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**Article**

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# Is there financial integration in the equity markets of the European Union?

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Both casual observation and empirical research suggest that developed equity markets around the world, including the major European markets, are now highly integrated. Financial integration is a key goal of the European Union (EU) and was one motive for the adoption of the euro. In this article, we examine how far the process of financial integration has gone in the equity markets of the EU. We use an econometric methodology that permits us to measure the equity market convergence while allowing for a range of possible time paths, and for heterogeneity across countries. Our tests reject the hypothesis of overall convergence in the European equity markets. We do, however, find evidence of convergence within three distinct and economically meaningful subgroups of European markets. We find no evidence that the Euro has hastened equity market convergence amongst its members, above and beyond the broader global trends of lowered institutional and legal barriers and market liberalization.

## I. Introduction

Financial integration is a key goal of the Single Market Programme within the European Union (EU), where it is expected to aid allocative efficiency and the efficacy of monetary and fiscal policy,<sup>1</sup> allowing sovereign debt to be financed at a minimum cost and assisting the even transmission of monetary policy across the Euro area. Baele *et al.* (2004) measure the state of financial integration in the Euro area, for five classes of asset: money, government bonds, corporate bonds, credit and equity. Their measures are based on the idea that full integration is achieved when all participants in financial markets face the same rules and have equal access to the services provided by financial intermediation. Operationally, this means that the return or yield on equivalent assets in different countries should be driven by common factors, and be relatively immune to local shocks. International stock markets sharing a common trend will be perfectly correlated over long horizons, thus implying that there are no gains to be made from international portfolio diversification (von Furstenberg and Jeon, 1989). Full-stock market integration would imply that risk-adjusted stock returns denominated in a common

currency are equal in all countries. Consequently, economic interdependence among a group of countries may emerge as an additional explanatory factor: common stochastic trends in stock markets of those countries potentially mirror their economic fundamentals that are related significantly with one another. Kasa (1992) provided one of the first studies – using cointegration methods – that examined whether there are long-run benefits from international equity diversification. The results indicated the presence of a single-common trend driving stock markets in a number of major economies.<sup>2</sup>

Equity markets provide a demanding setting for testing financial integration. Unlike, say, gilts and a short-term money, equities are securities written on complex real assets and the fundamentals of the real economy – growth rates, labour costs, competitiveness and institutional setting including taxation – may also display different degrees of secular convergence and will reflect different sectoral compositions. Observationally, a confounding factor is that some equity markets are dominated, in value terms, by foreign companies to which they have given a listing (for example, London and Amsterdam), and in all markets some firms are multinational, embodying the performance of overseas real assets.

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<sup>1</sup> The major institutional driving force for financial integration is the Financial Services Action Plan drawn up as part of the Lisbon Agreement in 2000.

<sup>2</sup> Moreover, Corhay *et al.* (1993) found a common stochastic trend among five major European stock markets over the period 1975 to 1991. Rangvid (2001) identified an increasing number of cointegrating relationships between European stock markets in the last three decades and concluded that these markets have experienced a process of convergence.

While the adoption of a common currency may aid financial integration by eliminating currency risk, the removal of institutional and legal barriers, the liberalization of global financial markets and increasing levels of cross-border merger and acquisition activity are also likely to increase financial integration. The literature<sup>3</sup> suggests that developed equity markets worldwide, including the major European markets, are now highly integrated. But the evidence of financial integration in some of the smaller European equity markets is more mixed. Here, idiosyncratic factors still play a significant role for stock prices. Worthington *et al.* (2003) find that the ‘Euro-11’ equity markets – the euro markets excluding Greece – are highly integrated, but find that the process of long-term integration is unaffected by the actual transition to the euro, and is indicative of the decade-long process of economic convergence following from the 1992 Maastricht Treaty. Furthermore, they find that the level of financial integration within non-euro participating Member States and non-EU members has also increased over this period, especially for the period after the introduction of the single currency.

In this article, we re-examine the convergence in equity markets in the EU using a much more powerful econometric methodology than hitherto that captures convergence while allowing for a wide range of possible time paths, and for heterogeneity across countries. The model from Phillips and Sul (2007) has both common and individual specific components, and is formulated as a nonlinear time-varying factor model. The time-varying formulation is particularly suitable for our analysis as the integration process proceeds at different speeds and to different extents in different countries.

Our tests reject the hypothesis of overall convergence in the equity markets we considered. These results are perhaps not surprising in the context of the whole of the EU, in which a number of members have only been in the EU from a comparatively short space of time. However, we find a lack of overall convergence even when the analysis is restricted to the countries in the Euro area.

Arguably, global convergence reflects too narrow a definition of integration. It requires that, normalized for an initial period, equity markets will converge to the same stochastic process asymptotically. In the language of the cointegration literature, this requires not only the presence of a single common factor, or  $N - 1$  cointegrating relations (asymptotically), but also that these cointegrating relations are of the form  $(1, -1)$ . Therefore, we also test the weaker requirement that there is convergence in clusters. Empirically, there are three distinct clusters among the members of the EU: (1) those stock markets that outperform the EU average, which are predominantly the new markets; (2) those equity markets that are concentrated around the average for the European economy as a whole; (3) mature markets (mostly Economic and Monetary Union; EMU). The fastest growing economies also have the fastest growing equity markets, and the slowest growing economies the slowest growth in equity markets. This is consistent with Lence and Falk (2005), who show using a simple dynamic general equilibrium asset pricing model, that the process of financial integration depends on fundamental similarities in technology, preferences and endowments among countries.<sup>4</sup> In order to control for the effect of different market compositions (Heston and Rouwenhorst, 1994; Dutt and Mihov, 2008), we also

report the results for more disaggregated indices at the sectoral level. These results confirm what we find for the aggregate equity markets.

The article is organized as follows. Section 2 describes the methodology used in the article and relates it to the analysis of cointegration. Section 3 details the data used in the analysis. Section 4 presents the empirical results and relates them to the existing literature on financial market integration. Section 5 concludes. The appendix considers the relationship between market efficiency, financial integration and cointegration.

## II. Econometric Framework

Models with a time-varying factor structure have been popular for some time in finance. Most of the empirical literature focuses on the return and a standard exercise is to decompose the return into its aggregate and idiosyncratic component. Our interest, however, is in long-run convergence, so we analyse the level rather than the change in stock prices. Stock prices as returns have a standard common factor representation, the main difference lies in the fact that here at least one of the fundamentals is a common trend driving the long-run component of stock prices. For instance, Menzly *et al.* (2002) develop a general equilibrium model where asset prices are given by a linear function of a stochastic trend in dividends plus a second term that reflects deviations from this trend. Cointegration and common stochastic trends in international stock markets imply that the long-run paths of stock market prices in these markets are driven by some shared economic growth factors underlying earnings and dividends (Crowder and Wohar, 1998). Essentially, there are fewer assets available to investors than a simple count of the number of markets would suggest, and therefore implying a more limited role for long-run gains from diversification (Hassan and Naka, 1996; Chen *et al.*, 2002).

