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Brian Lucey
School of Business Studies, University of Dublin, Trinity College

Raj Aggarwal
Kent State University, Kent

Cal Muckley
School of Business Studies, University of Dublin, Trinity College

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Raj Aggarwal
Brian M Lucey
Cal Muckley

Department of Finance,
College of Business Administration,
Kent State University, Kent, Ohio

School of Business Studies,
University of Dublin, Trinity College,
Dublin

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Brian M Lucey#

Cal Muckley

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Raj Aggarwal, Firestone Chair and Professor of Finance, Kent State University, Kent, OH 44242 USA. raggarwa@bsa3.kent.edu 1-330-672-1219
Brian M Lucey, Lecturer in Finance, School of Business Studies, University of Dublin, Trinity College, Dublin 2, Ireland: Blucey@tcd.ie 353-1-6081552 (#Corresponding Author)
Cal Muckley, Ph.D Candidate, School of Business Studies, University of Dublin, Trinity College, Dublin 2, Ireland; muckleyc@tcd.ie 353-1-6082338

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Abstract

This paper examines the integration of European equity markets over the 1985-2002 period using a relatively new cointegrating technique that assesses how the level of integration in equity price levels changes over time. This procedure is supplemented by two other dynamic techniques that also measure the extent of time-varying integration from complementary perspectives. The three methods are in agreement that there has been an increased degree of integration among European equity markets especially during the 1997-98 period. This evidence seems to indicate that despite several years of demonstrating political willingness by European leaders to integrate their economies, it was not until the establishment of the EMU and the ECB during the 1997-98 period that the markets deemed that European integration would in fact occur. The evidence presented in this study also indicates that Frankfurt is the dominant market for equities in Europe.

I. INTRODUCTION

The political, economic, and monetary union of Europe is clearly a major historic process. Prior to the current attempts at European unification, there had been centuries of intrigue, discord, and warfare amongst the European powers including two world wars and a century of cold war between socialist and capitalist states. The union of European states has a great deal of history to overcome and thus this union has understandably been a slow and deliberate process. Today unification is occurring against a backdrop of increasingly integrated global markets. Technology is making globalization more feasible and globalization is enhancing the returns to new technology. These mutually reinforcing trends of technology and globalization render national economies ever more open while raising global growth rates (see Aggarwal (1999))). In this environment, European countries face significant pressures to integrate even if only to compete with the large North American and Asian economies. This paper investigates when and how fast European markets integrated.

As well developed financial markets contribute significantly to economic growth (see Arestis, Demetriades and Lunitel (2001) and Beck, Levive and Loeysa (2000)), the development and integration of European financial markets is of particular importance. Further, the nature and extent of equity market integration is important for corporate managers as it influences the cost of capital and for investors as it influences international asset allocation and diversification benefits (e.g., Sentana (2000)). While it is clear that there is now substantial monetary integration in Europe, the extent of economic and financial integration is less clear. In this light, this paper examines the extent and evolution of European equity market integration.

European countries vary greatly in terms of the structures of their financial systems – some are bank-centered like Germany while others are market centered like the UK and Ireland, while still others have a mixed system. Further, there can be many different measures of financial market integration.

However, this paper concerns itself primarily with equity market integration. A choice exists as whether to focus on the integration of price levels or on the integration of asset risk profiles. Further complicating the issue is the fact that financial market integration is likely to vary over time and also the fact that financial data (especially price levels) are unlikely to be stationary.

Prior research on equity market integration has failed to satisfactorily account for many of these factors and much of it has focused on countries and areas other than Europe. For example, early attempts to assess international equity market integration, based on correlation and VAR (vector auto-regression) analysis, generally find rising equity market integration (see King and Wadhwani (1990) and Koch and Koch (1991)). However, these papers are static in nature, and generally measure only average degrees of integration over contiguous time periods. Other studies using variations of the GARCH approach to account for time-varying volatility find evidence of price and volatility spillovers across major national equity markets (see Hamo, Masulis and Ng (1990); Koutmos and Booth (1994; Fratzscher (2001)). Noting the changing nature of market integration, some studies have examined various sub-periods to assess the dynamics of international integration (see Bekert and Harvey (1995); Longin and Solnik (1995); Bodart and Reding (1999) and Ng (2000)). However, none of these studies have used dynamic cointegration techniques to examine how market integration changes over time; and as a result they neglect an important source of long-term information. Given the non-stationary nature of stock prices (and the stationary nature of stock returns), dynamic cointegration techniques can be very useful in examining international market integration.

It is being widely contended (at least in the popular press) that the globalization of the world economy is increasing. However, among economists there still seem to be some controversy regarding the integration of economies and markets. Indeed, a recent International Monetary Fund conference on this topic concluded that "economists lack evidence of increasing synchronization of the world's economies" (Brooks, Forbes, Imbs and Mody (2003)). Similarly, in the more limited context of Western Europe, the actual extent of financial market integration is still unclear. This paper is an attempt to fill this gap in our understanding.

This paper documents important findings. It builds on prior research by using a relatively new cointegrating technique that allows the assessment of how the nature and extent of integration in equity price levels changes over time applying it for the first time to assess equity market integration in Europe over the 1985-2002 period. Complementary techniques are also used, to measure changes in integration over time and include simple and multilateral correlation analysis and the dynamic Haldane-Hall Kalman filter methodology. The latter analyses largely corroborate the results provided by the dynamic cointegrating technique – that there has been an increased degree of integration among European equity markets, especially during the important 1997-98 period that demonstrated greatly increased levels of integration. Interestingly, the evidence seems to indicate that despite several years of political demonstrations of the willingness of European leaders to complete the EU project, it was not until the establishment of the EMU and the ECB that the markets deemed that European integration would in fact occur. The evidence also indicates that Frankfurt may be the equity market to which other markets in the EU are converging, challenging the perceived long held dominance of the London equity market.

The remainder of this paper is organized as follows. Section II presents the key events in the formation of the European Monetary Union (EMU), and thus motivates this analysis. It also reflects on issues in measuring international integration. Section III considers the prior evidence on financial market integration in general and emphasizes the importance of a dynamic methodology. Section IV briefly introduces the methodologies used in the paper. Section V further elaborates on the methodologies used and defines the data set investigated. Finally, Section VI presents and discusses the results and Section VII concludes.

II. INTERNATIONAL INTEGRATION IN EUROPE

Economic and Monetary Union in Europe

Economic and Monetary Union among the countries of Western Europe has a long history starting in modern times with the treaty of Rome in the 1950s. In 1969 the first decision to form the then *European Economic Community-EEC* into an *Economic and Monetary Union-EMU* was taken, and in 1971 the *Werner Plan* was adopted as a move to this end. This plan foundered on the stagflation and economic uncertainty and instability of the early 1970's. In 1979, however, the European Economic Community with the important exception of the UK formed the *Exchange Rate Mechanism-ERM* of the *European Monetary System-EMS* (of which the UK was a member). This was a system designed to impart stability to the exchange rates of the participating members, with the ultimate aim of using such stability as a move towards economic and monetary union (EMU). The pace of events sped up in the late 1980's. On July 1, 1987 the *Single European Act* was adopted. This provided a legal basis for the four freedoms of movement in the EEC – people, goods, services and capital. The purpose of this paper is to assess the extent to which important European capital markets, that is to say equity markets are integrated. Clearly, the Single Act paved the way to equity market integration. Table 1 shows the dates of selected key events in the formation of the EMU, commencing in 1988 (for additional details see one of the many books on European integration, e.g., Gillingham (2003)).

(Please insert Table 1 about here)

The process of economic and monetary union has been long and complex and is by no means complete. What is mostly complete is the process of monetary union, to the extent that across the majority of the union a single monetary unit, the Euro, is used. While there is some evidence that financial integration has grown rapidly in recent years, the evidence for it is still mixed. This paper is concerned with two issues: the extent to which equity markets have reflected the legislative and political changes and initiatives towards EMU and also the extent and evolution of European equity market integration.

Issues in Measuring International Integration

Measurement of the degree of integration can proceed from a number of points. Helpfully, these approaches may be delineated between direct and indirect measures. Indirect measures encompass issues such as corporate financing decisions, credit market spreads, and household financial decisions. On the other hand, direct measurements focus on comparisons of the prices of identical assets in different markets, in effect testing the law of one price. Regarding indirect measures of integration the most commonly used are: interest rate differences, the relative prices of banking products, the degree of cross border financial sector activity, and the pattern of corporate and governmental financing decisions (see Adam, Japepelli, Menichini, Padula and Pagano (2002) for an in-depth discussion of these and other indirect measures).

Centeno and Mello (1999) and Kleimeier and Sander (2000) use co-integration methodologies and find that the introduction of the *Second Banking Directive* in 1989, which in effect removed barriers to cross border banking, had a significant effect and led to greater integration of the retail banking markets. Tesar and Werner (1995), Lewis (1999) and Ayuso and Blanco (1999) have established that there is ample evidence of home bias in the asset allocation decisions of investors. Although they note that the degree of mismatch between actual and optimal asset allocation proportions has decreased they neglect to inquire after the extent and evolution of the international integration in asset markets which may be responsible for this bias. A purpose of this study is to fill this gap with respect to European equity markets.

