Sala-i-Martin (1991). Translated from the original application to growth of output, σ-convergence, in the current context, means that inflation convergence should be reflected in a reduction in the inflation differentials across countries over time. Such a diminishing dispersion is typically measured by sample standard deviation of the respective time series. However, as Quah (1995) points out in his recent study on growth convergence empirics, “what matters, instead, is how the entire cross-section behaves”.

A panel data analysis of inflation differentials’ convergence is conducted in order to fully exploit the effect of cross-variance in pooled time series of moderate length. Previous econometric research has demonstrated the specific advantages of utilizing panel data in studying a wide range of economic issues. A panel unit root test, which is the substance of the analysis, represents a valuable econometric tool. As shown by Levin and Lin (1992), the statistical power of a unit root test for a relatively small panel may be an order of magnitude higher than the power of the test for a single time series.

The data is divided into different groups with the main focus on the ERM and non-ERM countries over two time periods, before and after the ERM was established. The subsequent analysis allows us to derive convergence rates of particular groups. An increase in the convergence rate of the ERM countries over the two periods that surpasses that of the non-ERM countries would be a supportive argument for the positive role of the

ERM in contributing to accelerate inflation convergence. The results of this paper are supportive of convergence in general. It is also evident that the countries which continuously participated in the narrow ERM bands show a dramatically higher convergence rate during the period following establishment of the mechanism. Sensitivity analysis confirms robustness of the results and justifies the structure of different groups.

The rest of the paper is organized in a following manner. Section 2 describes the econometric methodology of the analysis of inflation rate differentials. Section 3 describes the used data and presents empirical results. Section 4 briefly concludes.

2. Methodology

The following econometric methodology utilizes a combination of cross-sections of individual time-series. Inflation for an individual country is defined as

$$\pi_t = \ln\left(CPI_t / CPI_{t-1}\right) \cdot 100 \qquad (1)$$

where CPI_t denotes the consumer price index at time t. Inflation is measured as a percentage change in the index over two successive periods.

We model the inflation ($\pi_{i,t}$) for a group of i individual countries with observations spanning over t time periods in the following way:

$$\pi_{i,t} = \alpha + \phi \pi_{i,t-1} + \varepsilon_{i,t} \qquad (2)$$

The fact that inflation is modeled as an AR(1) process does not represent any theory how the inflation is determined. It is rather a suitable form for the convergence test introduced later in this section.

When averaging inflation over individual countries at each time period, a simple mean of the inflation rate ($\overline{\pi_t}$) within the group can be described as

$$\overline{\pi_t} = \alpha + \phi \overline{\pi_{t-1}} + \varepsilon_t \tag{3}$$

where $\overline{\pi_t} = \frac{1}{n}\sum_{i=1}^{n} \pi_{i,t}$. The inflation differential is defined as the difference between an individual inflation and the average for the whole group at time t. Subtracting equation (3) from (2) yields

$$\pi_{i,t} - \overline{\pi_t} = \phi\left(\pi_{i,t-1} - \overline{\pi_{t-1}}\right) + \varepsilon_{i,t} \tag{4}$$

In the presence of pooling, the intercept α vanishes since, by construction, the inflation differentials have a zero mean over all the countries and time periods.[1] How are the countries pooled into different groups is described in detail in the following section.

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[1]The reason of zero intercept is because of the following. Let $d_{i,t} = \pi_{i,t} - \overline{\pi_t}$ and $g_{i,t} = \pi_{i,t-1} - \overline{\pi_{t-1}}$. If $d_{i,t} = \alpha + \phi g_{i,t} + \varepsilon_{i,t}$, then $\hat{\alpha} = \overline{d} - \hat{\phi}\overline{g}$. But $\overline{d} = \frac{1}{KT}\sum_{t=1}^{T}\sum_{i=1}^{K}\left(\pi_{i,t} - \overline{\pi_t}\right)$

$$= \frac{1}{KT}\sum_{t=1}^{T}\sum_{i=1}^{K}\pi_{i,t} - \frac{1}{T}\sum_{t=1}^{T}\overline{\pi_t}$$

$$= \frac{1}{KT}\sum_{t=1}^{T}\sum_{i=1}^{K}\pi_{i,t} - \frac{1}{KT}\sum_{t=1}^{T}\sum_{i=1}^{K}\pi_{i,t} = 0$$

The analysis is similar for $\overline{g}$, hence, $\hat{\alpha} = 0$.

