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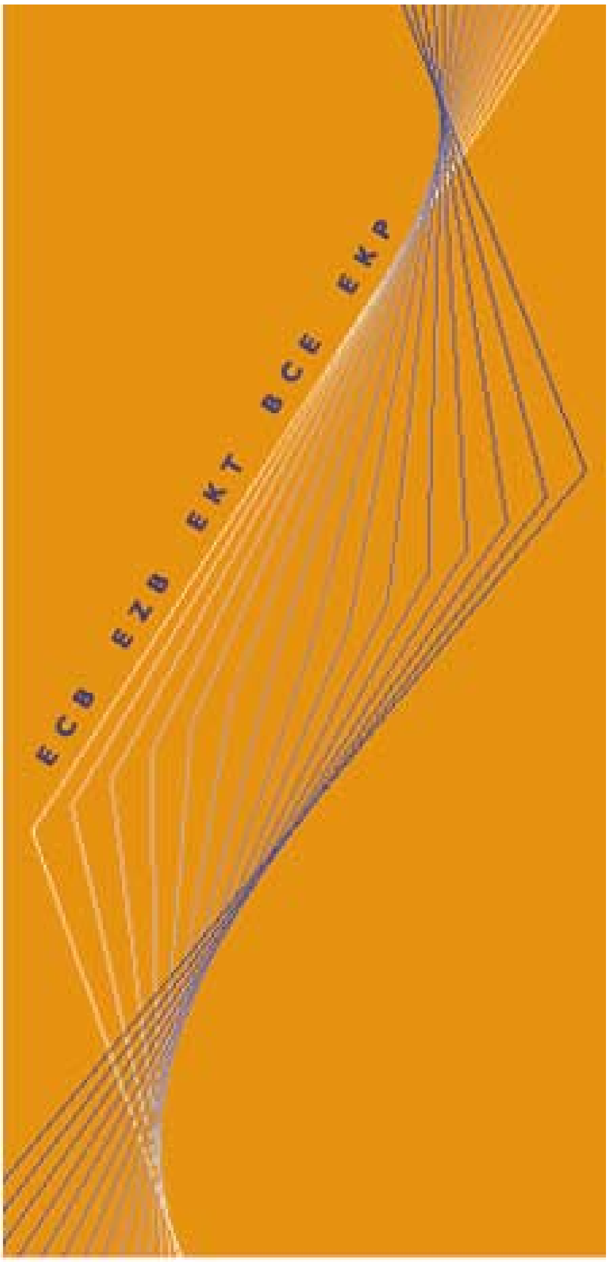

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FINANCIAL MARKET INTEGRATION IN EUROPE: ON THE EFFECTS OF EMU ON STOCK MARKETS

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March 2001

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Abstract

This paper analyzes the integration process of European equity markets since the 1980s. Its central focus is on the role that EMU, and specifically, changes in exchange rate volatility, has played in this process of financial integration. Building on an uncovered interest rate parity condition to measure financial integration, a trivariate GARCH model with time-varying coefficients yields three key results: first, European equity markets have become highly integrated only since 1996. Second, the Euro area market has gained considerably in importance in world financial markets and has taken over from the US as the dominant market in Europe. And third, the integration of European equity markets is in large part explained by the drive towards EMU, and in particular the elimination of exchange rate volatility and uncertainty in the process of monetary unification.

JEL classification: C32, F3, G15
Keywords: financial integration, stock markets, EMU, exchange rate volatility, GARCH model, time-variation.

1 Introduction

There is growing evidence that real convergence in Europe has not only been a pre-condition for successful monetary union, but that monetary union itself has strengthened *real* integration among its members (e.g. Frankel and Rose 1997). However, far less attention has so far been given to the question of whether EMU has caused a substantial increase in *financial* integration among European markets, and if so, which elements of EMU have been central to this integration process.

This paper analyzes the nature and the changes in the integration of European stock markets since the mid-1980s. It addresses two related questions: first, how strongly integrated are European stock markets, and has this degree of integration intensified over time? And second, what role has the drive towards EMU played in the process of European financial market integration?

While there is ample evidence that full convergence in European bond markets and money markets had been achieved by the mid- to late 1990s (e.g. Frankel 1994), it is far less clear whether, and to what extent, European equity markets have become more integrated. The answer to these questions has important implications both for investors' portfolio allocation decisions and for policy-makers in meeting the challenges of European integration and shaping policy responses to more integrated and interdependent financial markets in Europe.

To address the questions, the paper builds on an uncovered interest parity condition applied to asset prices to define financial market integration, and it employs a trivariate GARCH model for 16 OECD countries to test the implied integration hypotheses empirically. Addressing the first of these questions yields two key findings. First, European equity markets have become highly integrated with each other only since 1996. And second, the Euro area market has taken over from the US the role as the most important market in explaining equity returns in most individual European markets.

This leads us to the second question: what explains the increased role of the Euro area financial market? While there has been some research on the integration of European equity markets and its time variations (e.g. Longin and Solnik 1995, Bodart and Reding 1999, Hardouvelis et al. 1999), no systematic attempt has yet been undertaken to explain which factors have been driving the time variations in integration. This is the main contribution this paper aims to make. It compares the relative importance of the three EMU pillars of exchange rate stability, real convergence, and monetary policy convergence in explaining the time variations of equity market integration in Europe.

The paper develops a GARCH methodology with time-varying coefficients to analyze and compare the role of these three factors. The results indicate that EMU has indeed fundamentally altered the nature of financial integration in Europe. It is found that it was in particular the reduction and elimination of exchange rate volatility, and to some extent also monetary policy convergence, that has played a central role in explaining the increased financial integration among EMU members. Moreover, the shock transmission across equity markets is found to be asymmetric, i.e. negative shocks are more strongly transmitted, large shocks have a stronger impact than small shocks, and these asymmetry and threshold effects have become larger over time.

After reviewing some of the literature on financial integration in section 2, section 3 develops the empirical methodology to test for financial integration. Section 4 provides empirical tests of the model for a set of 16 OECD countries. Different methodologies for measuring time-variations in integration are discussed and illustrated in section 5. Section 6 then employs a GARCH model with time-varying coefficients to test which factors (exchange rate volatility, real convergence, or monetary policy convergence) explain the increased interdependence among Europe's financial markets. The findings are summarized and some policy implications are discussed in section 7.

2 Literature on financial integration

The fields of international macroeconomics and international finance have developed different but related methodologies to test for financial integration. In international macroeconomics, much work has utilized interest rate parity conditions to test for financial integration of money markets (e.g. Frankel and MacArthur 1988, Frankel 1991, Lemmen and Eijffinger 1996):[1]

Covered interest rate parity (CIP): $i_{i,t}^{t+k} = i_{w,t}^{t+k} + (f_t^{t+k} - s_t)$

Uncovered interest rate parity (UIP): $i_{i,t}^{t+k} = i_{w,t}^{t+k} + E_t(\Delta s_t^{t+k})$

$$= [i_{w,t}^{t+k} + (f_t^{t+k} - s_t)] + [E_t(\Delta s_t^{t+k}) - (f_t^{t+k} - s_t)]$$

with *i* as nominal interest rates, *f* the forward rate and *s* the spot rate. UIP is a broader definition of financial integration than CIP because it not only measures a "country premium", i.e. direct barriers to capital flows (measured by CIP, the first term on the r.h.s. in the last UIP equation) but also allows for an "exchange rate risk premium" as impediment to integration (the second term on the r.h.s.). There is a broad consensus that most of the deviation from UIP in developed markets is due to exchange rate risk premia whereas country premia have become smaller or disappeared over time (Frankel 1992).

On the contrary, much of the international finance literature has employed a capital asset pricing model (CAPM) in testing for financial market integration (Bekaert and Harvey 1995, Dumas and Solnik 1995, Ferson and Harvey 1991, Hardouvelis et al. 1999):

$$E_{t-1}(r_{i,t}) = \lambda_w \beta_{iw} + \lambda_d \beta_{id}$$

with $r_{i,t}$ as the excess return on the local portfolio *i*, λ the market risk premium, β_{iw} the risk of portfolio *i* relative to world portfolio *w* defined as $\beta_{iw} = cov_{t-1}[r_{i,t}, r_{w,t}] \,/\, var_{t-1}[r_{i,t}]$, and β_{dw} analogously for the domestic market portfolio *d*. The null hypothesis of full integration requires $\lambda_d = 0$, i.e. the local portfolio *i* is solely priced relative to the global portfolio *w*. Thus the basic intuition of the CAPM is that expected local returns (r_i) in a fully integrated market depend only on nondiversifiable international factors.

Regarding the empirical implementation of these concepts, various econometric methodologies have emerged over the years. Early attempts to test for international linkages of equity markets have mostly focused on atheoretical VAR models (King and Wadhwani 1990, Koch and Koch 1993, Eum and Shim 1993) and generally found rising cross-market correlations and growing regional interdependence.[2] More recent research on financial market integration has been conducted in a generalized ARCH (GARCH) framework in order to take into account the existence of ARCH effects in data of higher frequency. For instance, Lin and Ito (1994) and Koutmos and Booth (1995)

1 *An alternative measure is the Feldstein-Horioka condition, which states that in a fully financially integrated country an exogenous shift in savings should have no effect on investment. However, empirical tests produce often counter-intuitive results, such as implying a higher degree of financial integration for emerging markets than for developed countries. See e.g. Frankel (1992) for a discussion of this issue.*

2 *A quite distinct methodology used to detect stable long-run relationships across financial markets is based on cointegration analysis (e.g. Dickinson 2000, Richards 1996). It is less relevant for this paper here since cointegration analysis does not yield much information about the dynamics and time-variations in the degree of integration.*

find compelling evidence for some price spillovers and volatility spillovers between the London, Tokyo and New York stock markets.

A very important, but often ignored issue is that financial integration may exhibit strong variations over time. Most research testing for financial integration has either ignored this issue entirely or has looked at different sub-periods to obtain information about the dynamics of integration (e.g. Longin and Solnik 1995, Bodart and Reding 1999). Although comparing different sub-periods may yield a first proxy for long term changes, it masks much of the time variation since the degree of integration may often change frequently and exhibit high volatility.

A more promising approach is one in which time-varying coefficients are modeled explicitly through instrumental variables. Three types of instrumental variables have been used in the literature. First, there has been ample evidence that the removal of legal and non-legal barriers to capital flows have raised financial integration substantially, not only in developed countries but also for a number of emerging markets in recent years (e.g. Bekaert and Harvey 1995, Ng 2000).

Second, numerous studies have shown that the degree of real integration, measured by the correlation of business cycles, has a strong effect on financial integration (Fama and French 1989, Ferson and Harvey 1991, Jagannathan and Wang 1996). Moreover, the degree of financial integration tends to be highest during periods when both countries or the dominant country are in recession (Erb et al. 1994, Ragunathan et al. 1999). And third, there is evidence that exchange rate uncertainty can have a large effect on financial integration because exchange rate risk is an important source of risk priced on capital markets (e.g. Dumas and Solnik 1995, Bodart and Reding 1999, Hardouvelis et al. 1999).

A common feature of most of these instrumental variable approaches to integration is that they only look at a very small set of variables that may partly explain the time variation in integration. Such a narrow approach can be very problematic not least because the included variables may really pick up effects of other, excluded variables. This danger is particularly prevalent for the analysis of European financial markets for which a reduction in overall exchange rate volatility coincided with real convergence and convergence in monetary policy during the period leading up to EMU.

One therefore needs to carefully distinguish between these different sources of integration, and in particular one needs to take into account that what determines the degree of financial integration may not only be a country's own economic performance, but also the degree of real and financial convergence with other economies. Understanding the true factors behind the time variations in integration in European equity markets therefore requires a broader approach that compares the role of these different sources. This is the aim of the remainder of the paper.

3 Modeling integration: Theoretical motivation and empirical methodology

3.1 Theoretical motivation: An uncovered asset return parity (UAP) relation

Following the approach commonly used in international macroeconomics, I use an uncovered interest rate parity (UIP) condition as the starting point for measuring financial integration. From the UIP condition one can derive a simple uncovered asset return parity (UAP) relation for the degree of financial integration of the local equity market i with the world equity market *w:*

$$E_{t-1}[r_{i,t}] = E_{t-1}[r_{w,t}] + E_{t-1}[\Delta s_{i,t}] \tag{1.a}$$

or in *ex post* form

$$r_{i,t} = r_{w,t} + \Delta s_{i,t} \tag{1.b}$$

with *r* as the excess return of the market portfolio in local currency in excess of the risk-free Euro interest rate, and s_i the spot exchange rate of country *i*. This *ex* post UAP relation states that for a fully integrated market *i* asset returns r_i are equal to asset returns of the world market r_w after accounting for exchange rate changes $\Delta s_{i,t}$.

Just as the UIP condition, the UAP relation of (1.b) may often not be satisfied in reality. In addition to expectational errors, there are at least two types of reasons for why (1.b) may not hold. First, (1.b) ignores risk premia that are priced in the market, such as related to differences in volatility of market returns and exchange rates, and second, there may be other barriers to cross-country investment that prevent markets from being fully integrated. A more general formulation of equation (1.b) to test the degree of integration of market *i* with world markets w can therefore be written as

$$r_{i,t} = \phi_{i,t} \cdot r_{w,t} + \chi_{i,t} \tag{2}$$

with $\phi_{i,t}$ measuring the correlation between local returns r_i and global returns r_w, and $\chi_{i,t}$ as a vector of country specific factors, such as business cycle conditions, different types of risks and expectations, which can drive a wedge between local and world market returns. $\chi_{i,t}$ can be decomposed into a share that is expected from past information, $E_{t-1}[r_{i,t}]$, and an unexpected share, $\varepsilon_{i,t}$, i.e. a contemporary, idiosyncratic shock:

$$\chi_{i,t} = \beta_{i,t} E_{t-1}[r_{i,t}] + \varepsilon_{i,t} \tag{3}$$

Analogously, world market returns r_w can be expressed as a function of available information from the past, $E_{t-1}[r_{w,t}]$, and a contemporary innovation $\varepsilon_{w,t}$

$$\phi_{i,t} \cdot r_{w,t} = \beta_{iw,t} E_{t-1}[r_{w,t}] + \gamma_{iw,t} \varepsilon_{w,t} \tag{4}$$

Substituting equations (4) and (3) back into (2) yields

$$r_{i,t} = \beta_{iw,t} E_{t-1}[r_{w,t}] + \gamma_{iw,t} \varepsilon_{w,t} + \beta_{i,t} E_{t-1}[r_{i,t}] + \varepsilon_{i,t} \tag{5}$$

This relation, in essence, says that local returns $r_{i,t}$ are determined by information available from the past, both local and worldwide (the expected share of the returns), and by contemporary shocks, originating both locally and in the world market (the unexpected share).