In terms of indirect quantity indicators, Bekert, Harvey and Lumsdaine (2003) provide evidence on the significant steps in world equity market integration by identifying structural breaks in the size of international capital flows. Corroborating the results presented here - they find that integration has speeded up in the 1990's. Other studies of the prices of banking products in the EU find that that the degree of integration is much less. White (1998) and Blandon (2000) find that persistent differences in the cost of banking products continue to exist across the EU. de Bandt and Davis (1999) surmise that this lack of integration is due to the low degree of inter- and intra- country competition in EU banking markets. Moreover, Bank (1999)shows that in the EU such activity is far likelier to be within national boundaries than across such boundaries. This finding also carries through to the insurance market and indeed to the banc-assurance sector (see White (1998)). In contrast, also using an indirect measure, Gilmore and McManus (2002) find that EU companies are now much more readily accessing debt and equity markets outside their national market. Thus, while there is some indirect evidence of market integration in the EU, there is also evidence of persistent cross-border barriers in the EU credit and banking markets.

Regarding direct measures, financial economics tells us that integration of asset markets may be deemed complete when the law of one price holds. To measure this requires prices of homogenous assets to be compared across national borders.[1] It is the identification of these homogenous assets that makes measurement of equity market integration difficult. In particular, the assets being compared should have an identical risk profile - if one is not able to identify such identically risky assets than adjustments for risk are required. A finding of non-integration implies that barriers to the free movement of capital exist. These can be regulatory, cultural, legal or economic etcetera.

Finally, with respect to direct measures, there is the locus of interest.[2] In this paper we inquire

[1] While we do not explicitly attempt to find homogenous risk assets here, as will become clear from the discussion of the data, our dataset is designed in part to allow easier and more direct comparison of returns to equities across different markets, risk regimes and currencies.

[2] A caveat in respect to direct measures is the difficulty of testing the *ex-ante* expectation using *ex-post* realized returns. For example, one major problem is that for markets that are subject to the same exogenous shocks, such as

after the existence of long-term and short-term relationships between European equity markets. We also consider the extent to which the equity markets in general are converging towards the German and UK markets, and which of these two dominates. In sum, this approach amounts to an inquiry into the dynamic statistical behavior of the European equity markets from a variety of complementary view points. In contrast to many papers that test for integration following the theoretical lead of Errunza, Losq and Padmanabhan (1992) and Errunza and Losq (1985), this study explicitly recognizes changes over time in the properties of market integration. In so far as it investigates the similarity or otherwise of price behaviour between markets, this paper amounts to an estimation of a sophisticated set of direct measures of integration.

III. PRIOR EVIDENCE OF FINANCIAL MARKET INTEGRATION

In common with many studies, Kasa (1992) uses cointegration methods to test for the degree of integration of US, Japanese, UK, German and Canadian equity markets over the 1974-1990 period, and finds a single cointegrating vector. Cointegration has an easy appeal to the measurement of integration, as was pointed out by Bernard (1991). He notes that empirically a necessary condition for complete integration is that there be *n-1* cointegrating vectors in a system of *n* indices.

Chan, Gup and Pan (1992) use the Engle-Granger simpler specification to examine Asian markets, and find in favor of segmentation. Such an approach was also used in Allen and Macdonald (1995), who found for the 1970-1992 period that the Australian market seemed to be segmented from other developed markets with only 6 of 16 markets cointegrated with Australia. Chan, Gup and Pan

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commodity market changes or political events, artificially induced equity market integration will be observed. In such cases, there will be an imposed degree of co-movement even without any actual equity market integration. We have not explicitly controlled for such shocks here, but are confident that the heterogeneous nature of the national economies from which the equity indices used are drawn, militates against one shock identically affecting all elements. Moreover, there is no reason to believe that there has been an increase neither in the number nor in the magnitude of common exogenous shocks which might be responsible for the observed integration.

(1997) expanded their previous study, both in terms of the time period covered and in terms of the number of countries. They found a decrease in integration in the 1980's. Similar results for world markets are found by Arshanapalli and Doukas (1993), again using simple bivariate cointegration analysis.

Chou, Ng and Pi (1994), applied the more sophisticated Johansen technique to G7 countries over the 1976-1987 period and two sub-periods, and find some evidence of increased integration in the latter period. Hung and Cheung (1995) provide similar findings for Asian markets, using similar methodologies. de Fusco, Geppert and Tsetsekos (1996), also use Johansen methods to find that emerging markets were generally not cointegrated with the US over the 1989-1993 period. A similar approach was adopted by Sheng and Tu (2000) who used Johansen techniques to examine the interrelationship of Asia-pacific markets around the Asian financial crisis. They found that there was evidence of pair wise cointegration only for SE Asian 'tiger' countries. For US – Central European markets however, using cointegration methods, Gilmore and McManus (2002) find evidence of cointegration. Ratanapakorn and Sharma (2002) and Manning (2002) also find cointegration between SE Asian, European and US markets.

Evidence for European countries is mixed. Using bivariate cointegration approaches Gallagher (1995) finds no evidence of cointegration between Irish and either German or UK equity markets. Kearney (1998) also examines this issue, using Johansen methods, and finds contrary results with the Irish market being part of a long-run relationship with the UK market (and with certain macroeconomic variables). Kanas (1988) examined the relationship between the U.S. and six large European equity markets pre and post October 1987, and finds no evidence of cointegration. Finally, Serletis and King (1997) uses a variant of two of the approaches we use and finds over the 1971-1992 period that European markets did demonstrate integration.

Need for Dynamic Procedures in Assessing Integration

A weakness of these studies is that a focus on comparative statics misses the important element of time variation in equity risk premia. The seminal works by Campbell (1987), Harvey (1989), Harvey (1991) and Bekert and Harvey (1995) all show that the risk premium of equities is indeed time-varying. Thus, any attempt to model the integration of markets without taking account of this time variation may yield confusing and partial results. A number of approaches have been deployed to take account of time-varying equity risk premia in assessing equity market integration.

Koch and Koch (1991) use a simultaneous equation model that they estimate over a number of contiguous sub-periods. They find significant and increased linkages among world equity markets. Similar in spirit to this is Longin and Solnik (1995) who use correlation and covariance matrix estimates, finding that over the 1960-1990 period there was a general increase in integration with covariance increasing markedly in times of macroeconomic instability. Hardouvelis, Malliaroupoulos and Priestley (1999) directly examine the speed of integration among the EU equity markets. This is done by the development of an explicit equilibrium asset-pricing model with a time-varying measure of integration. They find that the degree of integration is closely related to the probability of a country entering into EMU. Integration increases substantially over time and seems to be complete by mid 1998. Sentana (2000) by contrast, focuses on the question whether the EMS has contributed to lower corporate cost of capital by estimating a time varying Asset Pricing Theory (APT) model. He finds that not only was there only a small decrease in the cost of capital attributable to EMU, but that there was also no evidence that country risk was decreasing, indicating no great degree of integration. Rangvid (2001) uses a dynamic cointegration approach, focusing on quarterly share indices for France, Germany and the UK over the 1960:1 – 1999:1 period. He finds evidence of increasing convergence since 1982. Fratzscher (2001) uses a GARCH methodology to examine financial market integration in Europe and finds that the move towards EMU contributed towards increasing integration of financial markets in Europe. However, he finds that the degree of financial market integration in Europe has been very unstable and volatile over time.

In summary, given the non-stationary nature of stock prices dynamic cointegration techniques can be very useful in examining international market integration. Thus, in examining time-varying cointegration in Europe, this study, we believe, fills an important gap in the literature.

IV. ESTIMATING INTEGRATION AND CHANGES OVER TIME

A number of methods can be used to estimate the nature and extent of financial market integration and how it changes over time. Starting with simple correlation analysis, we use estimates of traditional cointegration, the Haldane and Hall Kalman filter technique, and dynamic cointegration analysis as described in this section.

Cointegration Methods

Substantial empirical evidence indicates that individual equity indices display unit root (non stationarity) characteristics. However, there is equally strong evidence that linear combinations of these nonstationary indices may themselves be stationary, that is to say, they may be cointegrated. The essence of cointegration is that the series cannot diverge arbitrarily far from each other, implying that there exists a long-term relationship between these series and that they can be written in an Error Correction form. By definition, cointegrated markets exhibit common stochastic trends. This, in turn, limits the amount of independent variation between these markets. Hence, from the investors' standpoint, markets that are cointegrated will present limited diversification opportunities. The requirement for assets that are integrated in an economic sense to share common stochastic factors, which is an alternative definition of cointegration, is pointed out in Chen and Knez (1995).

Two primary methods exist to examine the degree of cointegration among indices. As this area is by now well known we do not provide a detailed statistical description of these techniques. For such a description see, for example, Enders (1995). The first is the Engle-Granger methodology (see Engle and Granger (1987)) which is bivariate, testing for cointegration between pairs of indices. The second is the Johansen-Juselius technique (see Johansen (1988) and Johansen and Juselius (1990)), hereafter referred to as the JJ technique which is a multivariate extension and allows for more than one cointegrating vector or common stochastic trend to be present in the data. The advantage of this is that the JJ approach allows testing for the number as well as the existence of these common stochastic trends. In essence , the JJ approach involves determination of the rank of a matrix of cointegrating vectors.