Specifically, consider the  $N$ -dimension panel of stock prices  $X_t$ , the  $i$ th element,  $X_{it}$ , has a standard factor representation

$$X_{it} = \lambda'_{it} \mathbf{f}_t + u_{it} \quad (1)$$

where  $\mathbf{f}_t$  is a  $k$ -dimensional vector of common factors at time  $t$ ,  $\lambda_{it}$  is the vector of corresponding loadings, which are allowed to be time varying,<sup>5</sup> and  $u_{it}$  is a stationary idiosyncratic component.

Estimating Equation (1) directly is impossible without imposing some restrictions on Equation (1) since the number of unknowns in the model exceeds the number of observations. This is why it has often been found convenient to assume that the time-varying loading coefficients are constant over short-time periods. Nevertheless, Phillips and Sul (2007) note that a possible pattern of convergence of  $X_{it}$  can be easily analysed without the need to directly estimate Equation (1). Specifically, they suggest a different specification of Equation (1) allowing for time variation in the factor loadings as follows:

$$\begin{aligned} X_{it} &= \delta_{it} \mu_t \\ &= \left( \sum_{j=1}^k \lambda_{it}^j \frac{f_{jt}}{\mu_t} + \frac{\mu_{it}}{\mu_t} \right) \mu_t \end{aligned} \quad (2)$$

<sup>3</sup> See, for example, Chow and Abbott (1993), Darbar and Deb (1997), Francis and Leachman (1998), Hardouvelis *et al.* (2006), Meric and Meric (1997), Serletis and King (1997), Malliaris and Urrutia (1996) and Geersing *et al.* (2008).

<sup>4</sup> They also argue that there need not be a connection between financial integration, where similar assets in different countries display the same risk-adjusted expected returns, market efficiency, where asset prices fully reflect all information and cointegration. They argue that in a dynamic general equilibrium asset pricing model, the relationship between these three concepts depends on fundamental similarities in technology, preferences and endowments.

<sup>5</sup> Menzly *et al.* (2002) derive a similar structure from a DSGE model, where the loadings on the stochastic trend and actual dividends vary with the business cycle, increasing during peaks and decreasing during troughs.

where the common factors are replaced by a unique factor  $\mu_t$  and the loadings  $\delta_{it}$  have a random component, which absorbs  $u_{it}$ . If the common factor  $\mu_t$  also captures the stochastic common trend in the data, the time dependence of the loadings  $\delta_{it}$  depends only on the original loadings  $\lambda_{it}$ . It is not necessary to assume that there is a dominant common factor for this representation to hold. Global convergence occurs if  $\lambda_{it}^j \rightarrow \lambda^j \forall i, j$  as  $t \rightarrow \infty$ . Then, in this case,  $\delta_{it} \rightarrow \delta \forall i$  as  $t \rightarrow \infty$ . Moreover, if this condition holds for certain subgroups, then the  $X_{it}$  diverges overall, but the panel may be decomposed into specific convergent clusters.

### Relation to the cointegration literature

Much of the previous literature looking at long-run convergence in stock markets regards cointegration as evidence of convergence. In this section, we review the relation between the cointegration hypothesis and the Phillips and Sul test of relative convergence and we highlight the difference between relative and absolute convergence.

Equity markets will exhibit relative convergence if  $X_{it}/X_{jt} \rightarrow 1$ , this definition is accomplished if  $\delta_{it} \rightarrow \delta \forall i$  as  $t \rightarrow \infty$ . Relative convergence implies that in the long run, equity markets share a common trend which can be stochastic or deterministic. If the common trend  $\lambda_{it}'\mathbf{f}_t$  is a stochastic trend, then the indices for any pair of countries  $i$  and  $j$  are cointegrated in the long run with a cointegrating vector  $(1, -1)$ . This convergence concept does not require that  $\delta_{it} = \delta_{jt}$  in any finite sample, but only  $\delta_{it} \rightarrow \delta \forall i$  asymptotically. Notice that absolute convergence, defined as  $X_{it} - X_{jt} \rightarrow 0$ , also requires that the speed of divergence of  $\mu_t$  is slower than the speed of convergence of  $\delta_{it}$ .

On the other hand, if  $X_{it}$  and  $X_{jt}$  are cointegrated, then the ratio  $X_{it}/X_{jt}$  typically converges to a constant or a random variable, the former occurring when the series have a nonzero deterministic drift. In this sense, the definition of relative convergence places an additional restriction on the (asymptotic) cointegrating vector. However, the clustering procedure based on the relative convergence measure allows us to disentangle asymptotic cointegration in situations where the cointegration test has low power. Suppose that there are two groups  $\delta_{it} \rightarrow \delta_a \forall i \in G_a$  and  $\delta_{it} \rightarrow \delta_b \forall i \in G_b$ . Then, any pair of equity indices in each of the two subgroups is asymptotically cointegrated with cointegrating vector  $(1; -1)$ . Whereas, any pair of equity indices in opposite groups are asymptotically cointegrated with the cointegrating vector  $(1; -\delta_a/\delta_b)$ .

### Phillips and Sul (2007)

Phillips and Sul (2007) suggest a modelling approach based on the following relative measure:

$$h_{it} = \frac{X_{it}}{N_t^{-1} \sum_{i=1}^{N_t} X_{it}} = \frac{\delta_{it}}{N_t^{-1} \sum_{i=1}^{N_t} \delta_{it}} \quad (3)$$

which eliminates the common growth component by scaling and measures the transition element  $\delta_{it}$  for unit  $i$  relative to the cross-section average. Here, we consider the case of an unbalanced panel, where the number of cross sections,  $N_t$ , varies over time. Over time, the variable  $h_{it}$  traces out an individual trajectory for each  $i$  relative to the average, so we call this the ‘transition path’. At the same time,  $h_{it}$  measures unit  $i$ ’s relative departure from the common steady-state growth path  $\mu_t$ . Thus, any divergences from  $\mu_t$  are reflected in the transition paths  $h_{it}$ .

They model the time-varying factor loadings  $\delta_{it}$  in a semi-parametric form – implying nonstationary transitional behaviour – in the following way:

$$\delta_{it} = \delta_i + \sigma_{it}\xi_{it}, \quad \sigma_{it} = \frac{\sigma_i}{L_i(t)t^{\alpha_i}}, \quad t \geq 1, \sigma_i > 0 \text{ for all } i \quad (4)$$

where  $\delta_i$  is fixed,  $\xi_{it}$  is  $iid(0, 1)$  across  $i$  and weakly dependent over  $t$ , and  $L_i(t)$  is a slowly varying function, for example,  $L_i(t) = \log^{\beta_i} t$ , so that  $L_i(t) \rightarrow \infty$  for all  $i$ , as  $t \rightarrow \infty$ . Obviously, for all idiosyncratic decay rates  $\alpha_i \geq 0$ , the loadings  $\delta_{it}$  converge to  $\delta_i$ , allowing us to carry out a hypothesis test for convergence or divergence of the observed panel of time series  $X_{it}$ . Notice that this formulation allows for general flexibility in modelling the idiosyncratic transitional path, so it encompasses most cases of practical interest – the most important extension being to allow for individual rate effects  $\alpha_i$ . One role for the slowly varying component  $L_i(t)$  in Equation (4) is to ensure that convergence holds even when  $\alpha_i = 0$  for some  $i$ , although possibly at a very slow rate. This formulation accommodates some interesting empirical possibilities where there is slow transition and slow convergence.