Equation (5) now allows us to measure the degree of *integration* of market i with the world market *w:*

> **Definition of market integration:** Market *i* is more integrated the stronger domestic returns $r_{i,t}$ depend on contemporaneous world market shocks $\varepsilon_{w,t}$, with $\gamma_{iw,t}$ as the measure of the degree of integration of market *i*.

Much of the research on financial market integration of the 1990s has focused on the parameters β_{iw} and β_i as measures of integration. The danger of using the parameters β_{iw} and β_i to deduct information about financial market integration is that they also contain information about *market efficiency.*

> **Definition of market efficiency:** Market i is more efficient the faster market-relevant information are incorporated into asset prices. Under fully efficient markets, information from time *t-1* should not affect returns in period *t*, i.e. $\beta_{iw}=0$ and $\beta_i=0$. Therefore, β_{iw} and β_i are measures of the efficiency of market *i*.

The importance of the transition from equation (2) to equation (5) should now become apparent. Changes in the parameter $\phi_{i,t}$ of (2) can be either due to changes in market integration or due to changes in market efficiency. Equation (5) allows to distinguish between these two factors in explaining variations in local returns r_i. The transition towards full market efficiency ($\beta_{iw}=0$ and $\beta_i=0$), for instance, can be perfectly compatible with a move towards market integration (a rise in $\gamma_{iw,t}$).

Note that there is a fair amount of ambiguity about defining the term "integration". For money markets, cross-market integration is generally defined as the absence of cross-market arbitrage opportunities so that the law of one price holds (e.g. Frankel 1992). This definition, in essence, implies not only the absence of barriers to capital flows but also that investors will undertake capital transactions to eliminate arbitrage opportunities that arise. For equity markets, measuring arbitrage opportunities is more difficult as the persistence of the equity home bias puzzle underlines. What the equity home bias puzzle implies is that the elimination of formal barriers to capital flows, such as capital controls and transaction costs, has not been sufficient to induce cross-border capital flows as predicted by various asset pricing models. Accounting for factors such as risk aversion and uncertainties, e.g. exchange rate risk, has been shown to explain some part of the equity home bias, although the puzzle of the equity home bias remains largely unsolved (e.g. Lewis 1999). The definition of financial integration of equity markets used in this paper here therefore is a stricter one in that it not only looks at the openness of equity markets but directly measures the extent to which shocks are transmitted across equity markets.[3] The transmission of a shock not only requires market openness and the absence of barriers to capital flows, but it also requires that capital actually flows across markets in order to take advantage of market opportunities.

3.2 Empirical methodology: Trivariate GARCH models to measure financial market integration

Equation (5) serves as the starting point for the empirical model.[4] A key difficulty with testing (5) empirically is that the data generating process (DGP) is unobservable, i.e. it is impossible to know

3 *In contrast, Chen and Klez (1995) and Ayuso and Blanco (2000) try to measure the absence of abritrage opportunities directly by determining the distance between stochastic discount factors across makets, i.e. they measure integration as the extent to which risks are priced identically in different markets independent of an underlying asset pricing model.*

4 *A similar setup is used for testing financial integration of emerging markets by Bekaert and Harvey (1997), by Fleming and Lopez (1999) for the analysis of US treasury bills, by Karolyi and Stulz (1996) for Japanese firms' integration with the US market, and by Ng (2000) for the interaction of Pacific-Basin equity markets with those of Japan and the US.*

the full set of information that investors have used in each period to form their expectations. One therefore has to use instruments X_{t-1} of past market fundamentals to proxy this information set. Moreover, to compare and evaluate the relative importance of the Euro area market with that of the US, I further distinguish between regional shocks originating in the Euro area (denoted by subscript E) and global shocks coming from the rest of the world, proxied through shocks from the US market (subscript U). Thus the conditional first moments of the trivariate GARCH model in vector format are estimated as

$$r_{j,t} = \omega_{j,t-1} + \mu_{j,t} \tag{6}$$

with

$$\mu_{j,t} = \begin{bmatrix} \mu_{i,t} \\ \mu_{E,t} \\ \mu_{U,t} \end{bmatrix} = \begin{bmatrix} 0 & \gamma_{iE,t-1} & \gamma_{iU,t-1} \\ 0 & 0 & \gamma_{EU,t-1} \\ 0 & \gamma_{UE,t-1} & 0 \end{bmatrix} \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{E,t} \\ \varepsilon_{U,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{E,t} \\ \varepsilon_{U,t} \end{bmatrix} \tag{7}$$

$$\omega_{j,t-1} = \begin{bmatrix} \omega_{i,t-1} \\ \omega_{E,t-1} \\ \omega_{U,t-1} \end{bmatrix} = \begin{bmatrix} \beta_{ii} & \beta_{iE} & \beta_{iU} \\ 0 & \beta_{EE} & \beta_{EU} \\ 0 & \beta_{UE} & \beta_{UU} \end{bmatrix} \begin{bmatrix} X_{i,t-1} \\ X_{E,t-1} \\ X_{U,t-1} \end{bmatrix} \tag{8}$$

where $r_{j,t}$ is a 3x1 vector of excess returns, $\omega_{j,t-1}$ a 3x1 vector of conditional mean returns that are themselves a function of past information on local, regional and global fundamentals X. The local innovation $\mu_{i,t}$ is explained through contemporaneous global shocks $\varepsilon_{U,t}$ and regional shocks $\varepsilon_{E,t}$ as well as a purely idiosyncratic component $\varepsilon_{i,t}$. Note that Euro area shocks are allowed to affect US returns on the same calendar day ($\gamma_{UE,t-1} \cdot \varepsilon_{E,t}$), whereas US shocks affect European markets only on the following day ($\gamma_{EU,t-1} \cdot \varepsilon_{U,t-1}$) due to the differences in trading times.

The measures of integration in the model (6)-(8) are the time-varying coefficients $\gamma_{iE,t-1}$ and $\gamma_{iU,t-1}$. They measure the contemporaneous dependence of market return r_i on regional shocks $\varepsilon_{E,t}$ and global shocks $\varepsilon_{U,t}$. This degree of integration is allowed to change over time. After testing the GARCH model with constant γ coefficients in section 4 in order to obtain the benchmark case, sections 5 and 6 will then allow γ to change over time and test which factors can account for the time variations.

Due to conditional heteroskedasticity in the idiosyncratic innovation $\varepsilon_{j,t}$ with, $\varepsilon_{j,t} | \Omega_{j,t-1} \sim N(0,\sigma^2_{\varepsilon,j,t})$ the 3x1 vector of conditional variance of $\varepsilon_{j,t,}$t is modeled as

$$\sigma^2_{\varepsilon,j,t} = \begin{bmatrix} \sigma^2_{\varepsilon,i,t} \\ \sigma^2_{\varepsilon,E,t} \\ \sigma^2_{\varepsilon,U,t} \end{bmatrix} = \begin{bmatrix} \alpha_{i0} \\ \alpha_{E0} \\ \alpha_{U0} \end{bmatrix} + \begin{bmatrix} \alpha_i \sigma^2_{\varepsilon,i,t-1} \\ \alpha_E \sigma^2_{\varepsilon,E,t-1} \\ \alpha_U \sigma^2_{\varepsilon,U,t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{ii} \varepsilon^2_{i,t-1} \\ \alpha_{EE} \varepsilon^2_{E,t-1} \\ \alpha_{UU} \varepsilon^2_{U,t-1} \end{bmatrix} + \begin{bmatrix} 0 & \alpha_{iE} & \alpha_{iU} \\ 0 & 0 & \alpha_{EU} \\ 0 & \alpha_{UE} & 0 \end{bmatrix} \begin{bmatrix} \varepsilon^2_{i,t} \\ \varepsilon^2_{E,t} \\ \varepsilon^2_{U,t-1} \end{bmatrix} \tag{9}$$

which implies that the conditional variance is determined by its own past variance, own past squared shock and by contemporaneous squared external innovations.[5] Note again that $\varepsilon^2_{U,t-1}$ is considered as "contemporaneous" because the US market opens and closes after the European markets and therefore affects these only on the following calendar day.

5 The coefficients for the effect of other countries'/regions' past conditional variance and past squared innovation are restricted to zero in (9). Empirical tests showed that these coefficients were mostly not significantly different from zero and therefore were excluded from the final model in order to reduce the large number of parameters to be estimated via maximum likelihood.

Finally, the GARCH model is jointly implemented for the data via maximum likelihood estimation of the log likelihood function

$$L(\theta) = -\left(\frac{T}{2}\right)\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\left(\ln\left|\sigma_t\right| + \varepsilon_t{}'\sigma_t^{-1}\varepsilon_t\right) \tag{10}$$

where θ is the parameter vector to be estimated, T the number of observations and σ_t the time varying conditional variance-covariance matrix. The Simplex algorithm is used to get initial values for the maximization problem. To obtain the parameter estimates, numerical maximization is employed through the algorithm developed by Berndt, Hall, Hall and Hausman (1974).

3.3 Asymmetry and threshold effects in the shock transmission

One particular feature of financial integration is that it tends to be asymmetric - negative shocks are more strongly transmitted than positive ones - and that they are often skewed - large shocks have a bigger effects than small ones. The asymmetry has been shown to partly result from the interaction of leverage and volatility feedback effects (Campbell and Hentschel 1992, Bekaert and Wu 1997): the effect of a positive shock on asset prices through improved leverage of firms (leverage effect) is partly offset by the increase in volatility (volatility feedback effect), whereas the two effects re-enforce each other for negative shocks. Large shocks tend to have bigger spillover effects because they are often unexpected and thus constitute news that need to be incorporated into asset prices.

To test this hypothesis in the GARCH framework, one can extend the conditional return and the conditional variance equations (7) and (9) in the following way:

$$\mu_{j,t} = \begin{bmatrix}\mu_{i,t}\\ \mu_{E,t}\\ \mu_{U,t}\end{bmatrix} = \begin{bmatrix}0 & v_{iE,t-1} & v_{iU,t-1}\\ 0 & 0 & v_{EU,t-1}\\ 0 & v_{UE,t-1} & 0\end{bmatrix}\begin{bmatrix}\varepsilon_{i,t}\\ \varepsilon_{E,t}\\ \varepsilon_{U,t-1}\end{bmatrix} + \begin{bmatrix}0 & \delta_{iE,t-1} & \delta_{iU,t-1}\\ 0 & 0 & \delta_{EU,t-1}\\ 0 & \delta_{UE,t-1} & 0\end{bmatrix}\begin{bmatrix}S_i^A\varepsilon_{i,t}\\ S_E^A\varepsilon_{E,t}\\ S_U^A\varepsilon_{U,t-1}\end{bmatrix}$$
$$+ \begin{bmatrix}0 & \tau_{iE,t-1} & \tau_{iU,t-1}\\ 0 & 0 & \tau_{EU,t-1}\\ 0 & \tau_{UE,t-1} & 0\end{bmatrix}\begin{bmatrix}S_i^T\varepsilon_{i,t}\\ S_E^T\varepsilon_{E,t}\\ S_U^T\varepsilon_{U,t-1}\end{bmatrix} + \begin{bmatrix}\varepsilon_{i,t}\\ \varepsilon_{E,t}\\ \varepsilon_{U,t}\end{bmatrix} \tag{11}$$

$$\sigma^2_{\varepsilon,j,t} = \begin{bmatrix}\sigma^2_{\varepsilon,i,t}\\ \sigma^2_{\varepsilon,E,t}\\ \sigma^2_{\varepsilon,U,t}\end{bmatrix} = \begin{bmatrix}\alpha_{i0}\\ \alpha_{E0}\\ \alpha_{U0}\end{bmatrix} + \begin{bmatrix}\alpha_i\sigma^2_{\varepsilon,i,t-1}\\ \alpha_E\sigma^2_{\varepsilon,EA,t-1}\\ \alpha_U\sigma^2_{\varepsilon,U,t-1}\end{bmatrix} + \begin{bmatrix}\alpha_{ii}\varepsilon^2_{i,t-1}\\ \alpha_{EE}\varepsilon^2_{E,t-1}\\ \alpha_{UU}\varepsilon^2_{U,t-1}\end{bmatrix} + \begin{bmatrix}0 & \varsigma_{iE} & \varsigma_{iU}\\ 0 & 0 & \varsigma_{EU}\\ 0 & \varsigma_{UE} & 0\end{bmatrix}\begin{bmatrix}\varepsilon^2_{i,t}\\ \varepsilon^2_{E,t}\\ \varepsilon^2_{U,t-1}\end{bmatrix}$$
$$+ \begin{bmatrix}0 & \varphi_{iE,t-1} & \varphi_{iU,t-1}\\ 0 & 0 & \varphi_{EU,t-1}\\ 0 & \varphi_{UE,t-1} & 0\end{bmatrix}\begin{bmatrix}S_i^A\varepsilon^2_{i,t}\\ S_E^A\varepsilon^2_{E,t}\\ S_U^A\varepsilon^2_{U,t-1}\end{bmatrix} + \begin{bmatrix}0 & \eta_{iE,t-1} & \eta_{iU,t-1}\\ 0 & 0 & \eta_{EU,t-1}\\ 0 & \eta_{UE,t-1} & 0\end{bmatrix}\begin{bmatrix}S_i^T\varepsilon^2_{i,t}\\ S_E^T\varepsilon^2_{E,t}\\ S_U^T\varepsilon^2_{U,t-1}\end{bmatrix} \tag{12}$$

with S^A as an indicator function that takes the value of 1 if the innovation is negative, and S^T as an indicator function that is equal to 1 if the shock is larger than its standard deviation over the full sample period. The above specification allows to distinguish between four types of shocks:

	Price effects	Volatility effects
Small, positive shocks	ν_{t-1}	ζ
Large, positive shocks	$(\nu_{t-1} + \tau_{t-1})$	$(\varsigma + \eta)$
Small, negative shocks	$(\nu_{t-1} + \delta_{t-1})$	$(\varsigma + \varphi)$
Large, negative shocks	$(\nu_{t-1} + \tau_{t-1} + \delta_{t-1})$	$(\varsigma + \varphi + \eta)$