Equation (4) establishes the base for the convergence methodology proposed by Ben-David (1995, 1996). Convergence in this context requires that inflation differentials become smaller and smaller over time. For this to be true, ϕ must be less than one. On other hand ϕ greater than one indicates divergence of inflation differentials.

After it has been estimated, the convergence coefficient ϕ may be exploited to calculate the actual rate of convergence within a given group. Letting $d_{i,t} = \pi_{i,t} - \overline{\pi}_t$, inflation differentials are assumed to decrease continuously with time according to

$$d_{i,t} = d_0 e^{-rt} \qquad (5)$$

where r is rate of decay or convergence rate.[2] The rate of change of the process illustrated by equation (5) can be equated to the rate of change of an inflation differential described by equation (4) between two successive periods.[3] Then it follows that the convergence rate r can be calculated from the convergence coefficient ϕ as

$$r = -\ln(\phi) \qquad (6)$$

The convergence coefficient ϕ for a particular group of countries can be obtained by estimating equation (4) using the Dickey and Fuller (1979) test. The augmented version of this test (ADF) is used in order to remove possible serial correlation from the

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[2]Rate of change in such a process is $\frac{\dot{d}}{d} = \frac{d_{i,t} - d_{i,t-1}}{d_{i,t-1}} = (e^{-r} - 1)$

[3] Rate of change in inflation differential in between two periods is calculated as

$$\frac{\dot{d}}{d} = \frac{\left(\pi_{i,t} - \overline{\pi}_t\right) - \left(\pi_{i,t-1} - \overline{\pi}_{t-1}\right)}{\pi_{i,t-1} - \overline{\pi}_{t-1}} = (\phi - 1)$$

data. Since the analysis is performed on the panel data, there will be no intercept by construction. Denoting the inflation differential as $d_{i,t} = \pi_{i,t} - \overline{\pi_t}$, and its difference as $\Delta d_{i,t} = d_{i,t} - d_{i,t-1}$, the equation for the ADF test is written as

$$\Delta d_{i,t} = (\phi - 1) d_{i,t-1} - \sum_{j=1}^{k} \gamma_j \Delta d_{i,t-j} + \varepsilon_{i,t} \tag{7}$$

where the subscript i = 1,...,k indexes the countries in a particular group. Equation (7) tests for a unit root in the panel of inflation differentials. The null hypothesis of a unit root is rejected in favor of the alternative of level stationarity if $(\phi - 1)$ is significantly different from zero or, implicitly, if ϕ is significantly different from one.

The number of lagged differences (k) is determined using a parametric method proposed by Campbell and Perron (1991) and Ng and Perron (1995). An upper bound of the number of lagged differences k_{max} is initially set at an appropriate level.[4] The regression is estimated and the significance of the coefficient γ_j is determined. If the coefficient is not found to be significant, then k is reduced by one and the equation (7) is reestimated. This procedure is repeated with diminishing number of lagged differences until the coefficient is found to be significant. If no coefficient is found to be significant in conjunction with the respective k, then k = 0 and a standard form of the Dickey-Fuller test is used in the analysis. A 10 percent value of the asymptotic normal distribution (1.64) is used to assess the significance of the last lag.[5]

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[4] k = 14 is used as k_{max} since quarterly data is used.

[5] Ng and Perron (1995) discuss the advantage of this recursive t-statistic method over alternative procedures where k is either fixed or chosen to minimize the Akaike Information Criterion.

Recent work has established that a sub-unity convergence coefficient ϕ is really a robust indication of convergence is tested by extensive simulation.[6] Ben-David (1995) performed 10,000 simulations for each of three possible cases where data should portray the processes of convergence, divergence, and neutrality. His numerous simulations provide ample evidence of convergence or divergence when these features are true exhibition of the situation. When using neutral data with no strong inclination in either way then the convergence coefficient tends towards unity.

What critical values should be used when analysis is conducted on panel data? The most available critical values for panel unit root tests were tabulated by Levin and Lin (1992). These values do not incorporate serial correlation in disturbances and are, therefore, incorrect for small samples of data. Using Monte Carlo technique, Papell (1995) tabulated critical values taking serial correlation into account and found that for both quarterly and monthly data in his data sets, the critical values were higher than those reported in Levin and Lin (1992).