When there is common (limiting) transition behaviour across units, we have  $h_{it} = h_t$  across  $i$ ; and when there is ultimate convergence in the growth pattern of stock indices, we have

$$h_{it} \rightarrow 1, \text{ for all } i, \text{ as } t \rightarrow \infty$$

In this case, in the long run, the cross-sectional variance of  $h_{it}$  converges to zero, so that we have

$$\lim_{t \rightarrow \infty} H_t = \lim_{t \rightarrow \infty} \left[ N_t^{-1} \sum_{i=1}^{N_t} (h_{it} - 1)^2 \right] = 0$$

where  $H_t$  provides a quadratic distance measure for the panel from the common limit. This is the property used to test the null hypothesis of convergence (and to group economies into convergence clusters). We discuss how to test for global convergence and classify clusters of convergent subgroups in the next section.

### Global convergence

Phillips and Sul (2007) propose a simple regression-based procedure to test the null of convergence in the nonlinear factor model (1). The null hypothesis of convergence may be written as

$$H_0 : \delta_i = \delta \quad \& \quad \alpha_i \geq 0 \quad \forall i$$

The test involves the weak inequality  $\alpha_i \geq 0$  and has power against divergence in terms of different  $\delta_i$  as well as divergence if  $\alpha_i = 0$ . Indeed, the alternative hypothesis is given by

$$H_A : \left\{ \begin{array}{l} \delta_i = \delta \quad \forall i \text{ with } \alpha_i < 0 \text{ for some } i \\ \delta_i \neq \delta \text{ for some } i \text{ with } \alpha_i \geq 0 \text{ or } \alpha_i < 0 \end{array} \right\}$$

The alternative hypothesis not only includes straightforward divergence but more importantly also includes the possibility of club convergence. The null implies that the cross-sectional variance of  $h_{it}$  converges to zero. They show that the null can be tested using a one-sided  $t$ -test on the coefficient  $b, t_b$ , in following regression<sup>6</sup>

$$\log \left( \frac{H_1}{H_t} \right) - 2 \log L(t) = a + b \log(t) + e_t$$

$$\text{for } t = [rT], [rT] + 1, \dots, T$$

<sup>6</sup> Notice that here we consider the case where heterogeneity in the transitional path is given by the decaying rate  $\alpha_i$ , this is, the most interesting case for empirical applications. The function  $L(t) = \log(t)$  is to be preferred in terms of asymptotic power, as argued by Phillips and Sul (2007).

with  $r > 0$ , where the  $t$ -test makes use of a HAC consistent standard error. Furthermore, they shows that  $b = 2\alpha$ , where  $\alpha$  is the lower bound of the support rate of the decay rates  $a_i$ . Notice that the regression starts at  $[rT]$ , the integer part of  $rT$  for some fraction  $r > 0$  (Phillips and Sul recommend that the fraction be set to  $r = 0.3$ ).

## Club convergence

This is a test for the global convergence of a series, but the regression test has power against cases of club convergence, so we can expect that the null hypothesis of convergence will be rejected for data in which there is evidence of club convergence. However, the log  $t$ -test can also be used as a test for cluster convergence when the cluster are exogenously chosen. In the application with equity markets, possible clusters arise from the introduction of the Euro. Equally, within a country, there might be clustering across sectors, or there may be – across countries – clustering in particular sectors. Possible subclusters among the broad categories just outlined are also allowed. The next section describes how a clustering mechanism test procedure can be employed which relies on the following stepwise and cross-section recursive application of log  $t$  regression tests.

A detailed analysis of the clustering procedure is given in Phillips and Sul (2007). The steps needed to implement the procedure are as follows.

- Step 1 (Cross-section ordering by final observation):* Order the members in the panel according to values in the last period.<sup>7</sup>
- Step 2 (Form a core primary group of  $r^*$  countries):* Selecting the first  $r$  highest members in the panel to form the subgroup  $G_r$  for some  $N > r \geq 2$ , run the log  $t$  regression and calculate the convergence test statistic  $t_r = t_b(G_r)$  for this subgroup. Then, the core group size  $r$  is chosen by maximizing  $t_b(G_r)$  over  $r$  under the condition that the  $\min\{t_b(G_r)\} > -1.65$ . If the condition  $\min\{t_b(G_r)\} > -1.65$  does not hold for  $r = 2$ , then the first unit is dropped and the same procedure is performed for remaining units. There is no convergence clusters in the panel if the same condition does not hold for every subsequent pair of units. Otherwise, a core group can be detected.
- Step 3 (Sieve the data for new club members):* Once a core convergence group is identified separately, evaluate additional individuals for membership of this group, that is, run  $t_b$  adding one index at a time to the original core group. If the corresponding test statistic  $t_b$  exceeds some chosen critical value  $\zeta$ , then the unit is included in the current subgroup.<sup>8</sup> After forming the subgroup, the log  $t$  test is run for the whole subgroup. If  $t_b(G_r) > -1.65$ , the forming of the subgroup is complete, otherwise the critical value  $\zeta$  is raised and the procedure is repeated.
- Step 4 (Stopping rule):* Once the first cluster has been detected,  $t_b$  is applied to the complementary set, that is, all remaining units

are jointly tested for convergence. If this group satisfies the convergence test, then we conclude that there are only two clusters. Otherwise, we repeat Steps 1–3 for remaining units. If no other subgroups are detected, the remaining indices do not contain a convergence subgroup and so they are classified as divergent.

## III. Data Description

We analyse the convergence pattern of stock market indices for the 26 countries<sup>9</sup> in the EU, since 1985.<sup>10</sup> The data set is composed of monthly stock price indices, including the aggregate stock prices and the sector-specific stock prices for each country.<sup>11</sup> All stock indices are denominated in euros, this is to offset possible divergence due to divergence in the bilateral exchange rate between countries. The US stock indices are also included as a control for global factors in the data set.

The indices are standardized to zero for a series-specific base year. Therefore, the first issue in the construction of the data set is to transform series to a common base year. The issue is complicated by the fact that the series have different starting times and the data set is a highly unbalanced panel. Furthermore, the base year has to be chosen at the beginning of the sample so as to avoid the problem that the convergence pattern is influenced by the standardization. We choose as the base date January 1981, and then discarded the first 8 years of observations to get rid of the base year initialization. Specifically, we fill in the data set as suggested by Stock and Watson (2002, Appendix A) with an EM algorithm that make use of the factor structure of the data set. This imputation strategy requires that the missing data can be considered as Missing At Random (MRA).<sup>12</sup> This condition is hardly satisfied in our case. However, we use this imputation of the missing data only for the reconstruction of the base year, and the empirical analysis uses only the actual data. In this sense, we believe that the computed base year for the standardization should not affect the empirical analysis.