The specification used in equations (9) and (10) is similar to the one that was first suggested by Glosten, Jagannathan and Runkle (1993, GJR), although it should be noted that there is some disagreement about the appropriate specification to model asymmetries and threshold effects.[6]

3.4 Specification tests

If the benchmark GARCH model (6)-(9) correctly specifies the DGP, then the following orthogonality conditions hold:

$$E\left[\varepsilon_{k,t}\varepsilon_{l,t}\middle|\Omega_{t-1}\right]=0 \quad , \quad k,l=i,E,U \quad , \quad \forall k \neq l \tag{13}$$

which states that the idiosyncratic shocks of the three markets are independent. If the unexpected share $\mu_{i,t}$ of the returns in country *i* is solely explained by regional and global shocks, then the idiosyncratic innovations $\varepsilon_{i,t}$ are not only orthogonal to regional and global shocks but are also independent from shocks occurring in other local markets *n*

$$E\left[\varepsilon_{i,t}\varepsilon_{n,t}\middle|\Omega_{t-1}\right]=0 \quad , \quad \forall i \neq n \tag{14}$$

The validity of these conditions constitute important specification tests of the model because if the innovations are not independent, then the integration measures γ_{t-1} may be biased.[7] If the conditions are fulfilled, then the conditional variance of the unexpected share $\mu_{i,t}$ of the returns and its conditional covariances for the local market i with global and regional shocks can be derived from equation (7) as

$$E\left[\mu_{i,t}^2\middle|\Omega_{t-1}\right]=\sigma_{i,t}^2=\gamma_{iE,t-1}^2\sigma_{E,t}^2+\gamma_{iU,t-1}^2\sigma_{U,t}^2+\sigma_{\varepsilon,i,t}^2 \tag{15}$$

$$E\left[\mu_{i,t}\mu_{k,t}\middle|\Omega_{t-1}\right]=\sigma_{ik,t}=\gamma_{ik,t-1}\sigma_{k,t}^2 \quad , \quad k=E,U \tag{16}$$

These relations are important not only to check whether the model is correctly specified, but they also allow us to derive variance ratios that provide a goodness-of-fit measure, i.e. a test for how much of the local return variance is explained by regional factors and by world factors:

6 *Henry (1998) compares the statistical properties of various GARCH specifications for US data and concludes that the exponential GARCH, the quadratic GARCH, and the GJR specification are the most appropriate ones and are similar in that they produce results that are closest to the data generating process. Due to its simplicity I decided to use the GJR specification although the EGARCH model was also tested and produced similar results.*

7 *Forbes and Rigobon (1999) and Boyer, Gibson and Loretan (1999) emphasize the existence of another type of bias if the conditional correlation coefficient ρ_{ik} is used as a measure of financial integration. Given the definitions of the correlation coefficient as $\rho_{ik} = \sigma_{ik}/\sigma_i\sigma_k$ and the regression coefficient of (7) as $\gamma_{ik} = \sigma_{ik}/\sigma_k^2$ one gets the relation between both as $\rho_{ik} = \gamma_{ik}(\sigma_k/\sigma_i)$. Both papers argue that ρ_{ik} may be a biased measure of financial integration if a rise in ρ_{ik} over time is due to an increase in the ratio of standard deviations σ_k/σ_i whereas the true degree of integration measured by γ_{ik} may actually stay constant or even fall. This is the case because, under the condition γ_{ik} <1, the ratio σ_k/σ_i rises as volatility increases. The analysis employed in this paper here is not open to this bias because it directly uses the regression coefficient γ_{ik} as a measure of financial market integration.*

$$VR_{iE,t} = \frac{\gamma^2_{iE,t-1}\sigma^2_{E,t}}{\sigma^2_{i,t}} \in [0,1] \quad (17)$$

$$VR_{iU,t} = \frac{\gamma^2_{iU,t-1}\sigma^2_{U,t}}{\sigma^2_{i,t}} \in [0,1] \quad (18)$$

4 Testing for financial integration

4.1 The data

The empirical analysis is conducted for a set of 16 countries, some of which are part of the Euro area (Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain), some of which have not adopted the Euro yet (Denmark, Sweden, UK), and five countries from outside the EU (Australia, Canada, Japan, Norway, Switzerland). The aim of taking such a broader sample is to analyze whether there are differences in integration between Euro members and other countries.

The data on stock market returns are the market indices calculated by Datastream International and have daily frequency from January 1986 to June 2000, or 3783 daily observations, for most countries and a somewhat shorter time period for a few countries where some of the time series started later. The return index for the Euro area is the weighted average of those markets that have joined the Euro. The Euro area index used for the empirical estimation for individual Euro area countries excludes this country from the index in order to focus only on shocks that are external to each market. Hence the Euro area return index rE,t for each individual market *i* is calculated as

$$r_{E,t} = \sum_{k \neq i} w_{k,t} r_{k,t} \Big/ \sum_{k \neq i} w_{k,t} \quad (19)$$

with *k* only including Euro area markets, except for market *i,* and w_k as the weights reflecting the share of market capitalization of market *k* in the total Euro area market.

There are two main reasons for choosing Datastream indices: first, they are broader measures of stock market returns since they also include firms with smaller capitalization and therefore provide a more accurate presentation of the whole market. Second, they tend to be more homogenous, thus allowing comparisons across markets. Moreover, it is important to emphasize that unlike in other studies mentioned in section 2, all data used here is denominated in domestic currency because using a common currency would have prevented an explicit analysis of the effect of exchange rate changes and uncertainty.[8]

8 *The underlying assumption of using returns in domestic currencies is that investors are able to hedge at least some of their foreign exchange exposure. Using returns denominated in a common currency would assume that investors are not able to hedge any of their exposure. This may also introduce a bias in that a high degree of integration may simply be due to a similarity in exchange rate changes rather than direct financial integration. The trivariate GARCH model was nevertheless also tested using common currency returns, but yielded very similar results to those obtained from using domestic currency returns.*

Table 1
Descriptive Statistics of Equity Returns

Daily Data, 2/1/1986–2/3/2000

	Average Return	Standard Error	Skewness		Kurtosis		LB(12)	
Belgium	0.028	0.883	-0.509	*	14.831	*	218.017	*
Denmark	0.023	0.796	-0.780	*	9.045	*	112.808	*
Finland	0.115	1.471	-0.079	*	5.286	*	67.494	*
France	0.038	1.155	-0.380	*	5.173	*	105.820	*
Germany	0.037	1.059	-0.567	*	9.265	*	32.897	*
Italy	0.048	1.465	-0.051		4.337	*	105.379	*
Japan	0.017	1.056	0.127	*	10.648	*	104.598	*
Netherlands	0.057	1.103	-0.174	*	8.422	*	29.786	*
Norway	0.035	1.327	-0.936	*	24.894	*	69.558	*
Austria	0.039	1.014	-0.081	*	10.350	*	460.210	*
Sweden	0.063	1.275	0.160	*	7.368	*	99.480	*
Spain	0.032	1.070	-0.345	*	5.862	*	67.902	*
Switzerland	0.040	0.851	-1.380	*	20.625	*	81.960	*
UK	0.033	0.856	-0.834	*	11.980	*	117.578	*
USA	0.037	0.961	-1.797	*	38.194	*	31.432	*

*Note: * Indicates significance at the 5% level. LB(12) is the Ljung-Box test for 12 lags.*
Data samples for Denmark, Finland, Italy, Spain are based on a somewhat shorter time period due to data availability.

A first look at the data characteristics (Table 1) shows that there is indeed strong evidence that negative shocks are more frequent than positive shocks (negative skewedness), that large shocks are more common than expected statistically (excess kurtosis) and that equity returns are autocorrelated.

There is strong empirical evidence that stock returns are predictable on the basis of past information (Harvey 1991, Ferson and Harvey 1993, De Santis and Gerard 1997), denoted by the vector X_{t-1} in equation (8). This vector is

$$X'_{t-1} = \left(r_{t-1}, \Delta sr_{t-1}, \Delta ts_{t-1}, \Delta dy_{t-1}, Df_t\right) \tag{20}$$

These control variables reflect the business cycle and agents' beliefs about an economy's prospects. The variables are commonly used in the literature, and are all lagged one period: own excess returns r, the change in short-term interest rates Δsr (30-day Eurocurrency rates as proxies for risk-free rates), the change in the term structure Δts, the change in the dividend yield in excess of the short-term interest rate Δdy, and a Friday dummy to cover end-of-the-week effects Df. As indicated in equation (8), for the local market i both the own control variables as well as those of the regional and global markets are included.

4.2 The results

Tables 2 and 3 present the results for the trivariate GARCH model (6)-(9) with constant coefficients, i.e. with coefficients that are assumed to be time-invariant. Table 2 gives a summary of the results, aggregating coefficients over the Euro area versus the non-Euro area and for different sub-periods. Three striking results emerge concerning (a) the overall degree of integration, (b) the relative importance of the Euro area versus that of the USA, and (c) the changes in these relations over time.

Table 2

GARCH Summary Results for Stock Market Integration

The GARCH model for country i without asymmetry and threshold effects, as defined in equations (6)-(9), is

$$r_{i,t} = \omega_{i,t-1} + \mu_{i,t} \tag{6.a}$$

$$\mu_{i,t} = \gamma_{iE}\varepsilon_{E,t} + \gamma_{iU}\varepsilon_{U,t} + \varepsilon_{i,t} \tag{7.a}$$

$$\sigma^2_{\varepsilon,i,t} = \alpha_{i0} + \alpha_i\sigma^2_{\varepsilon,i,t-1} + \alpha_{ii}\varepsilon^2_{i,t-1} + \alpha_{iE}\varepsilon^2_{E,t} + \alpha_{iU}\varepsilon^2_{U,t-1} \tag{9.a}$$

where $r_{i,t}$ is the excess return, $\omega_{i,t-1}$ the conditional mean return that is a function of past information on local, regional and global fundamentals X. The local innovation $\mu_{i,t}$ is explained through contemporaneous global shocks $\varepsilon_{U,t-1}$ and regional Euro-area shocks $\varepsilon_{E,t}$ as well as a purely idiosyncratic component $\varepsilon_{i,t}$. The measures of integration are the coefficients γ_{iE} and γ_{iU}, and are estimated as constant coefficients over each sample period. Table 2 lists weighted averages of the integration coefficients, with the weights being GDP shares. The GARCH model with asymmetry and threshold effects of equations (11) and (12) and its integration measures are accordingly:

	Price effects	Volatility effects		Price effects	Volatility effects
Small, positive shocks:	V_{t-1}	ζ	Small, negative shocks:	$(\nu_{t-1} + \delta_{t-1})$	$(\varsigma + \varphi)$
Large, positive shocks:	$(\nu_{t-1} + \tau_{t-1})$	$(\varsigma + \eta)$	Large, negative shocks:	$(\nu_{t-1} + \tau_{t-1} + \delta_{t-1})$	$(\varsigma + \varphi + \eta)$

	OWN EFFECTS		RETURN SPILLOVERS										VOLATILITY SPILLOVERS									
			FROM EURO-AREA					FROM USA					FROM EURO-AREA					FROM USA				
	price	volatil.	total	positive shock		negative shock		total	positive shock		negative shock		total	positive shock		negative shock		total	positive shock		negative shock	
				small	large	small	large		small	large	small	large		small	large	small	large		small	large	small	large
1/1986 - 6/2000	β_{ii}	α_{ii}	γ_{iE}					γ_{iU}					α_{iE}					α_{iU}				
ALL countries	0.068	0.119	0.344	0.269	0.294	0.348	0.373	0.359	0.232	0.327	0.292	0.387	0.042	-0.020	0.038	0.016	0.074	0.023	0.014	0.074	0.048	0.108
Euro-area	0.046	0.112	0.445	0.357	0.408	0.462	0.513	0.367	0.278	0.348	0.318	0.389	0.061	0.001	0.062	0.025	0.086	0.017	-0.007	0.085	0.030	0.122
Non-Euro-area	0.094	0.127	0.229	0.168	0.164	0.217	0.212	0.351	0.181	0.302	0.262	0.384	0.021	-0.044	0.010	0.006	0.060	0.030	0.038	0.061	0.069	0.092
1/1986 - 7/1992																						
ALL countries	0.106	0.146	0.200	0.132	0.175	0.182	0.225	0.312	0.148	0.323	0.145	0.320	0.028	-0.028	0.011	0.012	0.052	0.040	0.146	0.028	0.168	0.050
Euro-area	0.107	0.154	0.270	0.167	0.225	0.268	0.326	0.321	0.240	0.347	0.210	0.317	0.048	-0.042	0.019	0.003	0.065	0.039	0.191	0.026	0.216	0.051
Non-Euro-area	0.105	0.137	0.120	0.092	0.119	0.082	0.110	0.300	0.043	0.295	0.071	0.323	0.007	-0.012	0.002	0.023	0.037	0.041	0.096	0.031	0.114	0.049
8/1992 - 7/1993																						
ALL countries	0.145	0.160	0.089	0.058	0.033	0.211	0.186	0.318	0.321	0.286	0.301	0.265	0.096	0.251	-0.048	0.589	0.291	0.014	0.156	0.140	0.018	0.001
Euro-area	0.171	0.085	0.160	0.191	0.101	0.330	0.240	0.317	0.469	0.246	0.491	0.268	0.208	0.389	0.024	0.728	0.363	-0.068	-0.025	0.042	-0.105	-0.038
Non-Euro-area	0.115	0.245	0.007	-0.094	-0.046	0.076	0.123	0.319	0.152	0.332	0.083	0.263	-0.032	0.092	-0.130	0.430	0.208	0.108	0.364	0.251	0.158	0.045
8/1993 - 4/1998																						
ALL countries	0.003	0.105	0.352	0.427	0.304	0.499	0.375	0.392	0.252	0.336	0.356	0.440	0.095	0.083	0.138	0.086	0.140	0.007	0.103	0.025	0.098	0.020
Euro-area	-0.030	0.099	0.500	0.548	0.452	0.626	0.529	0.439	0.294	0.388	0.386	0.481	0.091	0.066	0.171	0.028	0.133	0.005	0.145	0.009	0.171	0.036
Non-Euro-area	0.041	0.113	0.183	0.289	0.134	0.353	0.198	0.338	0.205	0.276	0.322	0.392	0.100	0.103	0.099	0.152	0.149	0.010	0.055	0.044	0.013	0.001
5/1998 - 6/2000																						
ALL countries	0.037	0.073	0.701	0.621	0.589	0.806	0.774	0.358	0.266	0.313	0.372	0.418	0.080	0.021	0.117	-0.061	0.036	0.032	0.093	-0.004	0.157	0.061
Euro-area	0.009	0.055	0.911	0.848	0.834	1.006	0.992	0.345	0.435	0.323	0.484	0.373	0.113	0.023	0.156	-0.083	0.050	0.003	-0.054	-0.015	-0.018	0.021
Non-Euro-area	0.069	0.094	0.460	0.360	0.308	0.577	0.525	0.372	0.074	0.301	0.242	0.469	0.042	0.018	0.073	-0.035	0.021	0.065	0.261	0.009	0.358	0.106

Table 3

GARCH Results for Stock Market Integration, Individual Countries

The table description is identical to that for Table 2, with the difference that the coefficients in Table 3 are for individual countries and asymmetry and threshold effects are not listed in order to preserve space.