Because of these findings, the exact finite sample critical values for the resulting test statistics were computed using Monte Carlo methods in the following way. Autoregressive (AR) models were first fit to the first differences of each panel group of inflation differentials using the Schwarz (1978) criterion to choose the optimal AR models. These optimal estimated AR models were then considered to be the true data generating process for errors of each of the panel group of data. Finally, for each panel, the pseudo samples of corresponding size were constructed employing the optimal AR models described earlier with iid $N(0,\sigma^2)$ innovations. σ^2 is the estimated innovation

[6] $(\phi > 1)$ respectively for divergence

variance of a particular optimal AR model. The resulting test statistic is the t-statistic on the coefficient $(1-\phi)$ in equation (7), with lag length k for each panel group chosen as described above.

This process was replicated 10,000 times and the critical values for the finite sample distributions were obtained from the sorted vector of such replicated statistics. The derived finite sample critical values are reported for significance levels of 1%, 5%, and 10% in the tables along with the results of the ADF test conducted on different panel groups in the respective time periods.

3. Empirical observations

The time span of the data is from 1959:2 to 1994:4. The quarterly consumer price indices were obtained from the International Monetary Fund's International Financial Statistics. The data was divided into two time periods. The first one from 1959:2 to 1979:1 is called the pre-ERM period. The second one is called the ERM period. It starts in 1979:2, after the ERM was established, and ends in 1994:4. In order to check the robustness of our results to the exclusion of recent crises, we also perform estimation where the ERM period is truncated in either 1992:2 or 1993:2.

Quarterly inflation rates for 18 European industrialized countries were calculated as percentage changes in consumer price index between two successive quarters. Inflation differentials were computed as the difference between an individual inflation rate and its average for a whole group at time t. Inflation differentials were pooled for distinct groups of countries. The membership of a particular country in the ERM was applied as a criterion to differentiate such groups in a logical way. The groups are described in Table 1.

The terms ERM and EMS are often used interchangeably. This is incorrect and might cause confusion. The European Monetary System was established in March 1979 as a way to stabilize exchange rates volatility within the European Community. According to the EMS, the EC countries agreed to limit fluctuations to their bilateral exchange rates in an obligatory way by interventions of national central banks which is actually the Exchange Rate Mechanism. From the beginning, all EC countries were members of the EMS but only eight of them initially participated in the ERM: Belgium, the Netherlands, Luxembourg, Denmark, France, Germany, Ireland, and Italy. Spain joined the ERM in 1989 followed by the United Kingdom and Portugal in 1990 and 1991, respectively. Only Greece remained out. However, after the major exchange rate crisis in September 1992, the United Kingdom and Italy stopped participating. After another crisis in August 1993, the ERM was redesigned to allow for wider fluctuation bands.

In order to examine the question of whether inflation convergence is present in Europe and whether the ERM helped to lower inflation in its member countries, specific country groups must be created. One group is formed from non-ERM countries: United Kingdom, Greece, Austria, Sweden, Finland, Switzerland, Norway, and Iceland. These countries never participated in the ERM during the analyzed period. The only exception is the United Kingdom, but it is categorized as a non-ERM country due to its short participation in the ERM between 1990 and 1992.

The other crucial group is formed out of the Core ERM countries: Germany, the Netherlands, Belgium, Denmark, Ireland, France, and Luxembourg. The Core countries founded the ERM and never deviated from it. Italy is a founding member but since the beginning of the ERM Italian lira enjoyed wider fluctuation bands. Therefore, Italy is not included in such a crucial group. Very short membership periods of Spain and Portugal disqualify both countries as well.

The convergence test is performed on the two groups and reported in Tables 2 and 3. The results for the non-ERM group are our benchmark case. Comparison of the change in convergence rates between the pre-ERM and ERM periods for both groups has the following rationale: if the positive interperiod change in the convergence rate for the ERM group surpasses that of the non-ERM group, then this feature is a supportive argument for the active role of the ERM in contributing to accelerate inflation convergence of its member countries.[7] When looking at the Core ERM group we found that the convergence rate increased between the two periods by 13.22%. The same comparison of the non-ERM group is unfortunately precluded because convergence coefficient is statistically insignificant in the pre-ERM period. Comparison of convergence rates alone shows that the Core group is converging during the ERM period at the rate more than three times larger than the non-ERM group.

These findings allow us to formulate the main result of this paper. There exist inflation convergence among countries within Europe. It is also evident that the countries which continuously participated in the narrow ERM bands show a dramatically higher convergence rate during the ERM period than those staying outside the mechanism.