To illustrate, for a given lag length l, and assuming no deterministic components[3], we can write the Vector Autoregression (VAR) representation of the stock indices in levels as

$$\mathbf{E}_t = \mathbf{A}_1\mathbf{E}_{t-1} + \mathbf{A}_2\mathbf{E}_{t-2} + \ldots.. + \mathbf{A}_l\mathbf{E}_{t-l+} + \mu_t \qquad (1)$$

where $\mu_t \approx N(0,\Sigma)$ and E represents an (*n*x*1)* vector of stock equity indices, **A** is an (*n*x*n*) matrix of coefficients. We can represent this relationship more generally in the Vector Error Correction (VECM) format as

$$\Delta\mathbf{E}_t = \prod \mathbf{E}_{t-1} + \Gamma_1\Delta\mathbf{E}_{t-1} + \Gamma_2\Delta\mathbf{E}_{t-2} + \ldots.. + \Gamma_{l-1}\Delta\mathbf{E}_{t-l+1} + \Gamma_l\Delta\mathbf{E}_{t-l} + \mu_t \ . \qquad (2)$$

or

$$\prod \mathbf{E}_{t-1} = \Delta\mathbf{E}_{t-1} - \sum_{i=1}^{l}\Gamma_i\Delta\mathbf{E}_{t-i} - \mu_t \qquad (3)$$

[3] The selection of the lag length is important, but more important again is the treatment of deterministic components. In the presence of deterministic elements the estimation of the VAR and the determination of the cointegration vectors, and thus the rank of the system, becomes complex.

Where the right hand side terms of Equation (3) are stationary, it follows that $\prod \mathbf{E}_{t-1}$ is also stationary. The JJ technique endeavors to ascertain the rank, *r*, of Π. This gives the number of stable cointegrating vectors in the system, as Π can be demonstrated to be equivalent to $\alpha\beta'$ where β' is the vector of cointegrating relationships and α a matrix associated with the equilibrium errors $\beta'\mathbf{E}_t$.[4]

Alternatives to Cointegration

There are a variety of feasible alternative approaches to the Cointegration methodology. Two complementary methods are used here. The first is the Haldane and Hall (1991) Kalman Filter based methodology, while the second involves a dynamic estimation of the eigenvalues which sheds light on the multilateral correlations through time.[5] The Haldane & Hall (hereafter HH) method estimates a simple equation of the following specification

$$\ln\left(\mathbf{E}_{jt} / \mathbf{E}_{Bt}\right) = \alpha + \beta_t \ln\left(\mathbf{E}_{jt} / \mathbf{E}_{Xt}\right) + \varepsilon_{jt} \qquad (4)$$

via kalman filter estimation. Here the market subscripted B is the preimposed internal base market and that subscripted X is the preimposed external market. Thus, for example, in testing for integration among SE Asian markets, Manning (2002) imposes the US market as the external market (to which the SE Asian markets are assumed to be converging) and Hong Kong as the dominant local market. Here we set the Frankfurt market as the local base and the London market as the external market, and estimate the system.

[4] Serletis and King (1997) used this approach to examine European equity market integration, the BENELUX and France in particular were found to be converging to the US market.
[5] Manning (2002) examines Asian stock market integration taking the Haldane and Hall (1991) approach of specifying time varying coefficients via a Kalman filter. Most papers using this time varying approach have examined currency or interest rate relationships (e.g., Zhou (2003)).

We also invert these relationships, as we are not confident as to which market, over the time period of this study, represents the dominant market towards which the system may be converging. There are a number of indicators of convergence or divergence. Negative values of β_t indicate divergence, as does a tendency to move further from zero.

The Kalman filter used in this paper works in the following way. The equation is estimated over an initial period, to initialize the coefficients and related information. Thereafter it is updated with the addition of each daily data point. Let $Y_t = \alpha_t + X_t \beta_t + \varepsilon_t, \text{var}(\varepsilon_t) = \eta_t$ be the measurement equation of interest. If we set β_t as the coefficient of interest at time t, then the transition equation is given by $\beta_t = \beta_{t-1} + \nu_t, \text{var}(\nu_t) = \text{M}_t$. Given the estimate of β_{t-1} from information up to that period ($\beta_{t-1|t-1}$) with the associated covariance matrix Σ_{t-1}, the updated estimate is given by equations (5), (6) and (7).

$$S_t = \Sigma_{t-1} + \text{M}_t \tag{5}$$

$$\Sigma_t = S_t - S_t X_t'(X_t S_t X_t' + \eta_t)^{-1} X_t S_t \tag{6}$$

$$\beta_{t|t} = \beta_{t-1|t-1} + S_t X_t'(X_t S_t X_t' + \eta_t)^{-1}(Y_t - \alpha_{t-1} X_t \beta_{t-1|t-1}) \tag{7}$$

The second approach implies an investigation of the time series plot of the evolution of the system's eigenvalues. Complementary to cointegration analysis which inquires after comovements in the levels of the equity market indices; an eigenvalue analysis inquires after comovements in their returns. Thus an eigenvalue analysis serves to complement the previous analysis by capturing interdependencies of a relatively short-term nature. Essentially, it is a means of extracting the most important uncorrelated sources of information in a multivariate system. Components thus extracted are constructed in such a manner that the explanatory power of the incremental component is maximized given the restriction of orthogonality. This collapses to an inquiry into the eigenvalues and vectors of the data matrix. In this context eigenvalues may be understood as the unconditional variances of the projections of points on each of the components. Eigenvectors are the direction cosines: how far the original variable space is to be rotated.

Dynamic Cointegration Analysis

The JJ approach generates two statistics of primary interest. The first is the λ_{trace} statistic, which (in this instance) is a test of the general question of whether there exist one or more cointegrating vectors. An alternative test statistic is the λ_{max} statistic, which allows testing of the precise number of cointegrating vectors. These test statistics can be plotted over time to examine how the nature of market integration is changing over time.[6] This approach is in essence a visual application of the recursive cointegration approach of Hansen and Johansen (1992) that has also been applied in a somewhat different form by Rangvid (2001). The output from the approach which we have taken is twofold: first, the largest value of the λ_{trace} statistic which tests the general hypothesis of no cointegration versus cointegration, and second, the number of cointegrating vectors given by the λ_{max} statistic. A set of series that are in the process of converging should be expected, as in Hansen and Johansen (1992) and Rangvid (2001), to show increasing numbers of cointegrating vectors. Intuitively, this makes sense. Consider a set of p series which have n cointegrating vectors, $n<p$. This implies that there are n linear combinations of the p vectors that are stationary. If we later find that we have k vectors, $n<k<p$, there are additional combinations that can be used in the representation of the p data. If we have a static number of cointegrating vectors then recursive estimation will simply lead to an upward trend in the λ_{trace} statistic.

[6] Further details regarding the dynamic cointegration approach can be found in Barari and Sengupta (2002). There-in the process is described whereby the investigator can plot over time the values of selected test statistics from the JJ approach. The Barari and Sengupta (2002) paper concentrates on the λ_{trace} statistic.

V. STATISTICAL METHODOLOGY AND DATA

As discussed above, this paper uses a number of approaches to assessing the time-varying nature of financial market integration in Europe. In addition to estimating changes in simple correlations over time and the HH approach and the use of dynamic eigenvalue analysis, this paper also uses a recently introduced variation on the JJ approach, which in essence provides a visual representation of the extent and speed of the degree of integration.

Haldane and Hall Dynamic Eigenvalues

The Haldane & Hall convergence parameters are initialized over the January 1988-September 1989 period and thereafter the Kalman Filter updating occurs each day. Each country's convergence with respect to London and Frankfurt is estimated and the results presented.

In the case of the eigenvalue calculation, the initial calculation of the first three eigenvalues is shown. Next the evolution of the cumulative explanatory power of the first three eigenvalues over an approximate 12-month moving window beginning on the 1st of January 1988 and ending on the 30th September 2002 for daily data for the full set of European equity market indices is estimated and plotted. The analysis is time varying in that the window moves - by dropping the initial observation and including the incremental observation - for each estimate of the first three eigenvalues. The results of this process are presented as a time series plot of the cumulative percentage variation explained by the first three eigenvalues for each 12-month window. The bilateral correlations between the French, German, Italian and UK equity markets are also presented.

Dynamic Cointegration Analysis

Two different windowing strategies are deployed. The first, a recursive approach, is termed the *Global Plot*. It derives the statistic of interest over the chosen period t_0 to t_n. This period is then extended by j and the statistic is re-estimated from t_0 to t_{n+j}. Eventually, the estimation procedure reaches the end of the data (equivalent to the standard static JJ estimation over all time periods). The relevant statistic is then plotted. The interpretation proceeds by examination of the plotted statistic. An upward trend indicates either increased integration and/or a move towards integration, a downward trend indicates decreased integration and/or a move away from integration. In the estimation here we look forward 40 trading days, approximately two months of data, at each iteration.

An alternative, rolling approach is the *Local Plot*. Here, in essence, the statistic of interest is estimated over an l period window, from t_0 to t_{0+l}, and this is then moved k data points along the dataset and the statistic estimated from t_{0+k} to t_{0+k+l}. The statistic is thus estimated over a window of constant length. *Local Plots* focus on changes in cointegration during the previous l-period and provide a more refined tool to investigate the impact of external shocks on the market integration process. In contrast to the Barari (2002) paper which uses the Local Plot approach to examine all time periods, we use local plots to consider a number of subperiods of interest only. These subperiods emerge from the initial analyses.