This procedure requires us to choose the number of factors to be used in the factor models. Altering the number of factors does not have strong implications for the test of relative convergence, though it might have some effect when testing for the formation of different clusters. In the empirical exercise, we follow an agnostic procedure. We update the data set with the number of factors varying between 1 and 6, and then we average among the different results. This approach should be robust to the possible misspecification in the number of factors. Phillips and Sul (2007) observe that the small sample property of the convergence test and clustering procedure is greatly enhanced when the data are filtered and the procedure is applied to the trend, accordingly we use the HP filter<sup>13</sup> to extract the trend component of the series.

The aggregate equity market indices are shown in Fig. 1. Clearly, there are two distinct outliers: Slovakia, which is well below, and Bulgaria, which is well above. Table 1 lists the average cross-sectional correlation for the European markets for three sub-periods.

<sup>7</sup> In cases in which there is considerable volatility in the observations, Phillips and Sul (2007) recommend the use of the average over a window in the later part of the sample.

<sup>8</sup> The evidence from the Monte Carlo experiments in Phillips and Sul (2007) suggests the use of 50% critical values (i.e. sign test). In the empirical application, we choose a conservative position with  $\zeta = 0.3$ .

<sup>9</sup> Estonia is excluded from the analysis given the limited data availability.

<sup>10</sup> The construction of these indices ignores recent trends towards the merging of stock markets. In 2000, Euronext arose out of the merger of the stock exchanges of Amsterdam, Brussels and Paris. In 2001, the Portuguese exchanges joined Euronext.

<sup>11</sup> An additional appendix with data details, coverage and mnemonics is available from the authors upon request.

<sup>12</sup> See Rubin (1976) for some discussion of this implication of the MRA condition.

<sup>13</sup> The smoothing parameter is set to 14 400, the standard value with monthly series.

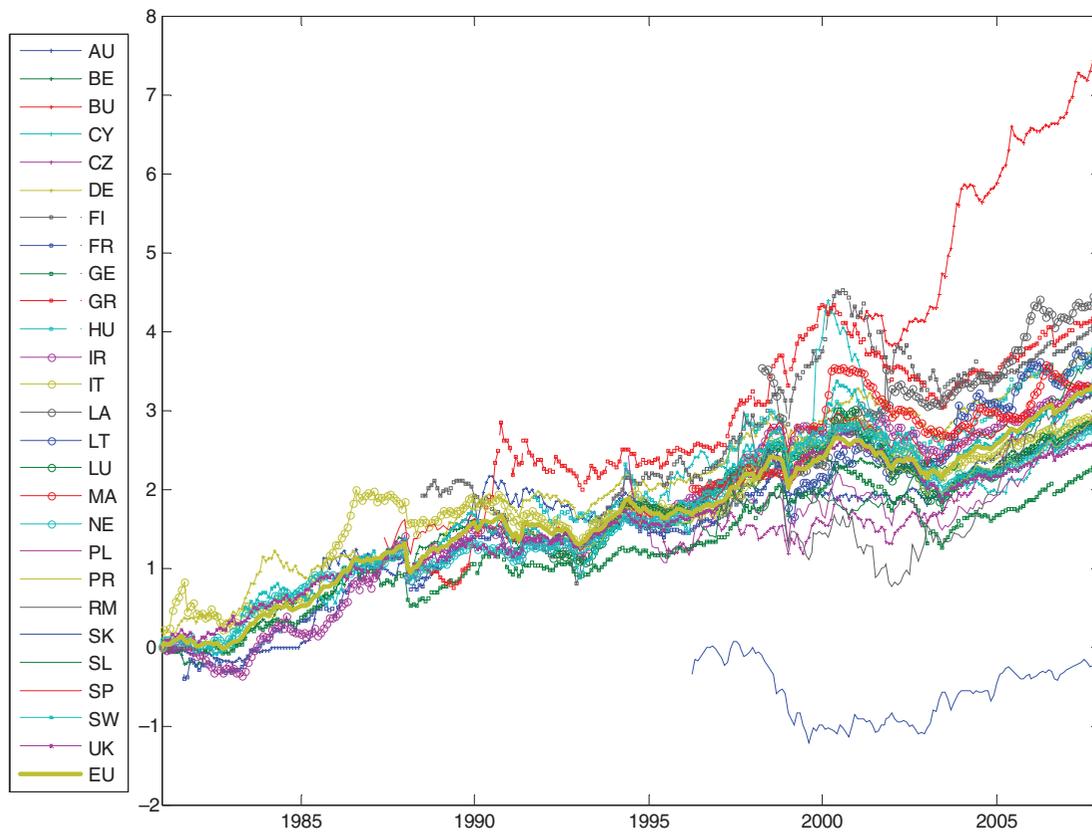


Fig. 1. Total market index EU

Table 1. Average cross-sectional correlations

	1981–1991	1992–1998	1999–2007
Level	0.623	0.725	0.590
Return	0.345	0.428	0.412

Partly because of the steady addition of new members, there is no obvious pattern of convergence in either levels or returns. Table 2(a) and (b) report the average cross-sectional correlation of each country with the EU as a whole in both levels and returns for the three sub-periods. For both levels and returns, the majority of countries that were members in the first period (1981 to 1991) had increased their correlations by the second period (1992 to 1998), but this did not in general continue into the last period (1999 to 2007). For returns, all countries that joined in the second period had also increased their correlation by the third period (Cyprus started with a negative correlation in returns), but this was not the case in levels, with some countries increasing correlations and some experiencing a decline.

#### IV. Results

##### Relative convergence tests

In this section, we apply the convergence analysis introduced by Phillips and Sul (2007) to the stock market price indices in the EU. Possible changes in convergence patterns due to the adoption of the

single currency for countries in the euro area are investigated by splitting the sample for these countries into a pre-euro period and a post-euro period. If the euro has fostered convergence among equity markets of the euro zone, this would in principle imply a stronger convergence pattern, and should result in lower values for the  $t_b$  statistic and in a higher value for  $\alpha$ , the lower bound of the support of the decay parameter. The Monte Carlo experiments in Phillips and Sul (2007) suggest that the properties of the test should be preserved in small samples, so we can analyse the two subsamples separately.

Table 3 summarizes the results when the tests are applied to all EU countries using both the aggregate stock market index and the sectoral indices. We analyse sectoral indices since the different compositions of the aggregate market might prevent aggregate stock market indices converging (see also Heston and Rouwenhorst, 1994; Dutt and Mihov, 2008). The only market for which there are signs of stable convergence are ‘metal, iron and steel’ and ‘industrials’. These sectors operate in markets that are increasingly international (partly by cross-border merger and acquisition) and country-specific factors have become less important.