	PRICE SPILLOVERS										VOLATILITY SPILLOVERS									
	FROM EURO-AREA γ_{iE}					FROM USA γ_{iU}					FROM EURO-AREA α_{iE}					FROM USA χ_{iU}				
	TOTAL	SUB-PERIODS				TOTAL	SUB-PERIODS				TOTAL	SUB-PERIODS				TOTAL	SUB-PERIODS			
	1986-2000	1/86-7/92	8/92-7/93	8/93-4/98	5/98-6/00	1986-2000	1/86-7/92	8/92-7/93	8/93-4/98	5/98-6/00	1986-2000	1/86-7/92	8/92-7/93	8/93-4/98	5/98-6/00	1986-2000	1/86-7/92	8/92-7/93	8/93-4/98	5/98-6/00
Euro-area:																				
Austria	0.237 **	0.119 **	0.224 **	0.313 **	0.364 **	0.181 **	0.095 **	0.270 **	0.322 **	0.210 **	0.043 **	0.057 **	0.129 *	0.024 *	0.078 **	0.002	-0.005 **	-0.057	0.033 **	0.066 **
	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.095	0.003	0.391	0.000	0.350	0.009	0.001
Belgium	0.294 **	0.194 **	0.029	0.373 **	0.547 **	0.278 **	0.275 **	0.252 **	0.305 **	0.214 **	0.094 **	0.046 **	0.105 *	0.039 **	0.080 *	0.050 **	0.076 **	-0.030	0.005	0.032
	0.000	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.054	0.000	0.014	0.000	0.000	0.646	0.300	0.169
Finland	0.855 **			0.665 **	1.096 **	0.723 **			0.695 **	0.772 **	0.047 **			0.079 *	0.769 **	0.013			0.001	0.009 **
	0.000			0.000	0.000	0.000			0.000	0.001	0.003			0.029	0.005	0.304			0.955	0.008
France	0.474 **	0.288 **	0.072	0.576 **	0.918 **	0.354 **	0.308 **	0.335 **	0.411 **	0.352 **	0.044 **	0.033 *	0.199 *	0.036 *	0.165 *	0.019 **	0.066 **	0.048	0.000	-0.006
	0.000	0.000	0.395	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.019	0.012	0.014	0.000	0.000	0.432	0.913	0.579
Germany	0.466 **	0.389 **	0.293 **	0.385 **	0.995 **	0.441 **	0.375 **	0.365 **	0.573 **	0.399 **	0.094 **	0.070 **	0.129 **	0.109 **	0.032	0.028 **	0.029 **	-0.017 **	0.010	0.018
	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.198	0.000	0.000	0.009	0.159	0.287
Italy	0.496 **	0.282 **	0.137	0.557 **	0.977 **	0.303 **	0.319 **	0.258	0.321 **	0.294 **	0.048 **	0.057 **	0.480	0.102 *	0.055 *	-0.002	0.036 **	-0.270	-0.002	-0.002
	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.000	0.302	0.097	0.036	0.716	0.000	0.393	0.851	0.733
Netherlands	0.204 **	0.062 **	-0.012	0.419 **	0.827 **	0.395 **	0.367 **	0.345 **	0.495 **	0.402 **	0.024 **	0.010	0.054	0.075 **	0.258 **	0.028 **	0.051 **	0.183 *	0.014	-0.017 **
	0.000	0.001	0.780	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.107	0.107	0.000	0.000	0.000	0.000	0.013	0.218	0.000
Spain	0.432 **	0.162 **	0.227 *	0.656 **	0.843 **	0.314 **	0.319 **	0.359 **	0.373 **	0.256 **	0.053 **	0.033 **	0.092	0.180 **	0.129 **	0.005 *	0.014 *	-0.238 **	0.004	-0.019 **
	0.000	0.000	0.021	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.450	0.000	0.000	0.099	0.062	0.003	0.805	0.000
Non-Euro-area:																				
Denmark	0.246 **	0.201 **	0.149 *	0.235 **	0.352 **	0.323 **	0.215 **	0.265 **	0.368 **	0.368 **	0.055 **	0.073 *	0.017	0.153 **	0.027	0.010 *	-0.001	-0.051	0.033 *	0.020 *
	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.013	0.862	0.000	0.102	0.017	0.941	0.441	0.012	0.056
Norway	0.426 **	0.271 **	0.200	0.437 **	0.561 **	0.411 **	0.532 **	0.475 **	0.434 **	0.322 **	0.059 **	0.101	0.711 **	0.115 **	0.063 **	0.008	0.246 **	-0.159	0.030	-0.001
	0.000	0.000	0.154	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.212	0.002	0.006	0.006	0.184	0.006	0.441	0.125	0.922
Sweden	0.539 **	0.338 **	0.184 *	0.701 **	0.873 **	0.464 **	0.458 **	0.450 **	0.520 **	0.431 **	0.032 **	0.046 **	0.221 *	0.156 **	0.008	0.007 *	0.015 *	0.013	0.036	0.042 *
	0.000	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.002	0.638	0.046	0.062	0.832	0.194	0.015
Switzerland	0.415 **	0.274 **	0.123 *	0.554 **	0.752 **	0.339 **	0.346 **	0.394 **	0.387 **	0.254 **	0.105 **	0.068 **	0.107	0.103 **	0.191 **	0.037 **	0.063 **	0.004	0.018 *	0.011
	0.000	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.101	0.000	0.001	0.000	0.000	0.934	0.073	0.530
UK	0.331 **	0.185 **	0.039	0.455 **	0.656 **	0.281 **	0.242 **	0.368 **	0.266 **	0.339 **	0.013 **	0.001	0.086	0.066 **	0.045 *	0.012 **	0.045 **	0.073	-0.009 **	0.017
	0.000	0.000	0.604	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.827	0.200	0.000	0.066	0.000	0.000	0.498	0.007	0.298
Japan	0.151 **	0.091 **	-0.044	0.016	0.330 **	0.312 **	0.275 **	0.258 *	0.304 **	0.365 **	0.018 *	-0.002	-0.167 **	0.122 **	0.040	0.036 **	0.033 **	0.161	0.013	0.107 *
	0.000	0.005	0.704	0.733	0.000	0.000	0.000	0.043	0.000	0.000	0.030	0.786	0.008	0.000	0.220	0.000	0.000	0.454	0.327	0.012
Canada	0.121 *	-0.062	0.071	-0.101	0.461 **	0.679 **	0.430 **	0.298 **	0.480 **	0.535 **	0.012	-0.004 *	0.020	0.021 *	0.023 **	0.062 **	0.017 **	0.049	0.014 *	0.042 **
	0.012	0.121	0.267	0.121	0.001	0.000	0.000	0.000	0.000	0.000	0.352	0.089	0.328	0.073	0.005	0.000	0.000	0.170	0.026	0.008
Australia	0.197 **	0.023	-0.080	0.121 *	0.282 **	0.459 **	0.408 **	0.486 **	0.526 **	0.372 **	0.023 *	0.005	0.057	0.098 **	0.039	0.032 **	0.098 **	0.130	0.025 *	0.025 *
	0.000	0.543	0.390	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.696	0.270	0.001	0.168	0.000	0.000	0.315	0.092	0.072

*p-values are listed in small numbers below the coefficients. **, * to the right of a coefficient show whether it is significant at the 1% level and the 10% level, respectively.*

First, the large size of the coefficients are a first indication that equity markets in Europe are highly integrated (Table 2): a shock of 1% in the Euro area leads on average to a change in returns of 0.344% in other markets whereas shocks in the USA have a similar impact of 0.359%. There is also strong evidence that the shock transmission is highly asymmetric and exhibits threshold effects: large, negative innovations in the Euro area have a coefficient of 0.373, whereas the corresponding coefficient for small positive shocks is only 0.269. As a rough estimate, the results indicate that on average negative shocks have a 25% larger effect than positive innovations, and large shocks have about a 10% bigger impact than small ones.

Second, while the USA is clearly the dominant market outside the Euro area, it is no longer the only dominant market within the Euro area. By comparing the periods 1986-1992 with 1993-2000 (Table 3) one can see that the US market was the most important one during the late 1980s and early 1990s but that the Euro area market has become the dominant force for individual Euro area countries since the mid-1990s. This holds for all of the eight Euro area countries but not for markets outside of the Euro area.

Third, there are some further striking changes over time in the degree and nature of financial integration. Not only has the integration of equity markets with those of the Euro area markets and the USA become stronger over time, but also the importance of own past shocks has become significantly smaller. Both of these findings underline how much more integrated and also efficient equity markets have become during the 1990s.

Fourth, the degree of integration has strongly increased within the Euro area since the announcement of the Euro members in May 1998 (Table 3). The size of the coefficients for the return spillover from the Euro area to individual Euro area markets has more than doubled from 0.445 for the full sample to 0.911 for the period May 1998-2000 (Table 2).

Fifth, a striking finding is that financial market integration within Europe was significantly lower during the ERM crisis of 1992-93 (Table 3). This finding is of particular interest because it is contrary to the finding of increased financial interdependence found during the Latin America and Asia currency crises (e.g. Baig and Goldfajn 1998).

Finally, not only has the transmission of shocks become stronger, but importantly, asymmetric and threshold effects have become larger over time. In other words, not only do shocks in one equity market raise volatility in other markets more now than before, but it is in particular the transmission of large and negative shocks that has increased more proportionally than the spillover of small and positive innovations. For instance, a large, negative return shock in the Euro area had a higher impact of only 0.093 (= 0.225 - 0.132) than a small, positive innovation during 1986-93. This difference rose to 0.153 (= 0.774 - 0.621) in 1998-2000 (Table 2).

Overall, these findings give strong support to the hypothesis that individual markets within the Euro area have become increasingly integrated over time and that the degrees of asymmetry and threshold effects have intensified.

5 Illustrating time-varying financial integration: Rolling estimation and recursive estimation techniques

The disadvantage of looking at longer time horizons and even at sub-samples, as presented in section 4, is that such an analysis provides only a very general picture of the overall integration process. However, the degree of integration may often change on a regular, possibly even a daily basis. The purpose of this sub-section is to illustrate the volatility in the integration of stock markets.

To capture the time-variation I use rolling estimation and recursive estimation techniques. For the rolling estimations, I take a 12-month regression window, starting from the period January 1986-January 1987, and move this 12-month window forward by one month at a time. For the recursive estimation, I start with the same regression for January 1986-January 1987 but then keep the starting date fixed and only move the end date forward by one month at a time.9 Both rolling and recursive methods have some shortcomings, but they provide a good first proxy of the volatility of the parameters of the system.

9 Kalman filtering is an often-used type of recursive method in which the model is updated each period, although it requires quite restrictive assumptions about the updating and smoothing of the time-varying parameters. McKenzie, Brooks and Faff (1999) provide a discussion and evaluation of alternative ways of measuring time variations in stock markets.

Figure 1

Comparing Methodologies for Estimating Time-Varying Coefficients for Integration with the Euro Area, Netherlands

The GARCH model estimated for country *i* is

$$r_{i,t} = \omega_{i,t-1} + \mu_{i,t} \quad (6.a),$$

$$\mu_{i,t} = \gamma_{iE}\varepsilon_{E,t} + \gamma_{iU}\varepsilon_{U,t} + \varepsilon_{i,t} \quad (7.a),$$

$$\sigma^2_{\varepsilon,i,t} = \alpha_{i0} + \alpha_i\sigma^2_{\varepsilon,i,t-1} + \alpha_{ii}\varepsilon^2_{i,t-1} + \alpha_{iE}\varepsilon^2_{E,t} + \alpha_{iU}\varepsilon^2_{U,t-1} \quad (9.a)$$

where $r_{i,t}$ is the excess return, $\omega_{i,t-1}$ the conditional mean return that is a function of past information on local, regional and global fundamentals X. The local innovation $\mu_{i,t}$ is explained through contemporaneous global shocks $\varepsilon_{U,t-1}$ and regional Euro-area shocks $\varepsilon_{E,t}$ as well as a purely idiosyncratic component $\varepsilon_{i,t}$. The measures of integration are the coefficients γ_{iE} and γ_{iU}, and are estimated as constant coefficients over each sample period. β_{ii} is a measure of market efficiency and measures the dependence of returns $r_{I,t}$ on own past returns $r_{I,t-1}$.

Fig.1 shows only the coefficient γ_{iE} for the integration of the Netherlands with the Euro area, using three different sample periods/techniques. The heavy, dotted line shows γ_{iE} for the entire sample period 1986-2000. The thin line presents the sub-period analysis for four different sub-periods, and the thick line shows the γ_{iE} estimates using 12-month rolling estimation windows.