Data

Daily data for the main EU countries, Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden and the UK are analyzed. The dataset commences on December 31 1987 and ends on 30 September 2002, providing 3847 data points in total. We explicitly do not include the US market, justified on two grounds. First, our locus of interest is the evolving process of integration in the European markets, in particular in response to the political economy of the EMU project. Second, we feel that numerous studies (see for example Kanas (1988) and Chan, Gup and Pan (1997)) have established the cointegrating nature of the relationship between the US and the UK markets. Thus, the effect of the US market is in fact felt here, albeit indirectly.

One of the criticisms that can be levied at many of the studies cited above is that they rely on indices that have potentially different construction and inclusion patterns. To allow for uniformity in the indices as much as possible, FTSE All-World indices are used here. These are sourced from Thompson Datastream. A much more comprehensive description of the FTSE world indices can be found on their website, at http://www.ftse.com. Notably, the FTSE indices are designed to be consistent across countries and thus allowing comparative studies. All data are denominated in € terms.

VI. RESULTS

Simple Correlation Analyses

As a preliminary analysis we look at Table 2. This shows the Pearsonian correlation coefficients between European equity market indices. Panel A shows the overall correlations across the 1988-2002 period, while Panel B shows the increase in these correlations from the 1988-1995 period to the 1996-2002 period (all but two bivariate correlations increased). While there are methods to formally test the equality or stability of correlation matrices we have not used these as the focus is on extracting the extent and nature of time variation. However, this table shows clearly that there are significant positive correlations between the indices, and that these have increased over time. Some bivariate relations show very large increases: Finland with each other country, Sweden with both Finland and France, the UK with

Belgium, Denmark, Italy and Germany. Within the 4 largest countries, Germany, UK, Italy and France, the increases in bivariate correlations are very high. Therefore, it seems that there has been an increase in integration. Next, we calculate a 100 day rolling correlation coefficient for the larger European countries, as shown in Figure 1 which also confirms that the degree of interrelationship among European stock markets has clearly increased.

(Please insert Table 2 and Figure 1 about here)

Dynamic Cointegration Analyses

In order to use the JJ technique, two preliminary steps need to be undertaken. First, the data have to be checked for their degree of integration. Clearly, the data in the JJ methodology require the same degree of integration to be present. Two unit root tests are used for this purpose. Shown in Table 3 are the results of the Augmented Dickey-Fuller and Phillips-Perron tests on the levels and differences of the series under investigation. In all cases the series in levels displayed a unit root and no unit root in first differences, thus showing that all are I(1). The second step is that of choosing an appropriate lag length for the JJ methodology. Testing by means of both the likelihood ratio and multivariate Akaike and Bernanke Information Criteria we found that a lag of 1 is appropriate.[7]

(Please insert Table 3 about here)

Shown in Figure 3 is a plot of the recursively estimated global λ_{trace} statistic and in Figure 4 the number of cointegrating vectors. A number of points are evident from these graphs. First, over all time-periods the λ_{trace} statistic exceeded the 95% critical value, giving us some confidence that over the 1988-

[7] Our analysis of the JJ methodology was undertaken using the CATS (Cointegration Analysis of Time Series)

2002 period these EU markets were in fact multivariately integrated. Second, there is an increase in both the number of cointegrating vectors and the λ_{trace} statistic over this period, although this is not monotonic. This tells us that the markets were in the process, generally speaking, of integrating further.

Examination of the two plots in more detail yields some further insights. First, there are two regions where the λ_{trace} statistic lies between the 95% and 99% critical values, regions for which we could infer that the market was integrated but with less confidence. The first period lies between early 1991 and early 1994. This first period comes immediately after the shocks of German reunification and the collapse of the Soviet Union and terminates after the establishment of the EMI. This period also witnessed the Single EU Act and the debates surrounding the Maastricht Treaty. The second period is approximately 1996, and appears to correspond to the period between the Madrid Declaration II, which outlined the desire to move to EMU and the Dublin Declaration, which began the legal, moves thereto.

(Please insert Figures 3 and 4 about here)

We can also see that the data indicate that integration proceeded rapidly after the December 1996 period, with the number of cointegrating vectors rising from 2 to 6 by end 1998. This is broadly in line with the results found by Hardouvelis, Malliaroupoulos and Priestley (1999). This period saw the Treaty of Amsterdam, the declaration of 11 nations as eligible for consideration for EMU membership and the creation of the European Central Bank (ECB). The period End Feb - End June 1998 saw the largest increase in percentage terms in the λ_{trace} statistic, corresponding to the time period wherein the 11 nations were nominated and the ECB established. The largest fall in the λ_{trace} statistic occurs between February and May 2000, a period during which, with the exception of the commission decision to allow in Greece as an EMU country, there was little EMU related activity.

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programme, from Estima (http://www.estima.com/).

While the results from the Global plot are generally in support of increased cointegration and thus increased integration over time, this is not the case with the Local plot. We use 500 daily observations, or approximately 2 years, as our fixed sample, and move forward 4 weeks at a time, or 20 days. Shown as Figure 5 are the local plot analyses. The horizontal axis shows the timeperiod over which the cointegrating relationships are estimated and plotted. The vertical axis calibrates the λ_{trace} statistic. A number of features are evident. The most striking is that with very rare periods of exception the λ_{trace} does not indicate cointegration, at the 95% confidence level. Accepting that the number of data points, at 500, is relatively small given the complexity of the system being investigated, and accordingly dropping the confidence level to 90% we see substantially increased evidence of cointegration.

(Please insert Figure 5 about here)

There are two time periods when even this low level of confidence is not reached – May 1993 to September 1995 and April 1993 to June 1996. The series briefly dips again in the October 1994-September 1996 period Comparing to the global plot we see that while the cumulative degree of cointegration was in some cases over the 95% critical value for these periods it was not always so, indicating a certain degree of congruence between the two results. These periods were, as discussed earlier, relatively turbulent in the process of EMU formation.

We also note that the speed of integration can be quite high. While an analysis over the October 1994 - September 1996 period would conclude no evidence of integration, even at 90%, the same analysis over a window of identical length a year later would conclude exactly the opposite, and a year later again would conclude cointegration at the 99% confidence level. This allows us to focus in, if desired, on the periods when the statistic λ_{trace} shows rapid increases or decreases. In the analysis here we see a number of periods of interest. Thus the period from August 1993, when the ERM almost collapsed, charts the beginning of a period where the local plot begins to drop towards a rejection of cointegration. There is a significant dip in the series at the April 1996 – March 1998 period, corresponding to the commencement of negotiations on the Dublin Declaration and ending around the time of the Phase III membership announcement, when the series pick up again markedly.

The highest point of the series is reached over the September 1996 – august 1998 period, a period commencing with the Dublin Declaration and the Treaty of Amsterdam and ending just after the ECB establishment. However, it is intriguing that thereafter there has been a slow and steady decline in the rolling measure of equity market integration we present here. One exception is the August 1998 – July 2000 period, a period congruent with the rising tide of the height of the bull (bubble?) market lifting all the markets in synchronicity. This bull market is also clearly evident in the global plots, which reach a peak at the peak of the bull market.

Haldane and Hall Results

The Kalman Filter is initialized over the period 1st January 1988 to the 20th September 1989 and the plots therefore show the dynamic estimates of the convergence parameters from 21st September 1989 to the 30th September 2002. Shown in Figures 6 and 7 are the HH convergence factors. What is immediately clear is that a strong case can be made that European markets are converging to both Frankfurt and London, within both cases the convergence parameters rapidly tending towards 0, the convergence benchmark. It also seems clear that with a few minor exceptions this convergence was substantially completed by the mid 1990’s. Following Manning (2002), we calculate the average convergence factor, and Figure 8 shows the unweighted average of the two sets of convergence factors. The evidence is that the markets had substantially converged by March 1994, after the establishment of the European Monetary Institute.

(Please insert Figures 6, 7 and 8 about here)

These results are congruent with the results from the recursive dynamic cointegration analyses that also showed the EMI establishment as an important factor. However, this period also saw the time varying convergence parameter turn negative, which is another indicator of divergence. They do however trend upwards reaching zero by mid 2000 and oscillating around zero thereafter. An examination of the plot does indicate that it has taken some time for convergence to be approached. It is also worthy of note that the average deviation of the average HH convergence factors for Frankfurt is closer to zero than that for London. While both of these measures are statistically different from zero, the Frankfurt measure being closer to zero may indicate that the markets are converging more rapidly towards Frankfurt than to London. It is also worth noting that in no case do individual convergence factors for any country, whether in respect to Frankfurt or to London measure as being statistically equal to zero. In Table 4 are shown the results of such a test. As all Kalman Filter estimates, even after successful initialization, take some time to settle to a 'true' path, we chose January 1993 onwards the period to statistically analyse. This corresponds with the introduction of the Single European Act, and also, from inspection, when the series begun to settle. What is interesting is that in no case can we conclude that the equity markets have converged, all parameters being statistically different from zero.

(Please insert Table 4 about here)

We can conclude therefore from the HH factors that the European markets are, while converging, have not yet converged completely. A bi-polar relationship is still evident, the average HH convergence factors for Frankfurt and London being statistically indistinguishable from each other.