Furthermore, the tests indicate that a reduction in the dispersion of stock market indices can be observed in many markets when the analysis is confined to the last decade. This suggests that globalization is playing an increasing role as one of the main drivers of real and financial integration between markets. Fig. 2(a) shows the cross-sectional covariance of the converging markets, whereas Fig. 2(b) shows the same measure for non converging markets.<sup>14</sup>

<sup>14</sup> The panel in the analysis is unbalanced, and when new countries enter the analysis, they might be very far from the average of the countries already present in the analysis, causing an increase (jump) in the cross-sectional variance which might seriously reduce the power of the test. This seems to be the case for the ‘pharmaceutical and bio’ sector.

**Table 2. Average cross-sectional correlations: (a) returns and (b) level**

	1981–1991	1992–1998	1999–2007
(a)			
AU	0.248	0.479	0.438
BE	0.379	0.531	0.464
BU	–	–	0.071
CY	–	–0.167	0.193
CZ	–	0.345	0.428
DE	0.228	0.522	0.526
FI	0.123	0.434	0.433
FR	0.384	0.544	0.585
GE	0.431	0.493	0.579
GR	0.094	0.414	0.436
HU	–	0.378	0.514
IR	0.451	0.480	0.464
IT	0.292	0.405	0.548
LA	–	–	0.238
LT	–	–	0.275
LU	–	0.396	0.422
MA	–	–	0.186
NE	0.464	0.537	0.574
PL	–	0.415	0.512
PR	–	0.426	0.513
RM	–	–	0.279
SK	–	–	0.147
SL	–	–	0.229
SP	0.573	0.491	0.561
SW	0.410	0.529	0.565
UK	0.424	0.476	0.551
(b)			
AU	0.718	0.571	0.603
BE	0.790	0.835	0.679
BU	–	–	0.650
CY	–	0.473	0.396
CZ	–	0.104	0.601
DE	0.717	0.833	0.707
FI	–0.324	0.757	0.473
FR	0.767	0.803	0.673
GE	0.744	0.829	0.580
GR	0.353	0.761	0.595
HU	–	0.762	0.655
IR	0.774	0.800	0.717
IT	0.706	0.722	0.667
LA	–	–	0.492
LT	–	–	0.539
LU	–	0.833	0.618
MA	–	–	0.511
NE	0.769	0.810	0.476
PL	–	0.592	0.733
PR	–	0.825	0.605
RM	–	–	0.556
SK	–	–	0.316
SL	–	–	0.497
SP	0.525	0.837	0.748
SW	0.776	0.819	0.686
UK	0.779	0.817	0.559

Table 4 reports results of the tests applied to countries that joined the euro in 1999. In this case, we have a larger number of markets

for which convergence is detected. Besides ‘metal, iron and steel’ and ‘industrials’, convergence is now detected for ‘chemicals’, ‘electronic and electric goods’, ‘industrial transport’, ‘financial’, ‘pharmaceutical and bio’ and ‘health’. Furthermore, in the latter part of the sample, there seems to be signs of convergence of aggregate stock market indices among EMU countries. Moreover, in the latter subsample for the Euro area countries, there is evidence of an even number of markets where relative convergence is detected. Figure 3(a) and (b) plot the cross-sectional covariance for the EMU countries. Not surprisingly, the magnitude of the cross-sectional dispersion of stock indices is much smaller for the countries in the currency union. These results mainly reflect a higher degree of similarity of the markets in the EU, and a process of integration between markets in the area that has been fostered by a common effort to create a single common market.

In summary, the analysis of the EU or EMU finds that in the latter part of the period there is some evidence of convergence in a number of markets. However, it is important to note that from Figs 2 and 3, it is clear that these reflect a reverse of the divergence pattern that started in the middle of the 1990s. Furthermore, the turnaround occurs well after the introduction of the euro – usually around 2002 to 2003. Therefore, it is not clear whether the evidence of increased convergence in the last subsample is to be regarded as a reflection of the introduction of the common currency. Indeed, the increase in integration among markets in the last part of the sample seems to be shared by all countries in the EU. Perhaps, the faster degree of convergence and lower dispersion found among the Euro area countries might be attributed to similarities among countries and the fact that most of the Euro area countries have been part of the common market area for a longer period.

The magnitude of the  $\alpha_{i,s}$ s suggests that even when some convergence is detected, the speed of convergence remains always very low. This suggests that global convergence, if it is to be observed at all, is going to be very slow.

#### Cluster analysis

The rejection of relative convergence does not rule out the presence of (asymptotic) cointegration between subsets of equity markets. Specifically, equity markets can share the same common trend, but with loadings that are different for subgroups of markets. Indeed, the null hypothesis of the  $\log(t)$  test of Phillips and Sul is robust to the presence of club convergence between countries.

We perform the analysis of club convergence for all equity markets. The general finding is that there are usually one or two countries which show a pattern of divergence, whereas all the others tend to group into two to four clusters. Therefore, for most of the markets, the indices seem to share a common stochastic trend,<sup>15</sup> therefore asymptotic cointegration of the indices is detected. Table 5 summarizes the findings of the clustering analysis.<sup>16</sup>

Table 6 lists the results of the cluster analysis applied to aggregate stock market indices. Inspection of Fig. 1 suggests a common stochastic trend for countries in the EU, with the exception of Bulgaria and Slovakia.<sup>17</sup> In Fig. 4, we plot the average of each of the three clusters against the S&P 500 index (converted into Euros), the average of the EU as a whole and the average of the EMU countries. The first convergence club is formed by markets that in the whole sample have generally outperformed the EU average; divergence

<sup>15</sup> We perform ADF tests for a unit root of the cross-sectional average of each market and for all of them there is evidence in favour of a unit root with drift.

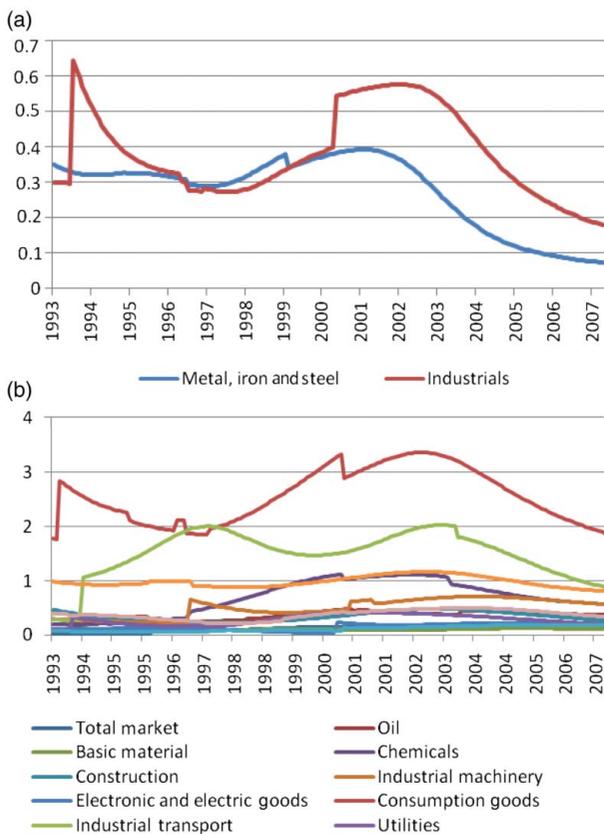
<sup>16</sup> Detailed tables for all the markets are available from the authors on request.