We now proceed to investigate several additional groups. First, Luxembourg was eliminated from the Core group. It should be noted that tiny Luxembourg maintains a currency union with Belgium but exhibits a different rate of inflation. The difference is insignificant in this analysis because the convergence rate during the ERM period is compared with that of the previous group, and both rates are found to be essentially equal. The increase in the convergence rate between the two periods is 11.01%. This confirms robustness of the main result, and also justifies elimination of Luxembourg from further analysis.[8]

We form a narrow ERM group consisting of the founding countries by adding Italy to the Core ERM group. It is interesting to see that interperiod convergence rate increased in case of this group by merely 3.69%. Such a result does not come as a surprise. The Italian lira enjoyed wider fluctuation bands within the ERM and is historically a currency of higher inflation. Its exclusion from the Core group proved to be well justified. Alternatively, this could be taken to prove that ERM membership does not guarantee convergence.

Spain and Portugal were added to the narrow ERM to form the broad ERM because both are currently members and have tried to lower their national inflation rates before officially joining the ERM. They did not succeed in this task, and the result is as we suspected. The broad ERM exhibits the lowest convergence rate at all. This is not surprising because this group contains very diversified mix of countries with quite different monetary histories regarding their affiliation with the ERM. Unfortunately the interperiod change in convergence rate cannot be calculated because of statistical insignificance of the convergence coefficient during the pre-ERM period.

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[7] This statement should be understood together with the fact that strongest motivation of why the ERM was established was to limit exchange rate fluctuations within the Core countries. Members that joined the mechanism later could, however, pursue additional reason to converge on low inflation.

An interesting result is obtained from analysis conducted on a reduced Core group, referred to as the Snake. The Snake is a group of four countries that formed an exchange rate arrangement preceding the ERM.[9] The creation of the ERM did not bring these countries an institution of exchange rate peg. The exchange rates of the Snake were already fixed throughout the pre-ERM period. Thus, the ERM arrangement of fixed exchange rates should not matter. Interperiod comparison shows that, indeed, the Snake exhibits an decrease of 6.6% in its convergence rate.

As a control group we use three panels of OECD countries that were not members of the EU. Panel containing Austria, Sweden, Finland, Switzerland, Norway, Iceland, United States, Canada, Japan, Australia, New Zealand, and Turkey was analyzed as a whole as well as divided into European and non-European OECD countries. Convergence coefficients for the pre-ERM period are insignificant without exception. In the ERM period the broad panel is insignificant as well. European countries show convergence at the rate that is comparable with the previously presented group of non-ERM countries. That means too low in comparison with the ERM countries. Non-European countries even show divergence of their differentials at the rate of almost 10%. The results support an active role of the ERM.

In order to test robustness of the analysis, several additional groups were constructed out of the Core countries in a systematic way. The ERM Core of six countries was reduced by one country at a time so that six combinations of five Core countries emerged. Tables 2 and 3 present results of the test for pre-ERM and ERM periods to

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[8]Similar comparisons were made also on other pairs of groups differing solely by exclusion of Luxembourg. The convergence rates were reassuringly found to be essentially equal.

answer the question of whether a particular country has some special influence on the inflation convergence of a certain group.

The convergence coefficients are significant at 5% level for the pre-ERM period and at the 1% level for the ERM period. When the two periods are compared, all groups show a similar sharp increase in convergence rates. The only exception is the convergence rate of the Core without Germany, which exhibits decrease from 45% to 31% over the two periods. Generally, it can be said that eliminating one country out of the group does not radically affect the group's convergence path. In other words, exclusion of a particular country does not affect the robustness of the analysis.

Two more sets of panels were constructed and tested in order to examine whether inflation convergence within a certain group was affected by specific events. Such events are the September, 1992, and the August, 1993, crises of the ERM. The original ERM period was truncated accordingly. The first period begins in 1979:2 and ends in 1992:2. The second period begins in 1979:2 and ends in 1993:2. The results are presented in Tables 4 and 5. Convergence coefficients are significant at 1% level in all cases. The narrow ERM and the Core groups reveal, through the magnitudes of the convergence rates, that the convergence process was not substantially affected by any of the two major ERM crises. The systematic part reveals that the convergence rates are not substantially affected by dropping one country from the Core panel and that the results remain robust. The Core countries followed very similar convergence paths no matter whether or not the crisis are excluded.

