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COUNTRY PAIR-CORRELATIONS AS A MEASURE OF FINANCIAL INTEGRATION: THE CASE OF THE EURO EQUITY MARKETS

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Abstract

In financial economics, co-movements between equity returns are generally interpreted as a measure of equity market integration. In line with this idea, the paper investigates whether the euro equity markets have become less segmented over the last decade referring to three different estimates of pair-correlations, i.e. unconditional correlations, ex-post rolling estimates of correlations and dynamic conditional correlations (DCC). The analysis shows that pair-correlations within the euro area have indeed increased, suggesting higher financial integration of the euro equity markets. Additionally, the paper addresses the related issue of which factors have driven this integration process. The idea is that the extent of market integration may depend upon certain macroeconomic factors, that influence the degree of economic integration across countries, and upon the elimination of exchange rate volatility associated with Stage Three of EMU. The findings show that the increase in integration is explained by the relaxation of restrictions to capital mobility and of institutional barriers and by the economic convergence in Europe, while Stage Three of EMU has not further boosted integration.

JEL Class.: C32, C52, G1, G15,
Keywords: Euro equity markets, pair-correlations, DCC model, financial integration.

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Country pair-correlations as a measure of financial integration: the case of the euro equity markets*

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1 Introduction

The main aim of this paper is to analyse the recent developments concerning European equity markets and to assess whether or not we are moving towards the creation of a euro equity market.

In particular, the work is organized as follows. First, we introduce some general considerations on recent trends in world financial markets and on the integration process of European financial markets. Second, we restrict our attention to the euro area equity markets and we investigate how their structure has been affected by recent integration policies and events and whether they have become less segmented. This analysis will lead us to some conclusive remarks on the impact of these changes on growth and economic development in Europe and on opportunities for investors.

2 Financial market integration: a general view

"In recent years, world financial markets have undergone some of the most rapid and extensive changes in any markets[1]". In particular, we have witnessed a dramatic acceleration of their integration and globalization. This development has been mainly fostered by the liberalization of capital movements and rapid technological progress, which together have created new investment and financing opportunities around the world. As well explained by existing literature on financial integration, easier access to global financial

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[1]Duisenberg (2000).

markets leads to a more efficient allocation of capital, which, in turn, will promote economic growth. However, this wider globalization also implies that capital markets are now exposed to new sources of shocks and that the financial crisis of one country can rapidly affect other financial markets worsening the effects on economic growth and financial stability. The Asian crisis and the Russian crisis in the late '90s provide an example of contagion risks in an integrated world.
Recent years have also been characterized by the broadening and expansion of derivative markets, due to rapid advances in technology, financial engineering and risk management. Derivative instruments are mainly conceived to adjust exposure to risk in financial markets. This is true on a macro scale, as the increased use of these instruments allows a more efficient allocation of risks in the economy, with beneficial consequences for the functioning of financial markets and economic growth. But the result is less straightforward for individual investors, which are now exposed to new risks, due to the leveraged nature of derivative instruments.

Developments in the euro area have been even more striking than in the rest of the world. The launch of the euro on 1 January 1999 was a historic event which boosted even further the integration of financial markets in the euro area. Since the early '70s, the European Commission has pushed for the creation of a European financial area, recognizing that financial markets are crucial for economic growth inside Europe. Indeed, financial markets are the catalyst between the supply and demand sides of the economy, providing the transmission mechanism for the whole economy [2].

Also the structure, or architecture, of financial markets has implications on welfare and economic growth. As Hartmann *et al.* (2003) point out, there are some relevant differences among the financial structures of the three main economic areas of the world, the euro area, the United States and Japan. In terms of overall size, as a percentage of GDP, the euro area financial system is similar to the one of the US and smaller than Japan.
On the investment side, the authors find that households in the US have a much stronger preference for equities (147% of GDP, at the end of 2001) than in the euro area and in Japan (respectively 67% and 21% of GDP, at the end of 2001). Plausibly, different social security benefits affect the investment choices of households. For example, in the euro area people have a lower incentive to invest in securities to integrate their pensions than in the US, as social security benefits are more generous[3]. The report by Hartmann *et al.*

[2]Two recent studies estimate the effect of further integration in Europe at about 1% in GDP growth. See Giannetti *et al.* (2002) and LondonEconomics (2002).