<sup>17</sup> We consider Slovakia as an outlier even though the clustering procedure of Phillips and Sul (2007) would include it in the second convergence group.

**Table 3. EU 27 countries**

	Jan 1989–Dec 2007	Jan 1989–Dec 1999	Jan 1999–Dec 2007
Total market	-0.9965 (-8.1409)	<b>-0.0598 (-0.9029)</b>	-0.1776 (-6.1309)
Oil	-0.3912 (-14.5407)	-0.5409 (-5.3215)	-0.1972 (-17.1493)
Basic material	-0.2606 (-12.0411)	-0.2393 (-6.1247)	-0.3619 (-22.7036)
Chemicals	-0.7747 (-6.3815)	-0.7958 (-24.4314)	<b>0.0434 (0.8466)</b>
Metal, iron and steel	<b>0.2230 (1.6300)</b>	-0.1022 (-3.5724)	<b>0.5011 (5.6344)</b>
Industrials	<b>-0.1422 (-1.4906)</b>	-0.3447 (-3.8691)	<b>0.2214 (2.4266)</b>
Construction	-0.2851 (-3.8284)	-0.3903 (-3.5618)	<b>-0.0785 (-1.0858)</b>
Industrial machinery	-0.6318 (-10.6933)	<b>-0.0567 (-0.9486)</b>	-0.2259 (-6.6771)
Electronic and electric goods	-0.5272 (-7.1786)	-0.1497 (-6.4032)	-0.2837 (-16.8939)
Consumption goods	-0.2728 (-4.6875)	-0.4974 (-6.9807)	<b>-0.0225 (-0.3799)</b>
Industrial transport	-0.4011 (-2.0442)	-1.4501 (-15.6113)	<b>0.0386 (0.4215)</b>
Utilities	-0.4450 (-4.5774)	-0.7142 (-6.9359)	<b>0.0475 (0.8781)</b>
Financials	-0.7626 (-12.3820)	<b>-0.0102 (-0.2868)</b>	-0.3987 (-24.5372)
Food and beverage	-0.2202 (-6.9203)	-0.9107 (-5.7441)	-0.1050 (-2.5967)
Pharmaceutical and bio	-1.0600 (-6.5505)	-0.4838 (-4.3916)	<b>0.4782 (5.0493)</b>
Health	-0.3560 (-5.3190)	<b>-0.1334 (-1.1883)</b>	-0.1560 (-2.8488)

Notes: Table 3 reports the value of  $\hat{\alpha} \simeq$  where  $\hat{\alpha}$  is the lower bound of the support rate of the decay rates  $\mapsto \circ$ . Notice that the regression starts at  $[rT] \simeq$ ; the integer part of  $\rightarrow$  for some fraction  $\rightarrow \triangleright 0$  (Phillips and Sul recommend that the fraction should be set to  $\rightarrow = 0-3$ ). The value in parenthesis is the  $\leftrightarrow$  value for the log  $\leftrightarrow$  test. Bold characters indicate that the value is significant at the 5% critical value.



**Fig. 2. Cross-sectional covariance of (a) convergent groups and (b) nonconvergent groups**

has increased since the mid-1990s. The second cluster is generally formed by small countries, whose markets are the more volatile and their average fluctuates around the EU average throughout all the samples. The third club is formed by the large economies, with

the exception of Poland and the UK, this group includes most of the large Euro area countries. Interestingly, this second group has followed the EU average very closely throughout the sample, but it seems to have decoupled around 1998, and settled at a slower growth rate.<sup>18</sup>

Figure 5 shows the common factors of the EU, the Euro countries, the three identified clusters and the S&P 500 index (converted into Euros). Clearly, the indices seem to share the same common factor, even though differences between markets are clear. This is confirmed by inspection of cross-correlations between the series as given in Table 7. The Euro area average is not too different from the EU average, pointing to the homogeneity of equity markets between the countries in the EU. Nevertheless, the Euro area markets seem to be heading towards a lower loading to the aggregate factor, with a decoupling sometime around 2002, as stressed above. The differences with the US seem mainly to reflect the accumulated loss in the first part of the sample, from 1981 to 1986.

**Macroeconomic fundamentals and convergence in equity markets**

Since the seminal work of Campbell and Shiller (1988), the relation between stock markets and their fundamentals have been widely documented in the literature. In this section, we give a sketch of how financial integration might be the natural result of deeper integration in the economies of a currency area when free capital mobility is allowed.

Consider the relation between the stock prices and some macroeconomic fundamentals,  $x_{it}$ .

$$S_{it} = b_i x_{it} + e_{it} \tag{5}$$

where  $e_{it} \sim I(0)$ . Stacking the vector of indices, this can be rewritten as

$$S_t = Bx_t + e_t \tag{6}$$

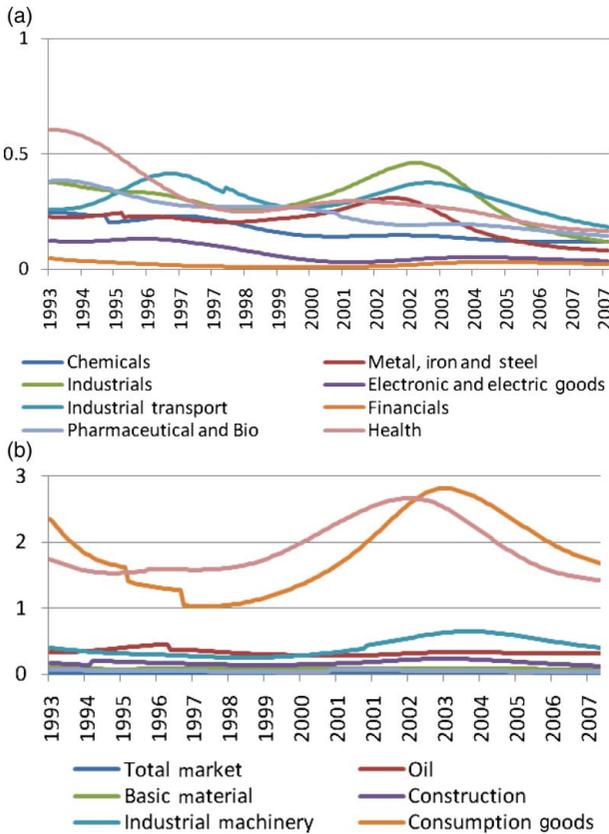
where  $B$  is a diagonal matrix. Notice that this relation can be derived from the optimizing behaviour of a maximizing agent, therefore,

<sup>18</sup> This result is not influenced by the inclusion of Poland.