Dynamic Eigenvalue Results

Shown in Figure 2 are the results of the eigenvalue analysis. The plot shows the cumulative R^2 of the first three eigenvalues estimated over a rolling 250 (approximately 12-month) observation window. Again, we see an increasing degree of common variance being explained by three eigenvalues. The explanatory power is static (if not declining) at between 12% and 15% up to mid 1997. Thereafter, corresponding to the Dublin Declaration implementing the Treaty of Amsterdam, the explanatory power and thus the degree of convergence and integration, picks up markedly. The period from the establishment of the ECB in mid 1998 to the irrevocable fixing of exchange rates in January 1999 and the period of the three months prior to the introduction of the euro show the most rapid increases in the degree of integration.

(Please insert Figure 8 about here)

It is clear that the multilateral correlations fall-off in the 1999 to 2000 period – congruent with the cointegration results – only to quickly commence another phase of increasing comovement which appears to persist up to and including the period ending October 2002. In contrast to the multilateral correlations the bilateral correlations presented in Figure 1 increase approximately monotonically. Consequently, it may be inferred that the major European equity markets are moving more closely together over time but that the peripheral markets do not share this property over all time periods.

VII CONCLUSIONS

It is important to assess the nature and extent of financial integration in Europe. Financial markets are important for economic growth and their integration would promote economic and, perhaps, political integration. Financial market integration is also important for corporate managers and investors. However, it is neither easy nor straightforward to measure financial market integration. This paper builds on prior research by examining time-varying integration of European equity markets over the 1985-2002 period. It uses a relatively new cointegration-based technique that allows the measurement of time varying integration in equity price levels to assess financial integration in Europe. This procedure is supplemented by other statistical complementary techniques that also measure the extent of time-varying integration. To our knowledge this is the first paper which has deployed all these measures simultaneously.

The measures indicate that on average the European equity markets have achieved considerable levels of integration. Even though these measures differ somewhat as to the extent and speed of integration, the evidence presented here is broadly in agreement on the importance of the 1997-1998 period demonstrating greatly increased levels of integration. It is notable that immediately after this period all of the measures indicate a decrease in measured integration. Further, the importance of the stock market bubble which crashed in early 2000, as a driving force of measured integration in Europe is clear from the results presented here.

Interestingly, the evidence presented here also indicates that despite several years of political demonstrations of the willingness of European leaders to complete the EMU project, the importance of yielding power (the Treaty of Amsterdam) and yielding policy instruments (the establishment of the ECB) emerges as a clear signal from the market. The evidence presented here also appears to indicate that Frankfurt remains the dominant market for equities.

Table 1: Key Political and Economic Events of the EMU Process

Date	Event
20-9-88	Margaret Thatcher, Prime Minister of the UK, delivers a heavily skeptical speech on the future development of the union (*Bruges Speech*)
12-4-89	*Delors Report* lays out the future roadmap for EMU
27-4-89	*Madrid Declaration* adopts the Delors Report and commits the EEC (sic) to EMU
9-11-89	*Fall of Berlin Wall*
9-12-89	*Strasbourg Declaration* declares that the EEC will move towards EMU. Start of Phase I of EMU
29-5-90	European Bank for Reconstruction and Development (*EBRD*) established
19-6-90	*Schengen I* agreement signed, providing for a common travel area in Europe
3-10-90	*German Re-unification*
15-12-90	*Rome Declaration* launches intergovernmental conference on EMU
10-12-91	*Treaty of Maastricht* agreed, transforming the EEC into the European Union
21-12-91	*Soviet Union collapses*
2-6-92	*Danish referendum rejects* Maastricht treaty
18-6-92	*Irish referendum accepts* Maastricht treaty
20-6-92	*French referendum accepts* Maastricht treaty
12-12-92	*Edinburgh Declaration* amends Maastricht treaty to assuage Danish and endorses moves to EMU
1-1-93	*Single European Market* (part of Maastricht treaty) in force. This represents the culmination of the original aims of the European Economic Community – the Common Market.
18-5-93	*Second Danish referendum* accepts Maastricht treaty
2-8-93	ERM bands widened from 2.25% to 15% each direction
29-10-93	*Brussels Declaration* on the start of Phase II of EMU
1-11-93	*European Union created* with ratification of all elements of Maastrich treaty
1-1-94	European Monetary Institute (*EMI*) – forerunner of European Central Bank is established, launching Phase II of EMU
12-6-94	*Austria votes to join EU*, including EMU
16-10-94	*Finland votes to join EU*, including EMU
13-11-94	*Sweden votes to join EU*, including EMU
28-11-94	*Norway votes to not join EU*
26-3-95	*Schengen II* extends common travel area
31-5-95	*Green Paper* on practicalities of monetary union (note transfer etc)
16-12-95	*Madrid Declaration II* adopts Jan 1 1999 for launch of Euro and start of Phase III of EMU
14-12-96	*Dublin Declaration* outlines the legal mechanisms for Phase III of EMU
2-10-97	*Treaty of Amsterdam* ratifies into law the Dublin Declaration
25-3-98	*Phase III membership notified*: 11 members that may adopt the Euro and move to Phase III named
3-5-98	*Determination Mechanism* for irrevocable conversion rates outlined
26-5-98	European Central Bank *(ECB) Board agreed*
1-6-98	*ECB established*
1-1-99	*Euro Launched*
22-9-00	*ECB intervention to support Euro*
28-9-00	*Danish Referendum rejects joining Euro*
2-1-01	*Greece becomes 12th Euro zone member*
1-1-02	*Euro replaces national currencies. Phase III ends. EMU Complete*

Table 2: Correlations and Changes in Correlations across Indices

Panel A: Overall Period Correlations - 1988-2002

	Belgium	Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Spain	Sweden	UK
Austria	0.33	0.24	0.19	0.30	0.37	0.26	0.25	0.31	0.31	0.29	0.26
Belgium	1.00	0.41	0.32	0.57	0.57	0.38	0.45	0.62	0.53	0.46	0.48
Denmark		1.00	0.32	0.42	0.44	0.31	0.36	0.45	0.41	0.43	0.37
Finland			1.00	0.44	0.41	0.26	0.34	0.46	0.42	0.54	0.41
France				1.00	0.70	0.42	0.57	0.74	0.68	0.62	0.67
Germany					1.00	0.41	0.56	0.71	0.64	0.60	0.58
Ireland						1.00	0.33	0.46	0.37	0.38	0.46
Italy							1.00	0.54	0.57	0.50	0.49
Netherlands								1.00	0.64	0.61	0.70
Spain									1.00	0.57	0.57
Sweden										1.00	0.56

Panel B: Correlation Increases 1996-2002 over 1988-1995

	Belgium	Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Spain	Sweden	UK
Austria	-0.03	0.00	0.05	0.01	-0.04	0.02	0.02	0.02	0.00	0.01	0.03
Belgium		0.04	0.09	0.11	0.07	0.06	0.11	0.10	0.06	0.04	0.11
Denmark			0.10	0.09	0.06	0.08	0.09	0.09	0.06	0.08	0.11
Finland				0.17	0.13	0.12	0.15	0.11	0.12	0.16	0.13
France					0.10	0.05	0.18	0.08	0.10	0.10	0.08
Germany						0.02	0.15	0.07	0.09	0.07	0.13
Ireland							0.06	0.04	0.05	0.04	0.06
Italy								0.15	0.14	0.11	0.15
Netherlands									0.08	0.07	0.06
Spain										0.07	0.08
Sweden											0.08

Table 3: Unit Root Tests: European Equity Indices, 1988-2002

Country	ADF Lags[a]	ADF	PP[#]	ADF Lags[a]	ADF	PP[#]
		Levels			Changes	
Austria	1	-1.94*	-6.35	3	-55.04	-3379.11
Belgium	3	-1.20*	-1.91*	0	-54.35	-3828.82
Denmark	0	-1.22*	-2.01*	0	-58.57	-3579.32
Finland	3	-1.34*	-3.74	0	-59.70	-3633.34
France	0	-1.16*	-1.74*	0	-59.55	-3608.81
Germany	0	-1.29*	-2.29*	0	-62.44	-3815.14
Italy	0	-1.12*	-2.16*	0	-58.16	-3589.47
Ireland	1	-1.23*	-2.21*	0	-60.09	-3701.08
Netherlands	3	-1.10*	-1.59*	2	-38.79	-3638.27
Spain	0	-1.11*	-1.88*	0	-59.93	-3620.22
Sweden	0	-1.26*	-2.51*	0	-58.47	-3554.50
UK	3	-1.09*	-1.66*	0	-60.47	-3591.35