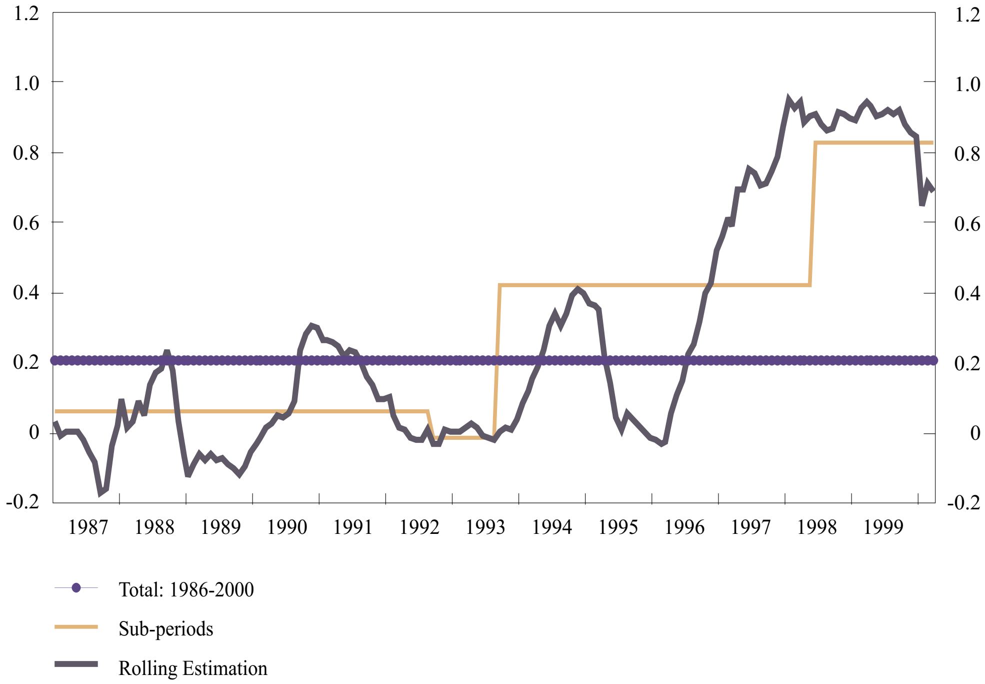


Figure 2

Time-Varying Integration, Euro Area Average GARCH 12-Month Rolling Estimates

The figure description is identical to that for Fig. 1, with the difference that Fig. 2 also shows the coefficients γ_{iU} for integration with the USA and $ß_{ii}$ for the effect of own past returns $r_{i,t-1}$. Fig. 2 shows the coefficient estimates not for an individual country but the coefficient average for the Euro area countries, with each country being weighted by its GDP share in the Euro area.

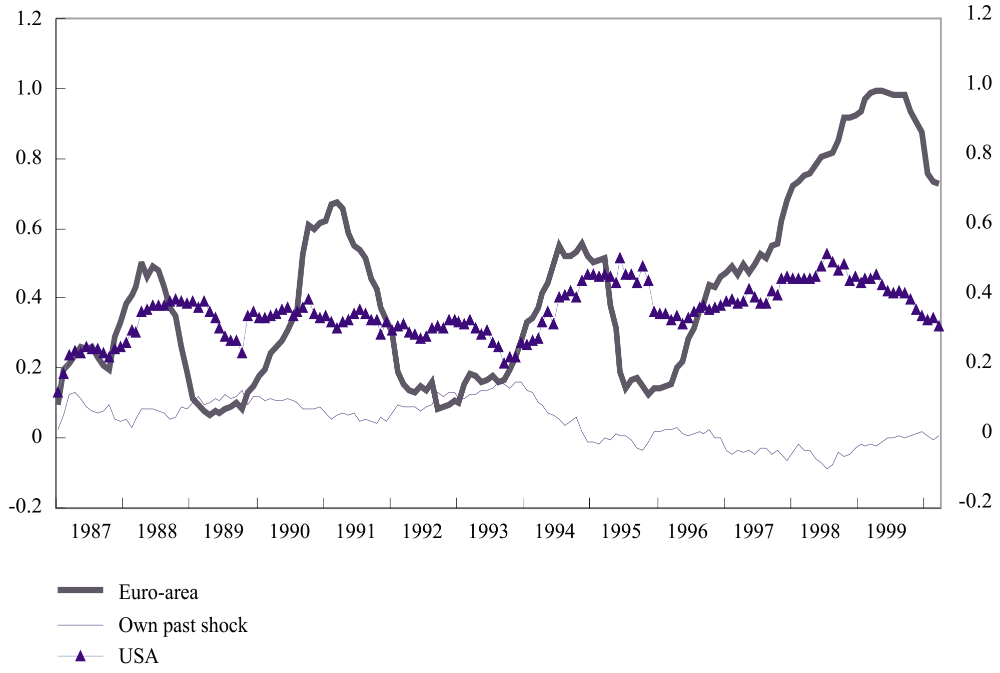


Figure 1 illustrates the shortcoming of using longer time periods to analyze financial integration. Figure 1 shows parameter γ_{iE} for contemporaneous spillovers from the Euro area to the Netherlands for different estimation methodologies. By comparing the parameters it becomes clear that even using the sub-period analysis of section 4 still hides a lot of information about the true time variation of γ_{iE}. The estimate of the 12-month rolling estimations shows how highly volatile the degree of financial integration can be.

Despite the volatility in integration, Figure 1 as well as Figure 2 for the Euro-area average and Figures 3.a-3.p for each individual country (Figures 2 and 3 also include parameters γ_{iU} for contemporaneous spillovers from the USA and $ß_{ii}$ for the effect of past own innovations) yield a number of important results. First, the results show that the Euro area has become the dominant market for most individual Euro area markets since the mid-1990s. The US market was the most important one for all individual European markets till the mid-1990s, but while its impact has remained roughly constant in the long run, the effect of Euro area shocks on individual markets has often more than doubled between the early and late 1990s.

Figure 3

Time-Varying Integration, Individual Countries: GARCH 12-Month Rolling Estimates

The figure description is identical to that for Fig. 1, with the difference that Fig. 3 also shows the coefficients γ_{iU} for integration with the USA and β_{ii} for the effect of own past returns $r_{i,t-1}$. Fig. 3 shows the coefficient estimates for each individual country.

Fig. 3.a:
Time-Varying Integration,
Italy

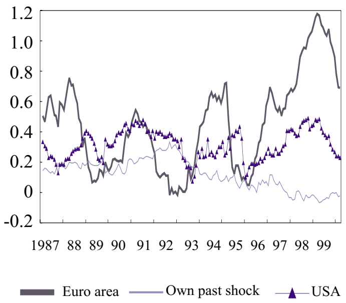


Fig. 3.b:
Time-Varying Integration,
Netherlands

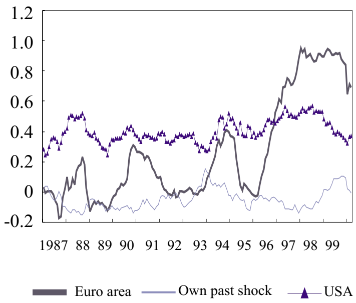


Fig. 3.c:
Time-Varying Integration,
Spain

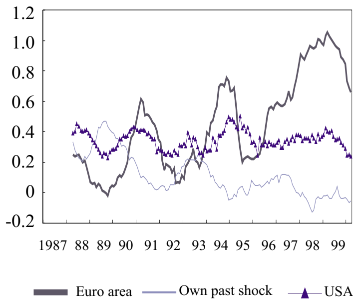


Fig. 3.d:
Time-Varying Integration,
UK

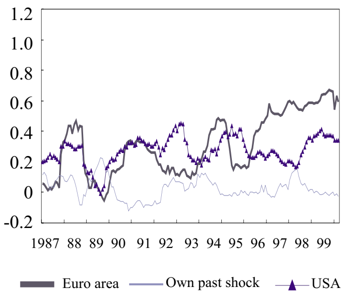


Fig. 3.e:
Time-Varying Integration,
Japan

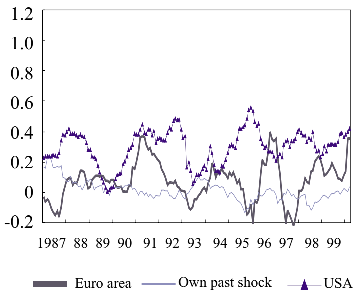


Fig. 3.f:
Time-Varying Integration,
Norway

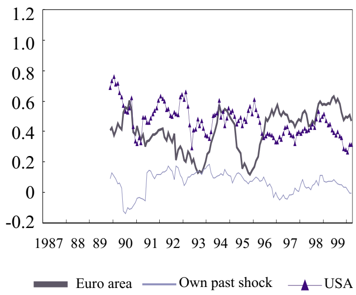


Fig. 3.g:
Time-Varying Integration,
Austria

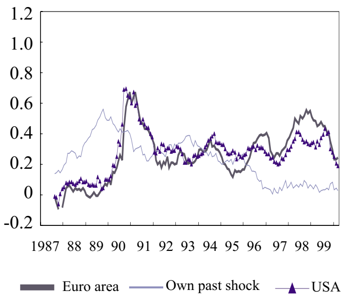


Fig. 3.h:
Time-Varying Integration,
Belgium

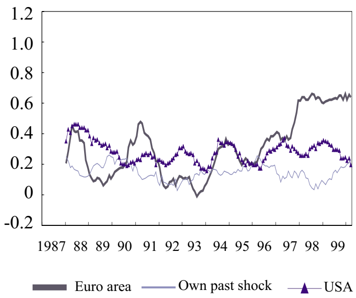


Fig. 3.i:
Time-Varying Integration,
Denmark

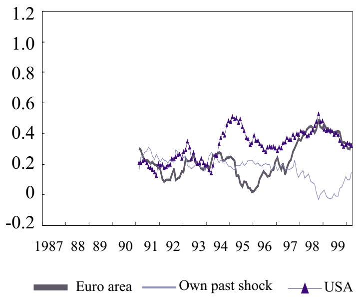


Figure 3 (continued)

Fig. 3.j:
Time-Varying Integration,
Finland

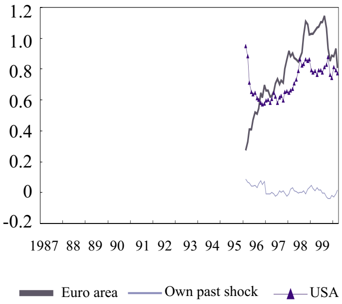


Fig. 3.k:
Time-Varying Integration,
France

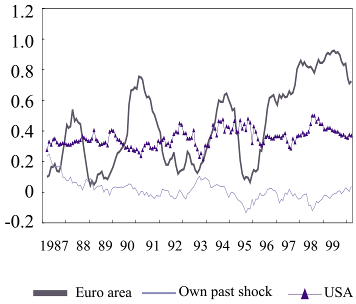


Fig. 3.l:
Time-Varying Integration,
Sweden

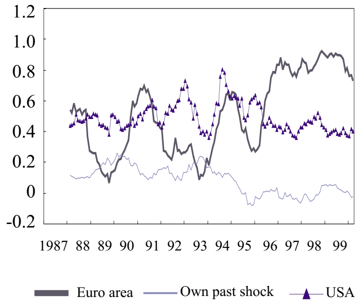


Fig. 3.m:
Time-Varying Integration,
Switzerland

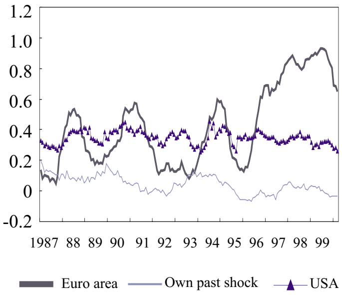


Fig. 3.n:
Time-Varying Integration,
Australia

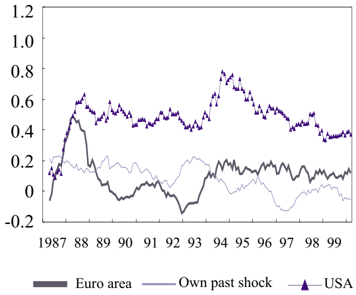


Fig. 3.o:
Time-Varying Integration,
Canada

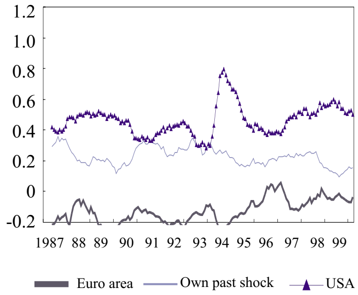
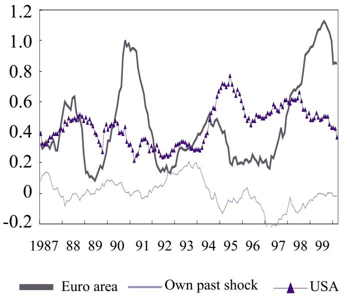


Fig. 3.p:
Time-Varying Integration,
Germany



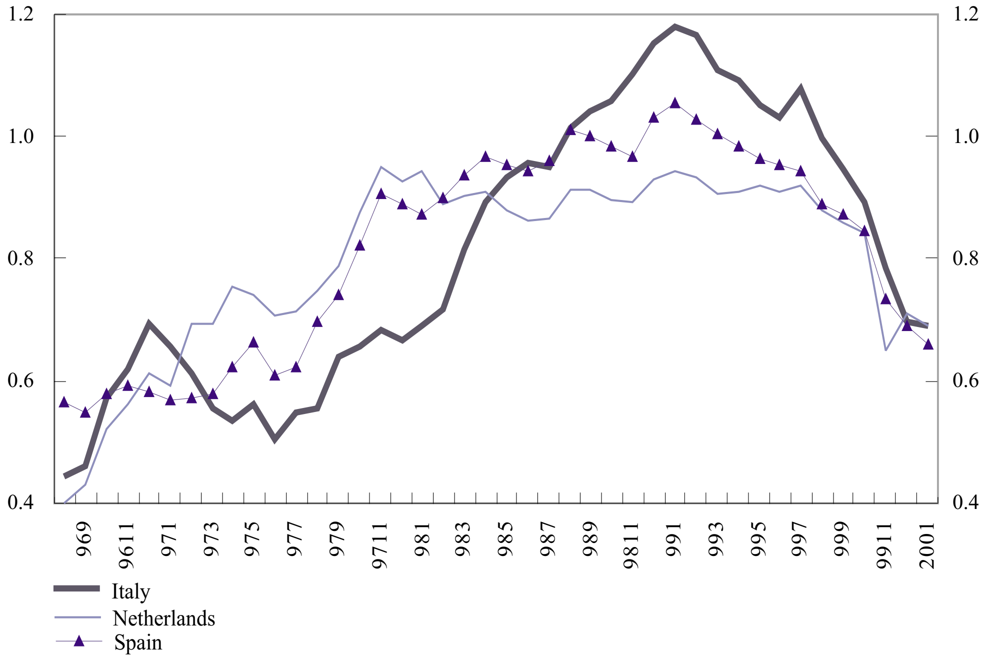
Second, the striking feature of the rolling estimations is the high degree of volatility of integration within the Euro area (γ_{iE}). The dynamics of integration for most Euro area markets show the same behavior: a low degree of integration during 1992-93 and 1995, a very rapid increase between 1996-99 and then a leveling off or even slight decrease in 1999-2000.