**Table 4. EMU 11 countries**

	Jan 1989–Dec 2007	Jan 1989–Dec 1999	Jan 1999–Dec 2007
Total market	−0.5667 (−7.5118)	−0.1323 (−2.3440)	<b>0.0204 (0.4630)</b>
Oil	−0.1337 (−4.8313)	−0.5576 (−5.2940)	−0.2900 (−17.9268)
Basic material	−0.1602 (−6.4790)	<b>−0.0897 (−1.3782)</b>	−0.2131 (−8.2021)
Chemicals	<b>0.1079 (4.7627)</b>	−0.4663 (−8.5208)	−0.1417 (−6.9474)
Metal, iron and steel	<b>0.0509 (0.4784)</b>	−0.2446 (−4.9756)	<b>0.3412 (3.6270)</b>
Industrials	<b>−0.0068 (−0.0681)</b>	−0.2031 (−2.4675)	<b>0.2748 (2.2024)</b>
Construction	−0.2375 (−5.2424)	−0.1358 (−6.0486)	−0.1349 (−1.8222)
Industrial machinery	−0.4682 (−6.1071)	<b>−0.0703 (−1.0448)</b>	−0.2836 (−3.2711)
Electronic and electric goods	<b>0.3564 (5.6149)</b>	−0.1022 (−3.0599)	−0.3528 (−5.0570)
Consumption goods	−0.3878 (−4.1626)	−0.5740 (−3.9291)	−0.1876 (−2.2613)
Industrial transport	<b>−0.1171 (−1.5686)</b>	−0.5209 (−10.4103)	<b>−0.0352 (−0.4401)</b>
Utilities	−0.1382 (−3.0427)	<b>−0.0325 (−0.7103)</b>	<b>0.0065 (0.3481)</b>
Financials	<b>−0.1613 (−0.9022)</b>	<b>0.6485 (6.9469)</b>	−0.6840 (−6.3304)
Food and beverage	−0.3036 (−5.0423)	−1.0012 (−5.2332)	<b>0.0180 (0.3014)</b>
Pharmaceutical and bio	<b>0.1392 (8.4137)</b>	−0.3434 (−3.3312)	−0.1171 (−5.3100)
Health	<b>0.1918 (4.8802)</b>	<b>−0.0474 (−0.2948)</b>	<b>0.0040 (0.1081)</b>

Note: Bold characters indicate that the value is significant at the 5% critical value.



**Fig. 3. Cross-sectional covariance of (a) convergent groups EMU and (b) nonconvergent groups EMU**

the  $b_i$  reflect agent's preferences over risk. If the macroeconomic fundamentals themselves have a common factor structure, then

$$x_t = \gamma F_t + \varepsilon_t \quad (7)$$

where  $F_t$  represents the common factors, if  $F_t$  is nonstationary and  $\varepsilon_t \sim I(0)$ , then the macroeconomic fundamentals are cointegrated. This is usually the case in the standard DSGE model (Lence and Falk, 2005) framework, where the long-run properties of the system

**Table 5. Cluster analysis summary**

	No. of clubs	Divergence countries
Total market	3	BU (SL, possible outlier)
Oil	2	LU
Basic material	2	LU
Chemicals	1	CZ, RM
Construction	1	CY, FI, SP
Industrial machinery	4	None
Electronic and electric goods	1	CY
Consumption goods	2	None
Industrial transport	3	AU, CZ
Utilities	4	None
Financials	2	(CZ, possible outlier)
Food and beverage	3	None
Pharmaceutical and bio	2	None
Health	3	GR

are driven by common supply shocks (i.e. total factor productivity has a common trend). Substituting this expression back into the expression for equity prices, we obtain

$$s_t = B\gamma F_t + B\varepsilon_t + e_t \quad (8)$$

If we consider the particular case of a single common factor, then  $B\gamma$  is an  $n \times 1$  vector whose generic  $i$  element is  $b_i\gamma_i$ . Convergence in this setting requires that

$$\frac{b_{it}\gamma_{it}}{b_{jt}\gamma_{jt}} \rightarrow 1 \quad (9)$$

Perhaps, the most trivial example is the case of two countries with the same preference over risk, and who share a common trend with equal loading (therefore, with convergence in the fundamentals).

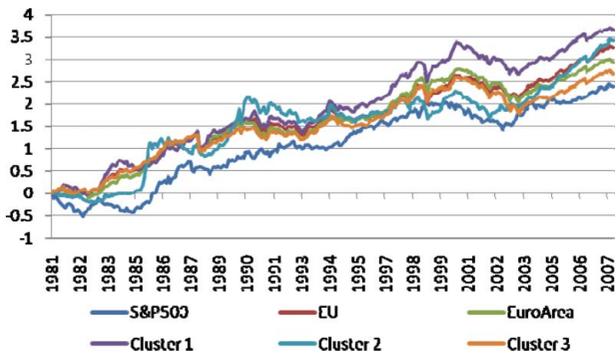
In the empirical analysis, we also considered the possibility of clustering among stock market indices. The clusters are defined such that market indices in the same cluster are converging to the same long-run value. The relation between markets in different clusters is such that a linear combination of two equity prices is stationary.

**Table 6. Club convergence in equity markets**

Name	t-Value		Club	Log t Test	Name	t-Value		Club	Log t Test
	Step 1	Step 2				Step 1	Step 2		
BU		Outlier <sup>a</sup>							
LA	Base	Core	S <sub>1</sub>	$t_{S1} = 0.784$					
GR	2.278	Core	S <sub>1</sub>						
F1	2.739	Core	S <sub>1</sub>						
DE	1.272	1.272	S <sub>1</sub>						
LT	0.073	0.188							
HU	0.856	2.470	S <sub>1</sub>						
SL	0.156	-0.73							
MA	0.126	0.828	S <sub>1</sub>						
CY		-2.484							
RM		-2.331				LT	Base	Core	S <sub>2</sub>
SP		1.891	S <sub>1</sub>		SL	2.135	Core	S <sub>2</sub>	
CZ	-0.148				CY	2.655	Core	S <sub>2</sub>	
IR		1.562	S <sub>1</sub>		RM	2.467	2.467	S <sub>2</sub>	$t_{S2} = 0.426$
SW		0.899	S <sub>1</sub>		CZ	1.550	2.472	S <sub>2</sub>	
AU		-1.383			AU	1277	0.540	S <sub>2</sub>	
IT		-1.948			IT		-0.129	S <sub>3</sub>	
PL		-2.656			PL		0.009	S <sub>3</sub>	
BE		-1.857			BE		-0.678	S <sub>3</sub>	
LU		-2.284			LU		-0.768	S <sub>3</sub>	
PR		-2.658		$t_{S1}^a = -5.491$	PR		-0.963	S <sub>3</sub>	$t_{S3} = 0.402$
FR		-0.926			FR		-0.507	S <sub>3</sub>	
NE		-1.591			NE		-0.992	S <sub>3</sub>	
UK		-3.197			UK		-1.952	S <sub>2</sub>	
GE		-2.286			GE		-5.275	S <sub>3</sub>	
SK		-4.245			SK		1.419 <sup>b</sup>	S <sub>2</sub>	

<sup>a</sup>The value of the log t-test for the group Bulgaria and Latvia is -8.676.