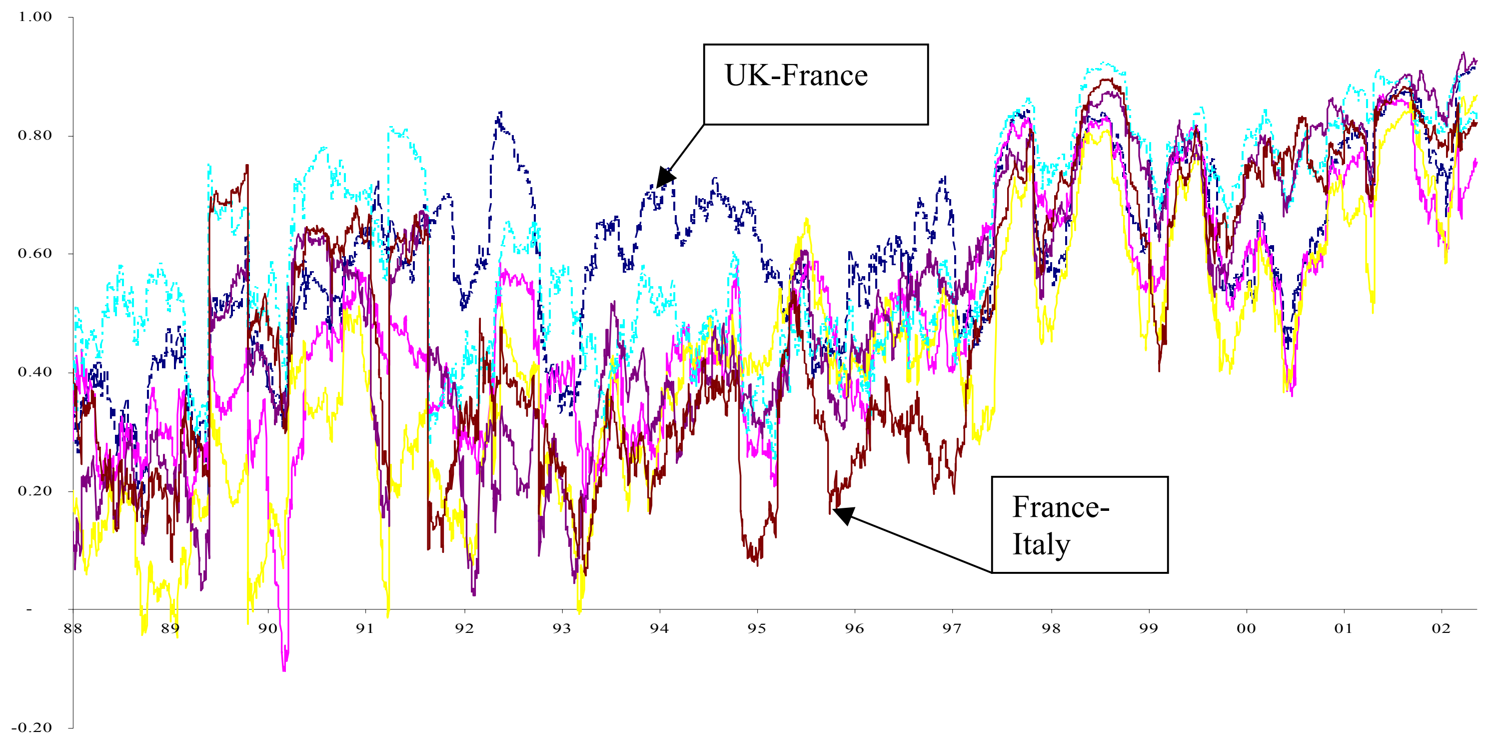
a Chosen by means of the Bernanke Information Criteria
* Significant at the 5% level.
\# Four lags are selected in all cases.

Table 4: Statistical Analysis of Haldane & Hall Convergence Factors

	Mean	Std. Deviation	T-statistic	p-value
Frankfurt Average Parameter	-.01	.011	-34.073	.000
London Average Parameter	.00	.008	-17.338	.000
	Convergence To Frankfurt			
Finland	-.02	.040	-31.135	.000
Austria	-.03	.014	-103.662	.000
Denmark	-.04	.032	-63.479	.000
Ireland	.00	.008	9.030	.000
Sweden	.00	.016	-12.092	.000
Belgium	-.02	.011	-94.822	.000
France	.01	.007	91.321	.000
Netherlands	.01	.007	93.328	.000
Italy	.01	.022	26.367	.000
Spain	.01	.006	88.064	.000
	Convergence To London			
Finland	.00	.009	-25.694	.000
Austria	-.01	.007	-97.275	.000
Denmark	-.02	.018	-49.437	.000
Ireland	.00	.009	9.051	.000
Sweden	.00	.012	-15.394	.000
Belgium	-.05	.029	-82.528	.000
France	.01	.004	86.628	.000
Netherlands	.02	.011	97.734	.000
Italy	.01	.016	19.008	.000
Spain	.01	.007	86.086	.000

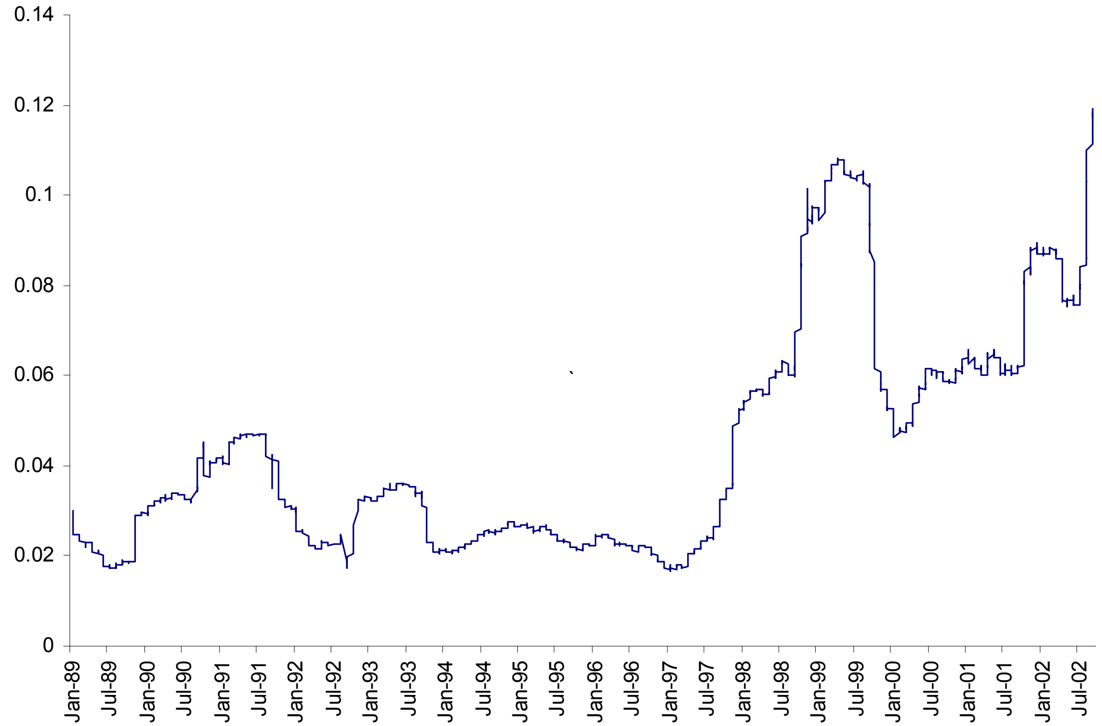
Notes: All statistics are calculated over the period January 1st 1993 to September 30 2002. T-statistics are calculated using the two sample student's t-test methodology assuming equal variances. The null hypothesis is that the mean parameter value is equal to zero. The term 'Av. Parameter' is to be interpreted as the series of average Haldane and Hall parameter estimates across the 10 equity markets with respect to the Frankfurt and London markets.

Figure 1: Rolling 100-day Bilateral Correlations for the UK, German, Italian and French Equity Markets.



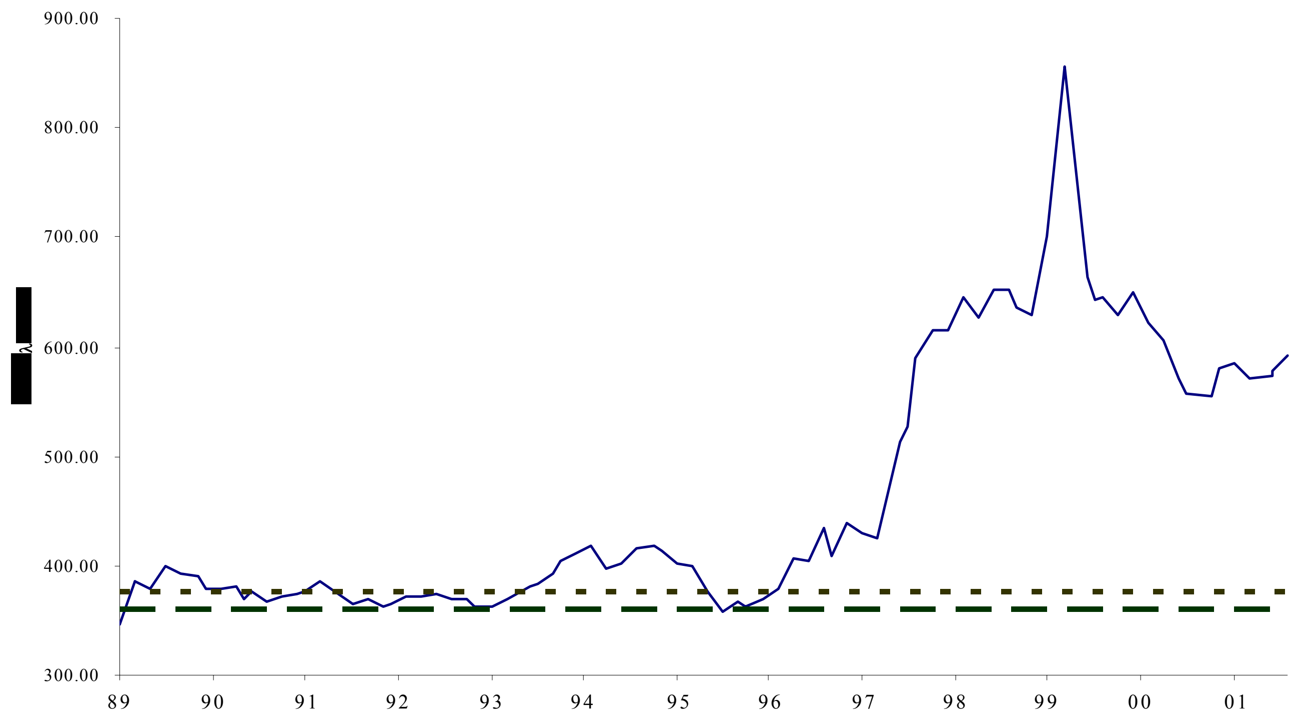
The Figure plots the time series of local bilateral Pearsonian correlations between the French, German, Italian and UK equity markets. Each statistic is estimated over a 100-day window. The first window is set between the 1st of January and the 23rd of May 1988. Thereafter the statistic is rolled forward by dropping the initial observation and adding the incremental observation at each estimate.