Third, there are some important differences in the timing of financial integration across Euro area markets. Figure 4 illustrates that countries that initially were considered unlikely candidates to join the Euro, such as Italy, experienced a somewhat later increase in financial integration than more probable candidates, such as the Netherlands and Spain. While the Netherlands and Spain experienced a quite steady increase in integration after a trough in 1995-96, a substantial rise in integration occurred for Italy only since late 1997/early 1998 when it became clear that also Italy would join the Euro.

Figure 4

Comparing Time-Varying Integration with Euro area: Italy, Netherlands, Spain. GARCH 12-Month Rolling Estimates

The figure description is identical to that for Fig. 1, with the difference that Fig. 4 shows only the γ_{iE} coefficient estimate using 12-month rolling estimations and for a shorter time period (September 1996 - March 2000) in order to emphasize the different integration dynamics across countries.



So far, one can only speculate about the explanation of these distinct features, but the timing of these events makes exchange rate volatility and credibility a strong candidate: the decline and low degree of integration in 1992-93 and 1995 may be explained through turbulence in the ERM, as a number of countries dropped permanently or temporarily out of the ERM in 1992-93, and a further but milder disturbance in 1995. Similarly, the rapid increase in the integration parameter since 1996-97 may be due to the stability and credibility of the ERM leading up to the adoption of the Euro. The following section provides a more systematic test of this hypothesis.

6 Explaining time-varying financial integration: The role of EMU

What explains the rapid increase and the volatility in the degree of financial integration in Europe? Was EMU the driving force behind this process? And more specifically, how important was the reduction and eventual elimination of exchange rate volatility and uncertainty through the ERM and the Euro?

6.1 Modeling time-varying integration

To explain the time variation in integration, I now relax the assumption of constant parameters and allow the integration parameters $\gamma_{iE,t-1}$ and $\gamma_{iU,t-1}$ of equation (7) to change over time. The behavior of these parameters is modeled as a function of a vector *Z* of underlying economic and financial variables that determine the decisions of investors:

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi'_{iE,1} Z_{iE,t-1} \tag{21}$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi'_{iU,1} Z_{iU,t-1} \tag{22}$$

As mentioned in section 2, the choice of variables to be included in the vector *Z* is a controversial issue. One would like to find variables that help explain the degree and the changes in the transmission of shocks from one market to another. The following two sub-section will test different specifications of this vector of instrumental variables.

6.2 The role of exchange rates

The central hypothesis to be tested is that exchange rates played an important role in the financial integration process in Europe. The existence of exchange rate uncertainty can function as an important device for market segmentation.[10] The more volatile and unpredictable exchange rates are and the more costly hedging against such uncertainty is, the stronger the degree of market segmentation and the lower the degree of correlation across markets. Thus a more volatile exchange rate of country *i* raises the national risk premium as investors require a higher return to compensate for increased uncertainty. Analogously, the reduction or elimination of currency risk, as entailed in EMU and the introduction of the Euro, may raise the degree of financial integration across countries.

To test this hypothesis, the behavior of the integration parameter is expressed only as a function of exchange rate volatility:

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} \tag{23}$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} \tag{24}$$

with $Evol_{iE}$ as the volatility of the daily DM exchange rate changes of country *i* over the past three months, and $Evol_{iU}$ as its US dollar exchange rate volatility.[11]

10 Other important limitations to the integration of financial markets can be the existence of transaction costs and the presence of government restrictions on market transaction, such as limiting the access to foreign exchange. For most of Western Europe's markets such constraints had been abolished by the late 1980s.

11 Exchange rate volatility for Germany in equation (23) is measured vis-à-vis other Euro area countries, weighted by their GDP shares.

Table 4

GARCH Model with Time-Varying Integration: Exchange Rate Volatility

The GARCH model estimated for country *i* is

$$r_{i,t} = \omega_{i,t-1} + \mu_{i,t} \quad (6.a),$$

$$\mu_{i,t} = \gamma_{iE,t-1}\varepsilon_{E,t} + \gamma_{iU,t-1}\varepsilon_{U,t} + \varepsilon_{i,t} \quad (7.b),$$

$$\sigma^2_{\varepsilon,i,t} = \alpha_{i0} + \alpha_i\sigma^2_{\varepsilon,i,t-1} + \alpha_{ii}\varepsilon^2_{i,t-1} + \alpha_{iE}\varepsilon^2_{E,t} + \alpha_{iU}\varepsilon^2_{U,t-1} \quad (9.a)$$

where $r_{i,t}$ is the excess return, $\omega_{i,t-1}$ the conditional mean return that is a function of past information on local, regional and global fundamentals X. The local innovation $\mu_{i,t}$ is explained through contemporaneous global shocks $\varepsilon_{U,t-1}$ and regional Euro-area shocks $\varepsilon_{E,t}$ as well as a purely idiosyncratic component $\varepsilon_{i,t}$. The measures of integration are the coefficients $\gamma_{iE,t-1}$ and $\gamma_{iU,t-1}$, and are estimated as time-varying coefficients as a function of exchange rate volatility vis-à-vis the DM ($Evol_{iE}$) and vis-à-vis the US$ ($Evol_{iU}$), with the exception that Germany's exchange rate volatility ($Evol_{iE}$) is measured vis-à-vis a GDP weighted average of other Euro-area currencies:

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} \quad (23)$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} \quad (24)$$

	DM Exchange Rate Volatility $Evol_{iE}$		US$ Exchange Rate Volatility $Evol_{iU}$			DM Exchange Rate Volatility $Evol_{iE}$		US$ Exchange Rate Volatility $Evol_{iU}$	
Austria	-0.173	**	-0.064	*	**Norway**	0.214	*	0.219	*
	0.026		0.033			0.100		0.086	
Belgium	-0.046		0.000		**Spain**	-0.071		-0.134	*
	0.046		0.000			0.091		0.075	
Denmark	-0.434	*	-0.156	*	**Sweden**	-0.350	**	0.083	
	0.202		0.075			0.058		0.055	
Finland	-0.190	**	-0.082		**Switzerland**	0.090		0.056	
	0.053		0.080			0.236		0.055	
France	-1.514	**	0.081		**UK**	0.069		-0.103	*
	0.201		0.067			0.089		0.052	
Germany	-0.157	*	0.032		**Japan**	0.073	*	-0.112	**
	0.075		0.067			0.039		0.044	
Italy	-0.034	**	-0.036	**	**Canada**	-0.106	**	0.153	
	0.013		0.014			0.037		0.185	
Netherlands	-0.365	**	-0.040		**Australia**	0.012		-0.042	
	0.081		0.054			0.046		0.040	

Robust standard errors are listed in small numbers below the coefficients.
***, * to the right of a coefficient show whether it is significant at the 1% level and the 10% level, respectively.*

Table 4 for the trivariate GARCH model shows that exchange rate volatility has a lot of power in explaining the time variation of integration. First, almost all the coefficients have a negative sign, indicating that higher exchange rate volatility leads to a lower degree of integration. Second, it is convincing that currency volatility vis-à-vis the DM is significant and large mostly only for the countries within the Euro area whereas it played less of a role for countries that were less dependent on the Euro area. And third, it is the volatility in the DM exchange rate that is the most important variable whereas the US dollar exchange rate did not seem as important in explaining the transmission of shocks from the US. What these findings indicate is that the important role of the US equity market in the world is only to a smaller extent explained by exchange rate volatility and due to other factors, such as its large and dominant market size.

Various types of sensitivity analyses were conducted. The results were robust to alternative specifications of the exchange rate volatility measure, such as using a shorter or longer time horizon. It was further tested whether the introduction of the Euro in January 1999 or the announcement of its members in May 1998 constituted a structural break that altered the relation between exchange rate uncertainty and financial integration. However, various specifications, such as using dummies for the period after the introduction of the Euro as well as looking at sub-periods prior to 1999, showed that the results of Table 4 are quite robust and confirmed the importance of the effect of exchange rate volatility on financial integration.

6.3 The role of EMU

The findings of section 6.2 indicate that exchange rates may have been a very important explanatory variable for the time-varying dynamics of financial integration in Europe. However, the danger with only looking at exchange rates is that it ignores other important factors that may have been driving the integration process. This danger is particularly strong for an analysis of financial integration in Europe because European economies have experienced significant real convergence and adhered to stricter monetary and fiscal policies in the process of European integration.

As discussed in section 2 above, real convergence can have an important effect on financial integration because asset returns reflect to some extent the business cycle. Having more similar business cycles and being more interdependent through trade may raise the degree to which shocks are being transmitted across financial markets. Similarly, since financial markets are very sensitive to changes in monetary policies, a high degree of financial integration in Europe may at least in part be explained through the convergence of monetary policies among European and in particular Euro area countries.

Since increased exchange rate stability went hand in hand with real and monetary convergence and were part of the same process, a potential problem therefore is that the exchange rate coefficients of equations (23)-(24) may pick up effects of excluded variables. A superior approach is to include a broader range of variables that also reflect real and monetary convergence. I focus on variables that are commonly used in the analysis of optimal currency areas (OCA),[12] one set measuring the degree of convergence of country *i* with the Euro area and another set relating to the convergence with the USA. The data appendix lists the definitions of the real convergence and monetary convergence criteria used in this paper.

6.3.1 Principal component analysis

The problem with the empirical implementation is that because real and monetary convergence as well as the move towards more stable exchange rates coincided, there is a high degree of correlation among many of the OCA criteria. One way of minimizing this problem of multicollinearity and avoiding spurious results is to form principal components from the OCA criteria. Through principal component analysis the time-series variables are linearly transformed into an equal number of principal components that are orthogonal to each other.

Principal components are formed separately for the real convergence criteria and the monetary policy convergence variables. To further reduce the problem of multicollinearity among the

12 See for instance Artis and Zhang (1998), and Bayoumi and Eichengreen (1998).

principal components of these two groups, I formed principal components only from four real convergence variables (correlation of cyclical components, correlation of dividend yields, correlation of term structure changes, trade integration) and two monetary variables (correlations in nominal short-term interest rates and in inflation rates). Table 5 gives an example for forming principal components for the Netherlands. It lists what share of the total variance of a particular variable is explained through a particular principal component. For most countries, the first two principal components explained most of the variation of the included variables. Therefore only two principal components for each group were included in the analysis.

Table 5

Principal Components, Netherlands

For the case of the Netherlands, Table 5 lists the share of the total variance of a particular variable that is explained through each of the principal components for the real convergence criteria (PCR_{iE}, PCR_{iU}) and the monetary policy convergence criteria (PCF_{iE}, PCF_{iU}).

	Real Convergence with Euro-area				Real Convergence with USA			
	$PCR1_{iE}$	$PCR2_{iE}$	$PCR3_{iE}$	$PCR4_{iE}$	$PCR1_{iU}$	$PCR2_{iU}$	$PCR3_{iU}$	$PCR4_{iU}$
Output growth	0.812	0.010	0.167	0.012	0.378	0.041	0.581	0.000
Dividend yields	0.223	0.775	0.001	0.001	0.187	0.779	0.035	0.000
Term structure	0.679	0.003	0.066	0.252	0.001	0.980	0.000	0.019
Trade	1.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	Monetary Policy Convergence with Euro-area				**Monetary Policy Convergence with USA**			
		$PCF1_{iE}$	$PCF2_{iE}$			$PCF1_{iU}$	$PCF2_{iU}$	
Interest rates		0.972	0.028			1.000	0.000	
Inflation rates		0.520	0.480			0.256	0.744	

The model of time-varying integration is then estimated using two principal components each of real convergence variables (*PCR1* and *PCR2*) and of monetary convergence variables (*PCF1* and *PCF2*) as well as exchange rate volatility (Evol):

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} + \psi_{iE,2} PCR1_{iE,t-1} + \psi_{iE,3} PCR2_{iE,t-1} + \psi_{iE,4} PCF1_{iE,t-1} + \psi_{iE,5} PCF2_{iE,t-1} \tag{25}$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} + \psi_{iU,2} PCR1_{iU,t-1} + \psi_{iU,3} PCR2_{iU,t-1} + \psi_{iU,4} PCF1_{iU,t-1} + \psi_{iU,5} PCF2_{iU,t-1} \tag{26}$$

Table 6 shows the results of the GARCH model with time-varying parameters of equations (25) and (26). Most of the principal components are significant in the analysis, thus confirming that real and monetary policy convergence have played some role in the process of financial integration. Most importantly, however, even after controlling for convergence criteria exchange rate volatility remains a significant force in explaining the time-varying degree of integration. The findings again confirm that it was in particular the DM exchange rate volatility that helps explain the changing degree of integration with the Euro area, whereas US dollar volatility plays less of a role in understanding the changing degree of return spillovers from the US market.