<sup>b</sup>From inspection of the data, Slovakia appears as a possible outlier and the clustering procedure would include it in both clusters 2 and 3.



**Fig. 4. Clusters**

This can be expressed as

$$\frac{b_{it}\gamma_{it}}{b_{jt}\gamma_{jt}} \rightarrow 1, \quad i, j \in G_1 \quad (10)$$

$$\frac{b_{it}\gamma_{it}}{b_{jt}\gamma_{jt}} \rightarrow \kappa, \quad i \in G_1, \quad j \in G_2$$

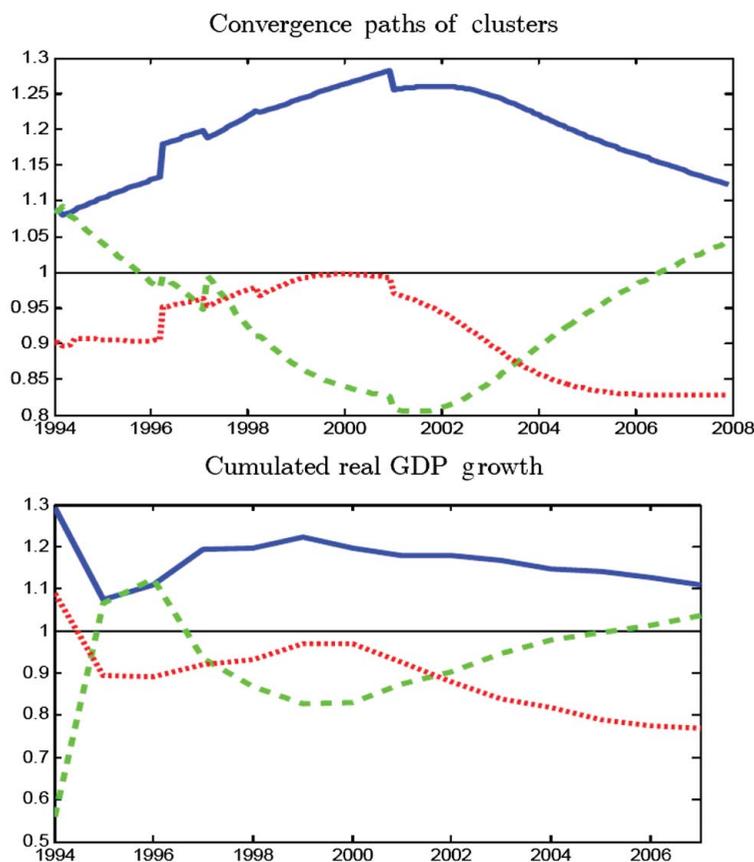
for a constant  $\kappa$ , this constant may reflect both differences in the loadings,  $\gamma$ s (different technology absorption capabilities) or different  $b$ s (different preferences of agents, where these might reflect, for instance, different levels of liquidity of markets).

Equity markets will be driven by underlying fundamentals, so there will only be convergence if there is convergence in the basic drivers of profits and dividends. This relationship between underlying economic performance and equity markets is brought out in

Fig. 5. First, we plot in the top panel, the average of each of the country clusters *relative* to the EU average. The first cluster (solid line) is always well above the EU average. The second cluster (dashed line) starts above average, spends some time below average and then moves above average in the last few years. The third cluster generally remains below average over all of the samples though it is very close to average around the year 2000. In the second panel, we carry out a similar exercise but now for accumulated real growth rates in GDP. For each cluster, we calculate the average growth rate in each year and accumulate it and plot it relative to the accumulated average of the EU. Although the results are not completely clear cut, there is a strong suggestion that relative movements in stock markets are related to relative movements in aggregate output.

## V. Summary and Conclusions

Whether the countries in the EU are experiencing a process of financial integration is a question of broad interest. In this article, we report evidence that seem to confirm the view that a process of integration is under way even though these seem to be rather slow. Furthermore, this process seems to be shared by most of the countries of the EU and not only those that are already part of the Euro zone. In this sense, our analysis supplemented and generalized the previous findings (see, e.g. Rangvid (2001) and Worthington *et al.* (2003)) that with mixed enthusiasm confirm these results for a subset of countries in the EU. The fact that the process is shared among all the countries and not only those that adopted the single currency suggests that this phenomenon cannot be solely attributed to the recent adoption of the single currency.



**Fig. 5. Cluster convergence and economic fundamentals**

*Notes:* The top panel shows the cluster convergence paths with respect to the EU average. The bottom panel plots the cumulated annual growth rates (data source: the Conference Board and Groningen database). The blue line refers to cluster 1, the green line refers to cluster 2 and the dotted red line refers to cluster 3.

**Table 7. Global factors correlations (a) level and (b) return**

(a)						
1991–1998	S&P 500 (in US\$)	S&P 500 (in Euro)	EU	Euro area	Cluster 1	Cluster 2
EU	0.852	0.748				
Euro area	0.900	0.817	0.989			
Cluster 1	0.902	0.822	0.988	0.996		
Cluster 2	0.303	0.227	0.561	0.507	0.548	
Cluster 3	0.894	0.798	0.988	0.990	0.988	0.529
1999–2007	S&P 500 (in US\$)	S&P 500 (in Euro)	EU	Euro area	Cluster 1	Cluster 2
EU	0.681	0.820				
Euro area	0.901	0.763	0.856			
Cluster 1	0.777	0.758	0.967	0.920		
Cluster 2	0.535	0.826	0.960	0.721	0.869	
Cluster 3	0.897	0.695	0.769	0.984	0.849	0.622
(b)						
1991–1998	S&P 500 (in US\$)	S&P 500 (in Euro)	EU	Euro area	Cluster 1	Cluster 2
EU	−0.034	−0.237				
Euro area	−0.039	−0.258				
Cluster 1	−0.019	−0.237	0.945	0.919		
Cluster 2	0.090	−0.092	0.714	0.639	0.631	
Cluster 3	−0.079	−0.299	0.893	0.911	0.847	0.567
1999–2007	S&P 500 (in US\$)	S&P 500 (in Euro)	EU	Euro area	Cluster 1	Cluster 2
EU	0.088	0.019				
Euro area	0.143	0.097	0.923			
Cluster 1	0.101	0.050	0.959	0.918		
Cluster 2	0.000	−0.073	0.802	0.594	0.688	
Cluster 3	0.127	0.070	0.917	0.983	0.891	0.602

Although, financial integration and the adoption of a common currency should be associated with convergence in short-term and long-term interest rates on sovereign bonds, this need not necessarily be so in equity markets. Differences in the performance of equity markets can persist if there are differences in the underlying drivers of profitability and dividends. Only when there is convergence in the fundamental drivers of economic growth will equity markets converge. We find in this article that an examination of equity markets in the 25 countries of the EU reveals three clusters that reflect differences in underlying growth rates. Therefore, the process of integration seems to reflect a more deep process of economic convergence among the countries.

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