Figure 2: Cumulative R-Squared Time Series Plot of the First Three Eigen-values.



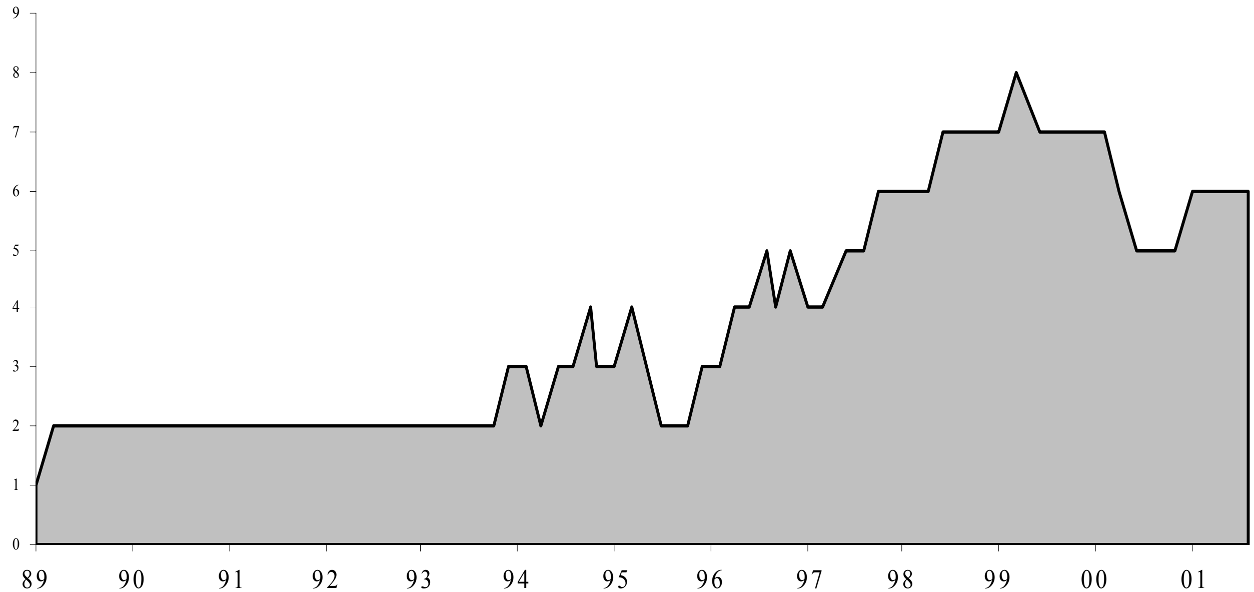
The Figure shows a plot of the cumulative R-squared of the first three eigenvalues calculated over a rolling 250 trading day window (approximately 12 months) of the full set of 12 equity markets from 1988 to 2002. The moving window drops the initial observation and includes the incremental observation for each calculation. The first observation is estimated over the period 1st January 1988 to 16th January 1989.

Figure 3: Lambda Trace Statistics.



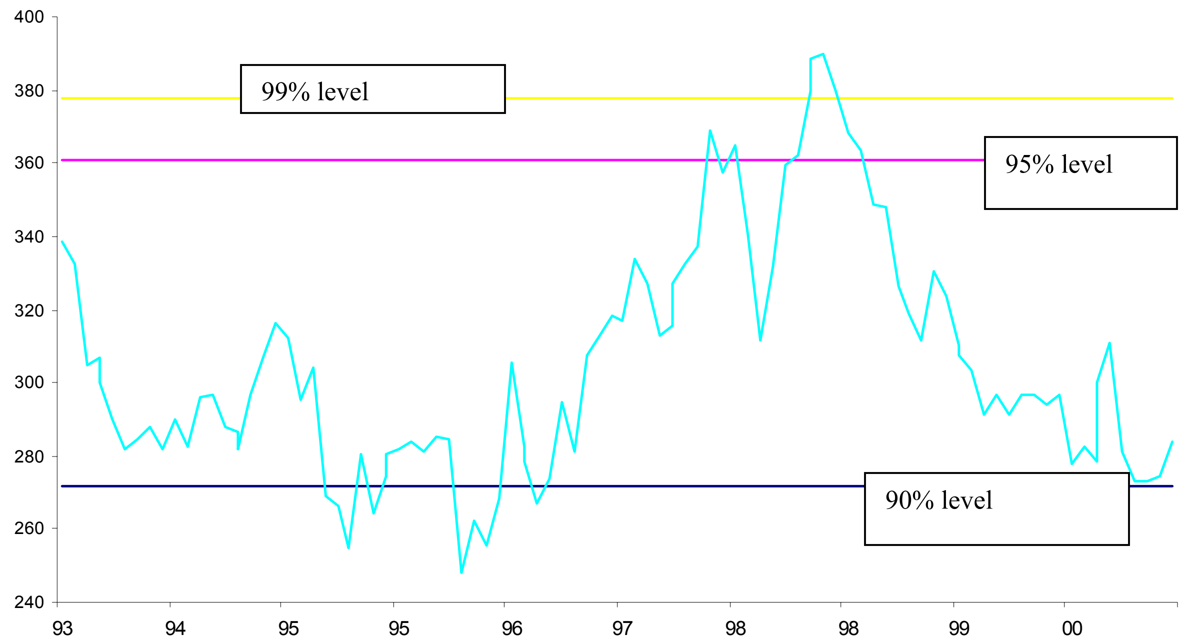
The Figure presents the Lambda Trace Statistics recursively estimated upon a window which commences over the period January 1988 to December 1989. Thereafter the window grows by 40 observations or approximately two months at each estimate. The analysis is performed and the results presented for the entire period from January 1988 to September 2002 using the full data set of 12 equity markets.

Figure 4: Number of Cointegrating Vectors.



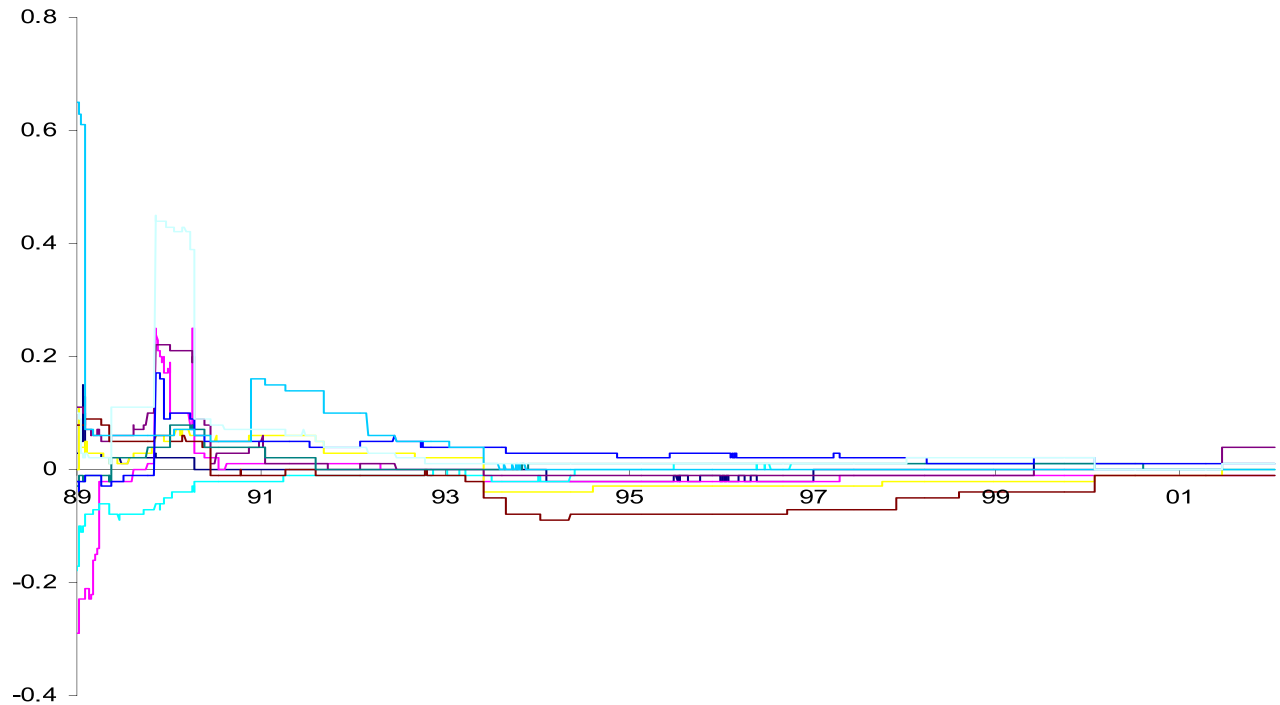
The Figure plots the number of cointegrating vectors exhibited by the full set of 12 equity markets. The statistics are recursively estimated commencing with the period January 1988 to December 1989 and thereafter growing by 40 observations or approximately two months for each subsequent estimate. It is the Lambda max statistic which is plotted and used to decide on the number of cointegrating vectors present.