Table 6

GARCH Model with Time-Varying Integration: Principal Component Analysis

The table description is identical to that for Table 4, with the difference that the time-varying coefficients $\gamma_{iE,t-1}$ and $\gamma_{iU,t-1}$, are now estimated as a function of the principal components for the real convergence criteria (PCR_{iE}, PCR_{iU}) and the monetary policy convergence criteria (PCF_{iE}, PCF_{iU}) as well as of exchange rate volatility vis-à-vis the DM ($Evol_{iE}$) and vis-à-vis the US\$ ($Evol_{iU}$):

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} + \psi_{iE,2} PCR1_{iE,t-1} + \psi_{iE,3} PCR2_{iE,t-1} + \psi_{iE,4} PCF1_{iE,t-1} + \psi_{iE,5} PCF2_{iE,t-1} \quad (25)$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} + \psi_{iU,2} PCR1_{iU,t-1} + \psi_{iU,3} PCR2_{iU,t-1} + \psi_{iU,4} PCF1_{iU,t-1} + \psi_{iU,5} PCF2_{iU,t-1} \quad (26)$$

	EURO-AREA					USA				
	Real Convergence		Monet. Policy Convergence		Exch. Rate Volatil.	Real Convergence		Monet. Policy Convergence		Exch. Rate Volatil.
	$PCR1_{iE}$	$PCR2_{iE}$	$PCF1_{iE}$	$PCF2_{iE}$	$Evol_{iE}$	$PCR1_{iU}$	$PCR2_{iU}$	$PCF1_{iU}$	$PCF2_{iU}$	$Evol_{iU}$
Austria	0.096 *	-0.091 **	0.331 **	-0.116 **	-0.138 **	0.174 **	0.065 **	0.210 **	-0.038 *	-0.081 **
	0.043	0.030	0.098	0.028	0.026	0.031	0.016	0.068	0.023	0.030
Belgium	0.001 **	-0.130 **	0.232 **	0.249 **	-0.001	0.025 *	-0.036 *	0.046	-0.032	0.000
	0.000	0.026	0.059	0.034	0.050	0.013	0.024	0.050	0.025	0.000
Denmark	0.069 *	-0.010 *	-0.018	0.078 *	-0.368 *	0.145 **	-0.076 *	0.183 *	-0.030	-0.161 *
	0.033	0.005	0.031	0.032	0.205	0.047	0.044	0.085	0.030	0.082
Finland	0.253 **	-0.006	0.766 **	-0.121 *	0.020	0.124 *	0.121 **	0.037	-0.218	-0.098 *
	0.061	0.007	0.185	0.072	0.064	0.067	0.045	0.139	0.149	0.095
France	0.112 **	-0.026 **	0.243 *	-0.253	-1.523 **	-0.003	-0.014	0.223 *	-0.205 *	-0.168 *
	0.038	0.005	0.150	0.191	0.218	0.029	0.022	0.097	0.099	0.078
Germany	0.603 **	-0.052 **	0.123 **	0.052	-0.378 **	0.085 **	-0.123 **	-0.027	0.009	0.183 *
	0.055	0.005	0.035	0.046	0.092	0.020	0.033	0.027	0.032	0.071
Italy	0.173 **	0.653 **	0.627 **	-0.365 **	-0.223 **	0.209 *	-0.151 *	-0.042	0.026	-0.029 *
	0.000	0.000	0.108	0.096	0.035	0.098	0.091	0.163	0.074	0.016
Netherlands	0.198 **	-0.009 *	0.056 *	-0.086 *	-0.305 **	0.077 **	0.049 *	-0.016	0.024	0.030
	0.024	0.004	0.033	0.034	0.080	0.025	0.021	0.022	0.025	0.061
Norway	-0.014	-0.007 *	0.520 **	-0.193 **	0.082	-0.016	-0.031	0.190 *	-0.179 **	0.175 *
	0.052	0.005	0.167	0.051	0.108	0.051	0.029	0.108	0.068	0.092
Spain	0.259 **	-0.017 **	0.095 *	0.030	-0.212 *	0.076 *	-0.075 *	0.133 **	-0.217 **	0.096
	0.034	0.005	0.050	0.036	0.100	0.042	0.042	0.048	0.050	0.101
Sweden	0.020 **	-0.019	0.385 **	0.217 **	-0.137 *	0.057	0.020 *	-0.187 *	-0.024	0.034
	0.003	0.038	0.098	0.049	0.064	0.049	0.011	0.098	0.055	0.057
Switzerland	0.359 **	-0.036 **	0.034	-0.073	1.053 **	0.050 *	0.024	0.061 *	0.034	0.008
	0.048	0.006	0.047	0.049	0.277	0.026	0.023	0.025	0.034	0.062
UK	0.151 **	-0.068 **	0.075	-0.012	-0.199 *	0.045 *	-0.011	-0.001	0.015	-0.107 *
	0.029	0.008	0.082	0.068	0.108	0.032	0.069	0.030	0.031	0.078
Japan	0.009	0.015	0.427 *	0.012	-0.017	0.030 **	0.010	-0.439 **	-0.101 **	-0.051 *
	0.048	0.013	0.184	0.067	0.065	0.004	0.020	0.086	0.033	0.040
Canada	0.063 **	-0.048 *	0.007	-0.050 *	-0.172 **	-0.002	0.005	-0.067 *	-0.008	0.216
	0.016	0.020	0.023	0.025	0.046	0.025	0.014	0.029	0.027	0.228
Australia	0.050	-0.037	0.089 *	-0.019	-0.023 *	0.101 *	0.011	-0.127	-0.237 **	-0.188 **
	0.069	0.053	0.034	0.023	0.057	0.049	0.030	0.029	0.025	0.039

Robust standard errors are listed in small numbers below the coefficients.
***, * to the right of a coefficient show whether it is significant at the 1% level and the 10% level, respectively.*

6.3.2 Individual variable analysis

The disadvantage of the principal component analysis is that through the linear transformation of the convergence variables the coefficients can not be interpreted in a meaningful way, by for instance comparing their sign or size. As an alternative specification, I test a simple specification of the model by including only one variable for each category which proved to have relative little correlation with each other: the correlation of output growth (y_{t-1}), the correlation of inflation rates (p_{t-1}) and exchange rate volatility ($Evol_{t-1}$):

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} + \psi_{iE,2} y_{iE,t-1} + \psi_{iE,3} p_{iE,t-1} \tag{27}$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} + \psi_{iU,2} y_{iU,t-1} + \psi_{iU,3} p_{iU,t-1} \tag{28}$$

Table 7 again confirms the importance of exchange rate volatility. However, since the variables for real convergence and monetary convergence are not fully representative for each category one ought to be cautious in drawing more general conclusions. The main purpose is to show that the importance of exchange rate volatility as a determinant for financial integration in Europe is quite robust to the specification of the model.

Table 7

GARCH Model with Time-Varying Integration: Individual Variable Analysis

The table description is identical to that for Table 4, with the difference that the time-varying coefficients $\gamma_{iE,t-1}$ and $\gamma_{iU,t-1}$, are now estimated as a function of the correlation of output growth (y_{t-1}), the correlation of inflation rates (p_{t-1}) and exchange rate volatility ($Evol_{t-1}$) with Germany (subscript E) and with the US (subscript U):

$$\gamma_{iE,t-1} = \psi_{iE,0} + \psi_{iE,1} Evol_{iE,t-1} + \psi_{iE,2} y_{iE,t-1} + \psi_{iE,3} p_{iE,t-1} \qquad (27)$$

$$\gamma_{iU,t-1} = \psi_{iU,0} + \psi_{iU,1} Evol_{iU,t-1} + \psi_{iU,2} y_{iU,t-1} + \psi_{iU,3} p_{iU,t-1} \qquad (28)$$

	EURO-AREA			USA		
	Real Convergence	Monet. Policy Convergence	Exch. Rate Volatil.	Real Convergence	Monet. Policy Convergence	Exch. Rate Volatil.
	y_{iE}	p_{iE}	$Evol_{iE}$	y_{iU}	p_{iU}	$Evol_{iU}$
Austria	0.904 **	0.353 **	-0.180 **	-0.111 **	0.001	-0.070 *
	0.110	0.084	0.025	0.024	0.058	0.033
Belgium	0.019	0.099 *	-0.056 *	0.019	0.009	0.000
	0.035	0.045	0.025	0.023	0.046	0.000
Denmark	0.330 **	-0.419 **	-0.479 *	0.133 **	0.096	-0.021
	0.073	0.149	0.200	0.048	0.080	0.093
Finland	0.380 **	0.049	-0.041	0.757 **	-0.059	0.111
	0.051	0.111	0.065	0.195	0.165	0.096
France	1.212 **	0.618 **	-1.027 **	0.009	-0.271 *	0.164 *
	0.117	0.078	0.208	0.027	0.130	0.074
Germany	0.717 **	0.259 **	-0.053 *	0.059 *	-0.047	0.098
	0.112	0.069	0.028	0.025	0.055	0.069
Italy	0.380 **	0.401 **	-0.032	0.083	0.298 **	-0.033 *
	0.039	0.095	0.033	0.071	0.109	0.014
Netherlands	0.445 **	0.123 **	-0.263 **	0.044	-0.033	-0.013
	0.057	0.045	0.087	0.033	0.046	0.058
Norway	0.079	0.192	0.230 *	0.063	0.293 *	0.205 *
	0.049	0.137	0.103	0.051	0.130	0.086
Spain	0.470 **	-0.349 **	-0.056 *	-0.088	0.084	0.040
	0.063	0.057	0.029	0.056	0.103	0.087
Sweden	0.130 **	0.482 **	-0.289 **	-0.017	-0.201 *	0.076
	0.032	0.091	0.055	0.042	0.089	0.052
Switzerland	0.279 **	-0.281 **	1.111 **	-0.010	-0.036	0.047
	0.068	0.082	0.252	0.031	0.089	0.057
UK	0.174 **	0.202 **	-0.270 **	0.182 *	0.071	-0.135 *
	0.024	0.058	0.105	0.074	0.068	0.054
Japan	0.020	0.050	-0.041	-0.006	-0.293 **	-0.036
	0.048	0.103	0.051	0.020	0.084	0.041
Canada	0.025 *	-0.015	-0.095 *	0.039	0.289 **	0.178
	0.013	0.027	0.040	0.037	0.047	0.184
Australia	0.034	0.139 **	0.097 *	-0.008	-0.125 *	-0.012
	0.030	0.040	0.047	0.024	0.058	0.042

Robust standard errors are listed in small numbers below the coefficients.
***, * to the right of a coefficient show whether it is significant at the 1% level and the 10% level, respectively.*

6.4 Specification and robustness tests

How well does the model explain the data of the time-variation of integration? The variance ratio test of equations (17) and (18) offer a goodness-of-fit test for the estimated models. Table 8 shows that the variance ratios are mostly around 0.2 for the model of equations (25)-(26), indicating that this model manages to explain about 20% of the time variation of local returns for the most recent period of May 1998 - June 2000. Although this might seem small, it should be kept in mind that the data has daily frequency, therefore including a lot of volatility. Moreover, these numbers compare very favorably to similar models conducted with either daily or weekly data (for instance, Ng 2000).

Table 8

Variance Ratio Tests

Using the results of the GARCH model of equation (6)-(9) with time-varying coefficients, the variance ratios with the Euro-area market (VR_{iE}), with the US market (VR_{iU}) and for both combined for country i are estimated as

$$VR_{iE,t} = \frac{\gamma^2_{iE,t-1}\sigma^2_{E,t}}{\sigma^2_{i,t}} \in [0,1] \tag{17}$$

$$VR_{iU,t} = \frac{\gamma^2_{iU,t-1}\sigma^2_{U,t}}{\sigma^2_{i,t}} \in [0,1] \tag{18}$$

	EURO-AREA & USA				EURO-AREA				USA			
	1/87 - 6/92	7/92 - 7/93	8/93 - 4/98	5/98 - 6/00	1/87 - 6/92	7/92 - 7/93	8/93 - 4/98	5/98 - 6/00	1/87 - 6/92	7/92 - 7/93	8/93 - 4/98	5/98 - 6/00
Austria	0.049	0.044	0.040	0.083	0.027	0.015	0.017	0.053	0.022	0.029	0.023	0.030
Belgium	0.103	0.068	0.117	0.182	0.021	0.012	0.046	0.113	0.082	0.055	0.070	0.070
Denmark	0.035	0.034	0.056	0.110	0.014	0.012	0.016	0.051	0.020	0.022	0.040	0.060
Finland	0.038	0.017	0.057	0.087	0.000	0.005	0.012	0.024	0.038	0.012	0.046	0.063
France	0.126	0.103	0.122	0.219	0.029	0.030	0.036	0.076	0.097	0.073	0.085	0.143
Germany	0.131	0.138	0.136	0.200	0.016	0.056	0.039	0.114	0.115	0.081	0.096	0.086
Italy	0.061	0.033	0.048	0.093	0.019	0.010	0.022	0.056	0.041	0.023	0.026	0.037
Netherlands	0.220	0.198	0.172	0.283	0.071	0.073	0.044	0.131	0.148	0.124	0.128	0.152
Norway	0.053	0.041	0.050	0.054	0.003	0.003	0.003	0.005	0.051	0.038	0.046	0.049
Spain	0.110	0.061	0.098	0.201	0.023	0.016	0.043	0.139	0.087	0.045	0.055	0.062
Sweden	0.125	0.077	0.125	0.197	0.037	0.017	0.051	0.119	0.088	0.060	0.074	0.077
Switzerland	0.176	0.175	0.199	0.192	0.131	0.147	0.167	0.160	0.045	0.028	0.033	0.032
UK	0.131	0.116	0.170	0.292	0.023	0.017	0.046	0.121	0.109	0.099	0.124	0.170
Japan	0.097	0.058	0.082	0.133	0.051	0.031	0.039	0.072	0.045	0.027	0.043	0.060
Canada	0.090	0.107	0.170	0.201	0.020	0.027	0.013	0.021	0.070	0.080	0.157	0.181
Australia	0.174	0.156	0.130	0.188	0.095	0.095	0.062	0.100	0.079	0.061	0.068	0.088

Note: EURO-AREA & USA shows how much of the total variance of the local market return is explained by both regional markets combined.

The changes in the variance ratios over the different sub-periods also confirm two findings: first, there has been a large increase in the variance ratios, indicating that individual markets have become more integrated over time. And second, the US market was the dominant one till the mid-1990s but then the Euro area market became significantly more important for European markets. Figures 5.a-d and 6.a for a representative group show in more detail how the variance ratio of the Euro-market increased strongly after 1995 for Euro area countries but not for those outside for which the US market remains dominant.