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[9]The Snake consisted of Germany, the Netherlands, Belgium, and Denmark; it also included France on several occasions. These countries fixed in 1973 their exchange rates with each other while jointly floating

4. Conclusion

This paper examines whether there exists convincing evidence of inflation convergence within the ERM and whether the ERM helped to accelerate the convergence. A methodology originally developed to investigate cross-country output convergence was applied to investigate inflation convergence within the European Union. The analysis is conducted on logically as well as systematically differentiated groups of countries pooled together over two basic time periods. These periods cover time span from the late 1950's to mid 1990's with 1979 (inception of the ERM) as a midpoint.

A group of countries that never participated in the ERM serves as a benchmark case. Results of the test conducted on this group are compared with those of the Core ERM countries that founded the ERM and never deviated from it. The findings allow us to formulate the main result of this paper. There exist inflation convergence among countries within Europe. It is also evident that the countries which continuously participated in the narrow ERM bands show a dramatically higher convergence rate during the ERM period than those staying outside the mechanism.

The main result is exposed to a sensitivity analysis. Convergence tests on modified groups of the ERM countries show robustness of the analysis and justifies the composition of the Core group. Systematic modification of the Core group itself is evidence of robustness as well. Eliminating one country from the group does not seriously affect the magnitude of the convergence rate and the converging path in neither the pre-ERM nor ERM periods. The influence of the ERM crises is also investigated.

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against other countries.

Magnitudes of rates show that the convergence process was not substantially affected by the ERM crises in 1992 and 1993.

Table 1
Groups of Countries in Each Panel Data Set

Group	No.	Countries
		Logical Grouping:
Broad ERM	9	Germany, the Netherlands, Belgium, Denmark, Ireland, France, Italy, Spain, Portugal
Narrow ERM	7	Germany, the Netherlands, Belgium, Denmark, Ireland, France, Italy
Core	7	Germany, the Netherlands, Belgium, Denmark, Ireland, France, Luxembourg
Core w/o Luxembourg	6	Germany, the Netherlands, Belgium, Denmark, Ireland, France
Snake	4	Germany, the Netherlands, Belgium, Denmark
Non-ERM	8	United Kingdom, Greece, Austria, Sweden, Finland, Switzerland, Norway, Iceland
non-EU	12	Austria, Sweden, Finland, Switzerland, Norway, Iceland, United States, Canada, Japan, Australia, New Zealand, Turkey
non-EU, Europe	6	Austria, Sweden, Finland, Switzerland, Norway, Iceland
non-EU, non-Europe	6	United States, Canada, Japan, Australia, New Zealand, Turkey
Core without:		**Systematic Grouping:**
Belgium	5	Germany, the Netherlands, Denmark, Ireland, France
Germany	5	the Netherlands, Belgium, Denmark, Ireland, France
Denmark	5	Germany, the Netherlands, Belgium, Ireland, France
France	5	Germany, the Netherlands, Belgium, Denmark, Ireland
Ireland	5	Germany, the Netherlands, Belgium, Denmark, France
Netherlands	5	Germany, Belgium, Denmark, Ireland, France

No. denotes number of countries in a particular group

Table 2
Logical and Systematic Grouping
Period 1959:2 - 1979:1

Group	No.	ϕ	t-stat(ϕ)	k	r (%)	Critical Values 1%	5%	10%
Broad ERM	9	0.94231	-0.79	13	5.94	-2.75	-2.01	-1.61
Narrow ERM	7	0.82170	-2.57**	10	19.63	-2.69	-1.97	-1.56
Core	7	0.80000	-2.53**	11	22.31	-2.71	-1.98	-1.54
Core w/o Luxembourg	6	0.79320	-2.43**	11	23.17	-2.70	-1.97	-1.53
Snake	4	0.74812	-2.15**	11	29.02	-2.75	-2.05	-1.64
Non-ERM	8	0.93067	-1.35	11	7.18	-2.78	-2.03	-1.63
non-EU	12	0.96438	-0.82	11	3.63	-2.74	-2.08	-1.69
non-EU, Europe	6	0.95828	-0.78	11	4.26	-2.74	-2.02	-1.62
non-EU, non-Europe	6	0.97190	-0.30	14	2.85	-2.75	-1.98	-1.60
Core without:								
Belgium	5	0.76645	-2.61**	10	26.60	-2.67	-1.98	-1.58
Germany	5	0.63781	-3.32***	10	44.97	-2.69	-1.99	-1.58
Denmark	5	0.85517	-2.04**	7	15.65	-2.74	-1.97	-1.58
France	5	0.78493	-2.44**	10	24.22	-2.69	-1.98	-1.59
Ireland	5	0.74606	-2.42**	11	29.29	-2.72	-2.00	-1.63
Netherlands	5	0.81110	-2.14**	11	20.94	-2.71	-2.01	-1.60