Figure 5: Local Lambda Trace Statistics.



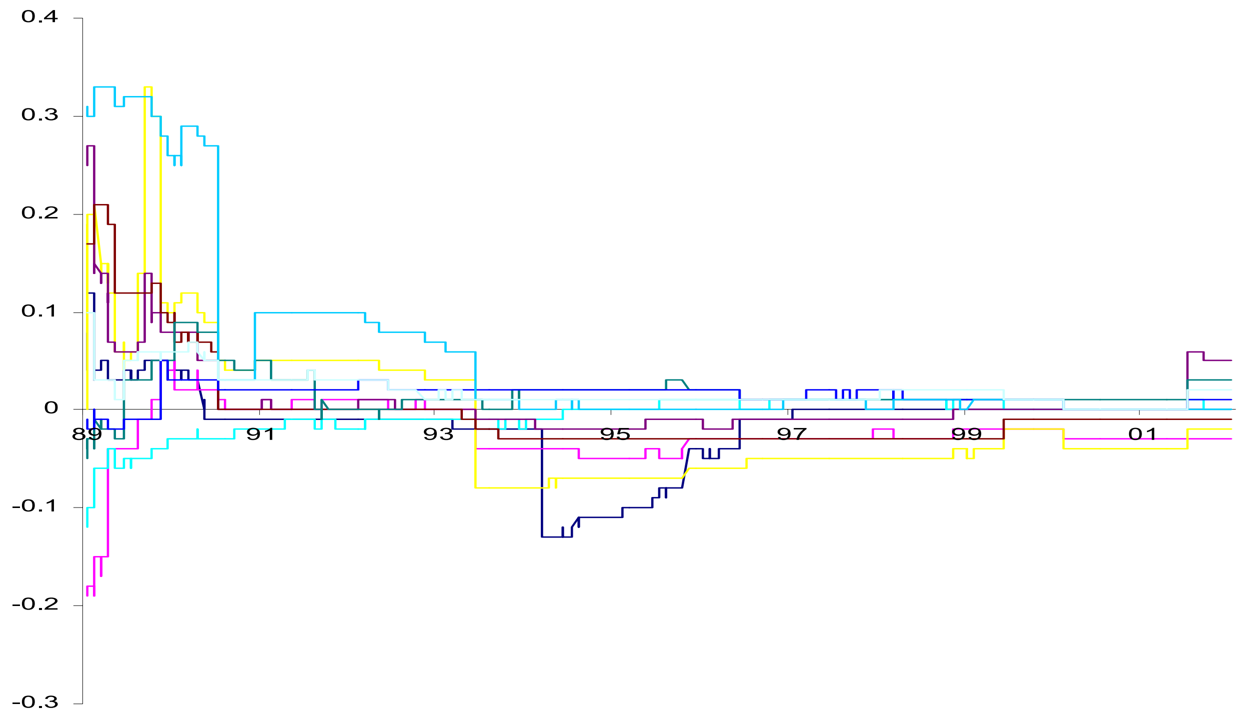
The Figure plots the local Lambda Trace statistics and also presents the 90%, 95% and 99% critical values. The plot commences for the period August 1991 to July 1993. Thereafter the local window slides discretely by 20 observations or approximately one month at each estimate.

Figure 6: Convergence to London



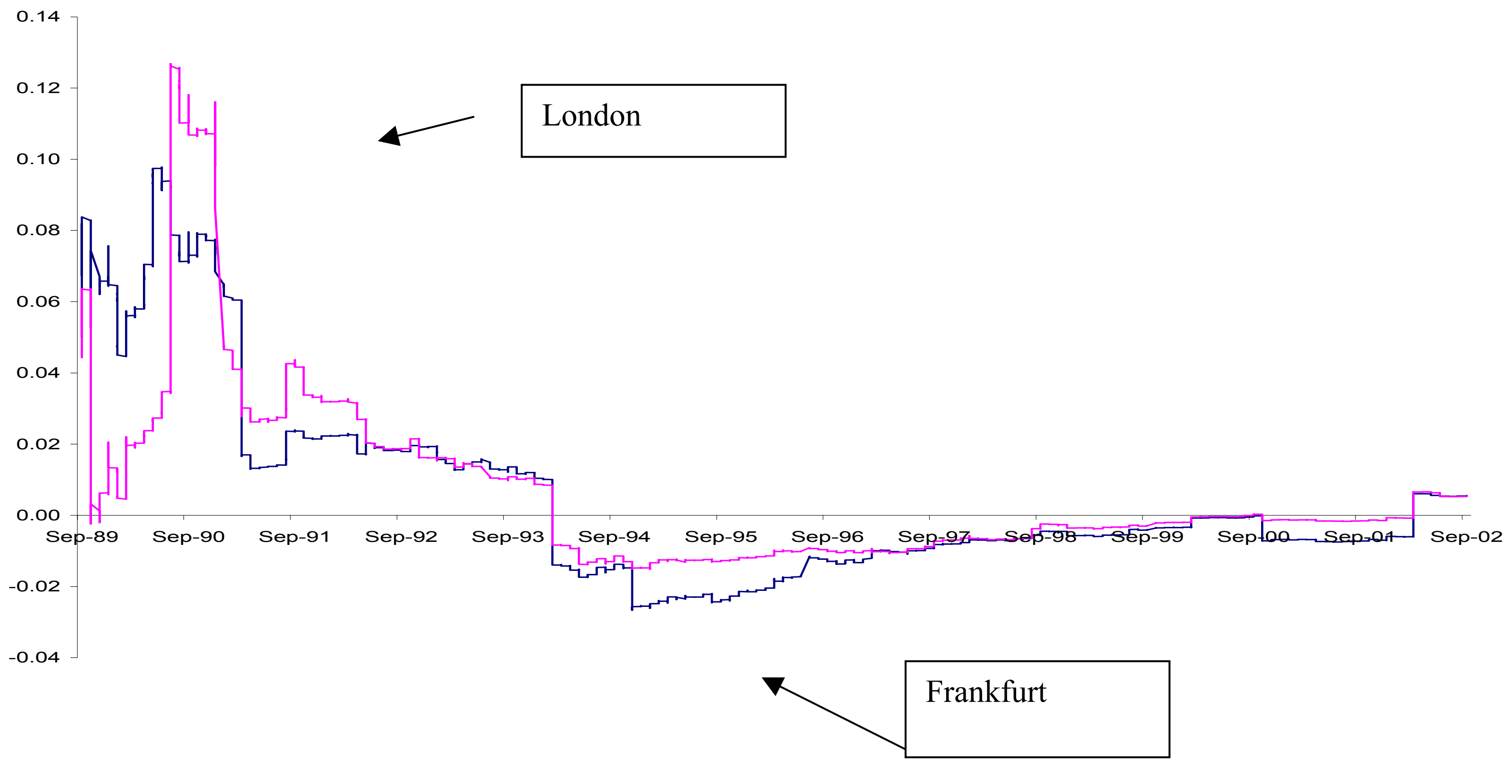
The Figure presents the Haldane and Hall Kalman Filter convergence parameters for the full set of 10 equity markets, with respect to the London market. The Frankfurt market is omitted. The convergence parameters are initialized over the January 1988 – September 1989 period and thereafter the filter updating occurs on a daily basis.

Figure 7: Convergence to Frankfurt



The Figure presents the Haldane and Hall Kalman Filter convergence parameters for the full set of 10 equity markets, with respect to the Frankfurt market. The London market is omitted. The convergence parameters are initialized over the January 1988 – September 1989 period and thereafter the Filter updating occurs on a daily basis.

Figure 8: Average Convergence using the Haldane and Hall Kalman Filter Methodology – 1989: 2002.



The Figure presents the Haldane and Hall Kalman Filter mean convergence parameters for the full set of 10 equity markets, with respect to both the London and Frankfurt indices. The convergence parameters are initialized over the January 1988 – September 1989 period and thereafter the Filter updating occurs on a daily basis.

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Institute for International Integration Studies
The Sutherland Centre, Trinity College Dublin, Dublin 2, Ireland