Figure 5

Variance Ratio Tests: Belgium, UK, Spain, Canada

Using the results of the GARCH model of equation (6)-(9) with time-varying coefficients, the variance ratios with the Euro-area market (VR_{iE}) and the US market (VR_{iU}) for country i are estimated as

$$VR_{iE,t} = \frac{\gamma_{iE,t-1}^{2}\sigma_{E,t}^{2}}{\sigma_{i,t}^{2}} \in [0,1] \tag{17}$$

$$VR_{iU,t} = \frac{\gamma_{iU,t-1}^{2}\sigma_{U,t}^{2}}{\sigma_{i,t}^{2}} \in [0,1] \tag{18}$$

Fig. 5.a: Variance Ratios, Belgium

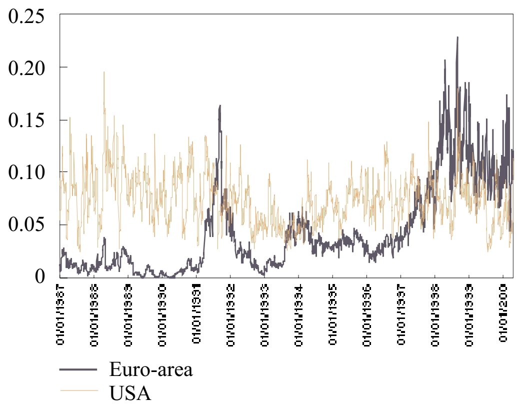


Fig. 5.c: Variance Ratios, UK

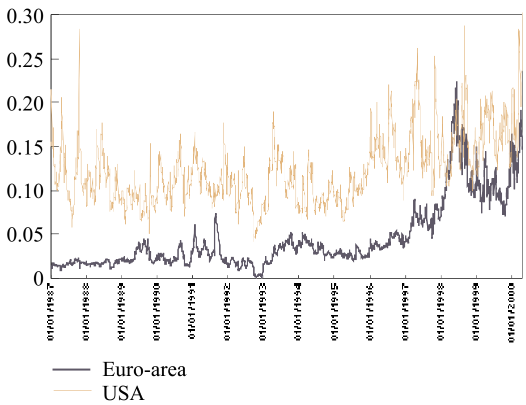


Fig. 5.b: Variance Ratios, Spain

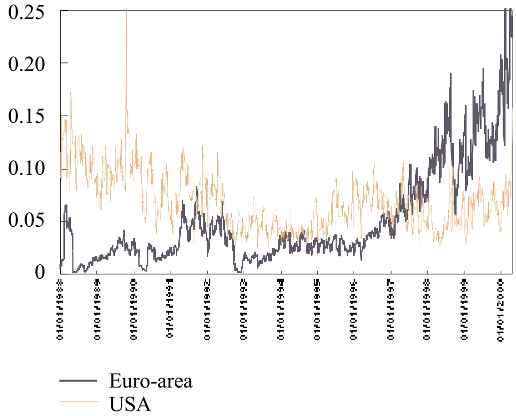


Fig. 5.d: Variance Ratios, Canada

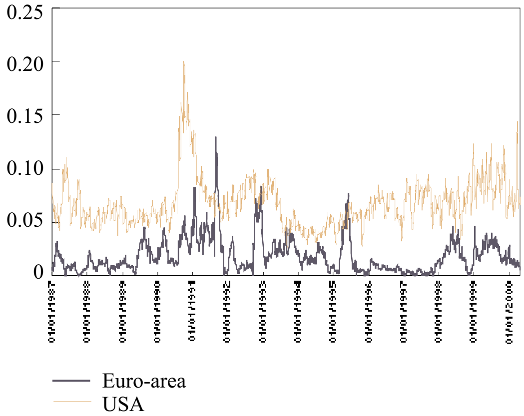


Figure 6

Variance Ratio Decomposition: Austria

Using the results of the GARCH model of equation (6)-(9) with time-varying coefficients, the variance ratios with the Euro-area market (VR_{iE}) and the US market (VR_{iU}) for country *i* are estimated as

$$VR_{iE,t} = \frac{\gamma^2_{iE,t-1}\sigma^2_{E,t}}{\sigma^2_{i,t}} \in [0,1] \tag{17}$$

$$VR_{iU,t} = \frac{\gamma^2_{iU,t-1}\sigma^2_{U,t}}{\sigma^2_{i,t}} \in [0,1] \tag{18}$$

Fig. 6.b shows the decomposition of the variance ratios into the shares explained by exchange rate volatility, by monetary policy convergence and by real convergence with the Euro area.

Fig. 6.a: Variance Ratios, Austria

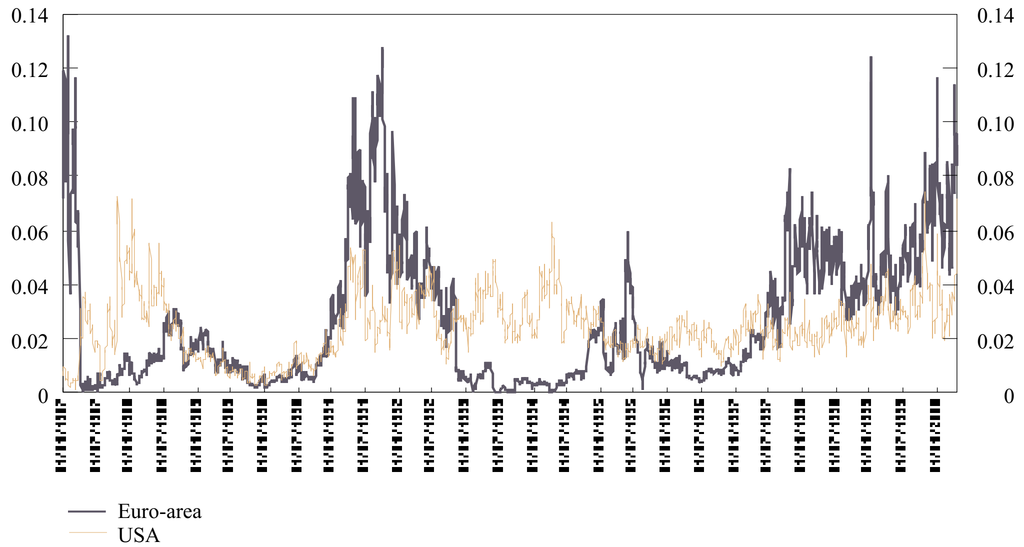


Fig. 6.b: Variance Ratio Decomposition, Austria

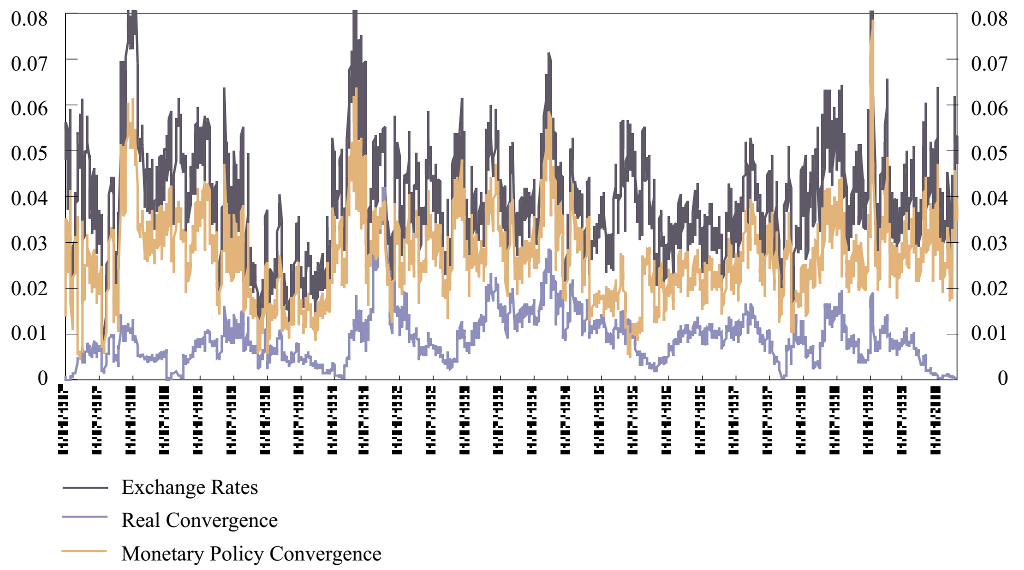


Figure 6.b for Austria shows the decomposition of the variance ratios into the share explained by real convergence, by monetary convergence and by exchange rate volatility. For Austria, monetary convergence and exchange rate volatility seem to have been the most important factors explaining financial integration with the Euro area. These results prove quite robust across countries.

A further specification test is to check the residual correlations. The first two columns of Table 9 confirm that the residuals of the local markets are indeed orthogonal to those of the Euro area and US markets (see equation (13) above). However, Table 9 also indicates that the residual correlation is positive and significant across most local markets (see equation (14)), suggesting that there is some other factors that explain the return correlation across local markets that is not included in the model. However, given that the correlation of the excess returns is substantially higher than the correlation of the residuals implies that the model has indeed substantial explanatory power.

Table 9

Testing for Independence and Omitted Common Factors

A correct specification of the benchmark GARCH model (6)-(9) requires that the following orthogonality conditions hold:

$$E\left[\varepsilon_{k,t}\varepsilon_{l,t}\middle|\Omega_{t-1}\right]=0 \quad , \quad k,l=i,E,U \quad , \quad \forall k \neq l \qquad (13)$$

which implies that the idiosyncratic shocks of the three markets are independent. The first two columns of Table 9 show the correlation of these idiosyncratic shocks. Moreover, if the unexpected share $\mu_{i,t}$ of the returns in country i is solely explained by regional and global shocks, then the idiosyncratic innovations $\varepsilon_{i,t}$ in country i should also be independent from shocks occurring in other local markets n

$$E\left[\varepsilon_{i,t}\varepsilon_{n,t}\middle|\Omega_{t-1}\right]=0 \quad , \quad \forall i \neq n \qquad (14)$$

These correlations are listed in columns 3 through 18 of Table 9.

	Euro Area	USA	Austria	Belgium	Finland	France	Germany	Italy	Netherl.	Spain	Denmark	Norway	Sweden	Switzerl.	UK	Japan	Canada	Australia
USA	0.015	1.000																
Austria	0.025	0.008	1.000															
Belgium	0.030	0.002	0.183	1.000														
Finland	-0.013	0.033	0.155	0.132	1.000													
France	-0.023	-0.011	0.151	0.348	0.254	1.000												
Germany	0.057	-0.024	0.326	0.310	0.278	0.383	1.000											
Italy	-0.052	0.015	0.163	0.177	0.179	0.245	0.197	1.000										
Netherlands	-0.038	0.007	0.180	0.400	0.279	0.500	0.477	0.253	1.000									
Spain	-0.066	0.038	0.220	0.267	0.183	0.332	0.268	0.299	0.303	1.000								
Denmark	0.038	0.022	0.206	0.225	0.188	0.169	0.290	0.159	0.264	0.197	1.000							
Norway	0.013	0.062	0.206	0.242	0.244	0.269	0.310	0.170	0.364	0.227	0.247	1.000						
Sweden	-0.030	0.026	0.158	0.245	0.400	0.318	0.283	0.227	0.340	0.287	0.169	0.343	1.000					
Switzerland	0.011	0.038	0.206	0.407	0.213	0.430	0.458	0.263	0.542	0.338	0.204	0.318	0.344	1.000				
UK	-0.030	0.033	0.108	0.236	0.232	0.427	0.249	0.202	0.540	0.263	0.153	0.273	0.291	0.393	1.000			
Japan	-0.059	0.020	0.045	0.111	-0.025	0.105	0.121	0.050	0.135	0.100	0.085	0.106	0.097	0.141	0.169	1.000		
Canada	-0.016	0.051	-0.020	0.011	0.114	0.069	0.037	0.018	0.159	0.055	0.042	0.064	0.098	0.107	0.162	0.121	1.000	
Australia	-0.074	0.072	0.085	0.057	0.080	0.043	0.117	0.068	0.116	0.159	0.171	0.167	0.122	0.154	0.119	0.238	0.116	1.000

average correlation: 0.211

	Euro-area	**Non-Euro-area**
Euro-area	0.266	
Non-Euro-area	0.202	0.179

7 Conclusions

This paper has analyzed the degree and nature of integration in European equity markets. It offers empirical evidence that the European unification process has raised the degree of integration, in particular among countries that have adopted the Euro. Overall, the results of the paper also indicate that the Euro area equity market has gained in importance in world financial markets since the mid-1990s, although the degree of financial integration has been highly volatile over the years.

The second aim of the paper was to investigate to what extent the drive towards EMU contributed to this financial integration process. It was found that reduced exchange rate uncertainty as well as monetary policy convergence of interest rates and inflation rates have been the central driving force behind the financial integration process in Europe. It was in particular the reduction of exchange rate uncertainty that explains much of the high degree of volatility in financial integration in the 1990s, in particular the periods of low integration during the ERM crisis in 1992-93 and 1995 as well as the rapid increase in integration since 1996, leading up to the adoption of the Euro in January 1999.

The findings of the paper have important implications for both investors and policy-makers. For investors, the high degree of integration means that the Euro area has become a more attractive place for investment. However, higher integration also implies that there are fewer opportunities to diversify portfolios within the Euro area, thus providing incentives to focus more on diversifying across sectors or across regions.

For policy-makers, the process of European financial integration poses some challenges. Financial integration has increased competition and market efficiency and, at the same time, continuing financial integration has made individual Euro area markets increasingly interdependent. Such rising interdependence may thus require prudential supervisors and security market overseers to increasingly adopt a Euro-area-wide approach.

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Data Appendix: Definitions and data sources

Equity return indices:

– Datastream International market indices. Frequency: daily (1/1986-6/2000), Source: Datastream

Control variables: Frequency: daily, Source: Datastream

– Own past excess returns r_{t-1}
– Change in short-term interest rates Δsr_{t-1} (30-day Eurocurrency rates)
– Change in the term structure Δts_{t-1}
– Change in the dividend yield in excess of the short-term interest rate Δdy_{t-1}
– Friday dummy for end-of-the-week effects *Df*

Real convergence criteria:#

– Correlations in growth rates of industrial production with Germany and with the USA over the past 12 months. Frequency: monthly, Source: OECD
– Correlations of cyclical components of industrial production with Germany and with the USA over the past 12 months, obtained from HP filtering. Frequency: monthly, Source: OECD, own calculations
– Correlations in the term structure changes with Euro area and with the USA. Frequency: daily, Source: Datastream
– Correlations in the change of dividend yields with Euro area and with the USA. Frequency: daily, Source: Datastream
– Trade integration with the Euro area and the USA: ratio of exports to plus imports from Euro area/USA to total trade. Frequency: monthly, Source: Eurostat, IMF
– Trade openness: ratio of total trade to annual GDP. Frequency: monthly, Source: Eurostat, IMF

Monetary policy convergence criteria: #

– Correlations in real short-term interest rates with Germany and with the USA over the past 12 months. Frequency: monthly, Source: IMF
– Correlations in nominal short-term interest rates with Germany and with the USA over the past month. Frequency: daily, Source: Datastream
– Difference in consumer price inflation with Germany and with the USA. Frequency: monthly, Source: IMF
– Correlations in consumer price inflation with Germany and with the USA over the past 12 months. Frequency: monthly, Source: IMF
– Financial depth: ratio of stock market capitalization to annual GDP. Frequency: daily, Source: Datastream.

The convergence criteria for Germany are calculated vis-à-vis other Euro area countries, weighted by their GDP share.

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