No. means number of countries in a particular group, k denotes number of lags, r denotes a rate of convergence in %. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively

Table 3
Logical and Systematic Grouping
Period 1979:2 - 1994:4

Group	No.	ϕ	t-stat(ϕ)	k	r (%)	Critical Values 1%	5%	10%
Broad ERM	9	0.90546	-3.53***	14	9.93	-2.84	-2.15	-1.72
Narrow ERM	7	0.79196	-5.30***	13	23.32	-2.76	-2.03	-1.64
Core	7	0.70098	-5.65***	13	35.53	-2.79	-2.06	-1.65
Core w/o Luxembourg	6	0.71047	-5.43***	13	34.18	-2.84	-2.05	-1.64
Snake	4	0.79908	-3.00***	10	22.42	-2.85	-2.06	-1.63
Non-ERM	8	0.89146	-3.94***	13	11.49	-2.83	-2.13	-1.75
non-EU	12	1.01594[D]	-0.73	14	1.58	-2.86	-2.10	-1.68
non-EU, Europe	6	0.87701	-4.02***	13	13.12	-2.82	-2.03	-1.63
non-EU, non-Europe	6	1.10338[D]	-3.45***	14	9.84	-2.82	-2.04	-1.63
Core without:								
Belgium	5	0.69853	-5.20***	13	35.88	-2.94	-2.12	-1.71
Germany	5	0.73191	-5.19***	8	31.21	-2.91	-2.12	-1.72
Denmark	5	0.73198	-5.21***	13	31.20	-2.83	-2.09	-1.69
France	5	0.70300	-5.14***	13	35.24	-2.82	-2.08	-1.67
Ireland	5	0.78863	-3.87***	10	23.75	-2.78	-2.07	-1.67
Netherlands	5	0.66162	-5.28***	13	41.31	-2.97	-2.13	-1.71

No. means number of countries in a particular group, k denotes number of lags, r denotes a rate of convergence in %. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. [D] denotes divergence.

Table 4
Systematic Grouping
Period 1979:2 - 1992:2

Group	No.	ϕ	t-stat(ϕ)	k	r (%)	Critical Values 1%	5%	10%
Narrow ERM	7	0.79545	-4.66***	13	22.88	-2.98	-2.17	-1.73
Core	6	0.76665	-4.85***	8	26.57	-3.02	-2.18	-1.76
Core without:								
Belgium	5	0.77640	-4.34***	8	25.31	-3.00	-2.16	-1.72
Germany	5	0.73439	-4.73***	8	30.87	-3.33	-2.30	-1.83
Denmark	5	0.73408	-4.66***	13	30.91	-3.10	-2.20	-1.77
France	5	0.76626	-4.54***	8	26.62	-3.08	-2.18	-1.69
Ireland	5	0.79625	-3.39***	10	22.78	-3.09	-2.14	-1.70
Netherlands	5	0.61215	-6.62***	10	49.08	-3.11	-2.24	-1.75

No. means number of countries in a particular group, k denotes number of lags, r denotes a rate of convergence in %.
***, **, and * denote significance at 1%, 5%, and 10% levels, respectively

Table 5
Systematic Grouping
Period 1979:2 - 1993:2

Group	No.	ϕ	t-stat(ϕ)	k	r (%)	Critical Values 1%	5%	10%
Narrow ERM	7	0.80527	-4.65***	13	21.66	-2.88	-2.13	-1.74
Core	6	0.72684	-4.78***	13	31.90	-2.98	-2.20	-1.77
Core without:								
Belgium	5	0.71491	-4.55***	13	33.56	-3.23	-2.26	-1.82
Germany	5	0.73446	-4.87***	8	30.86	-3.12	-2.26	-1.85
Denmark	5	0.75596	-4.44***	13	27.98	-3.06	-2.24	-1.83
France	5	0.72306	-4.48***	13	32.43	-2.94	-2.16	-1.74
Ireland	5	0.80237	-3.42***	10	22.02	-2.96	-2.16	-1.75
Netherlands	5	0.68443	-4.59***	13	37.92	-3.12	-2.26	-1.82

No. means number of countries in a particular group, k denotes number of lags, r denotes a rate of convergence in %.
***, **, and * denote significance at 1%, 5%, and 10% levels, respectively

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