[3]We suggest that the preference of American investors for equities can also be explained by the fact that expected gains in the US are generally higher than in Europe, making

(2003) also confirms the traditional distinction between bank-based financial systems (Europe and especially Japan) and market-based financial systems (traditionally the US system). This implies that financial institutions play a bigger role in the euro area and in Japan than in the US. However, the European financial system has changed in the last years and the introduction of the euro has strengthened even more the transformation towards a more market-oriented structure. Additionally, credit institutions are still a preferred source of financial intermediation[4] but other intermediaries, such as investment funds, pension funds and insurance companies, are widely increasing their business. These changes partly reflect the ageing population in the euro area, which rises the preferences for long term savings, and partly the increased confidence in the efficiency of equity markets to spread risks and allocate capital.

The process of integration leading to Stage Three of EMU and the euro itself have also affected the degree of integration of different segments of financial markets.

Not surprisingly, the impact on the integration of the euro money market within the euro area has been quite strong, even though with some differences. The euro area interbank deposit market, for example, has become highly integrated after the introduction of the euro[5], with little or no differences in the rates wherever the money is exchanged. Similarly, the derivative markets are highly integrated. The so-called Eonia[6] swap market, for instance, has expanded quite rapidly becoming a widely used instrument for managing interest rate risk. The market shows a high degree of standardization and competition and is largely used for hedging purposes. The situation is instead different for another segment of the money market, namely the repo market. A repo is a secured transaction, consisting of the exchange of a security and money with an agreement to reverse the transaction at a later date and at a given price. These transactions reduce risk and increase efficiency. The European Central Bank (ECB) uses secured transactions to provide liquidity over a two week horizon. In addition, securities which are accepted by the ECB are also accepted as collateral in the market for private

the risk worthwhile, and by the traditional higher confidence in their stock market with respect to European investors.

[4]To face the higher competition inside the sector and the competition arising from other financial intermediaries, banks all over Europe are merging and forming alliances. Moreover, besides expanding their size, euro-area banks are also trying to increase the number and the quality of their services, involving themselves in insurance and pension fund businesses.

[5]See among others Hartmann *et al.* (2001).

[6]Euro overnight index average. It is the overnight rate computed as the euro area interbank offered overnight rate for the euro.

repos, used by private sector institutions to manage their liquidity needs. The private repo market is still segmented because of fragmented infrastructures and differences in legislation. Finally, also the short-term security markets - such as the T-bills issued by governments, Commercial Paper issued by corporations and Certificate of Deposits issued by private financial institutions - are still fragmented because of a lack of harmonization of trading rules, issuance policy, legal systems and taxation.

As for security markets, the integration process has begun well before the launch of the single currency but it is undoubtable that the euro has then accelerated convergence processes. Since 1999, for example, there has been a marked rise in bond issuance in the euro area and a subsequent increase in the efficiency of this market. Prior to the introduction of the euro, there was a strong home-bias in portfolio allocations while the euro has made it easier for investors to improve their diversification strategies by investing across the euro area. Many large investors have now a euro area-wide perspective, rather than a national one, when deciding their portfolio allocations. This obviously implies a more efficient allocation of capital. Developments in the bond market regard both government and corporate bonds. Outstanding government bonds of the euro area countries were re-denominated in euros in early 1999 and, since then, all new bonds have been issued in euros and trading conventions of these bonds have been harmonized. As a matter of facts, total bond issuance has increased inside the euro area and differences in yields on different government bonds have strongly decreased. The remaining spreads in yields may be due to the fact that public debt issuance is still decentralized inside the euro area. The Giovannini Group[7] was supposed to provide recommendations to achieve this further step of integration but failed because of divergent views among the members of the group. The impact of the euro on the corporate bond segment has been even bigger and, as a matter of facts, this sector has grown quite strongly in recent years, starting to catch up with the US. However, comparing the two markets, the euro corporate share in GDP remains still low (for the euro area as a whole this share was 11% in 2001 against 27% for the US)[8]. In addition, the single currency has been a catalyst for restructuring the European stock market with developments which can benefit both investors and companies. Main

[7]A group of financial market participants and experts established by the European Commission in 1996 and chaired by Alberto Giovannini. Initially, the group had to advise the Commission on how to prepare the capital markets for the launch of the euro. Afterwards, the group continued to provide the Commission with economic analysis on capital market issues. Among others, a report by the Giovannini Group addressed the issue of government bonds. See GiovanniniGroup (2000).

[8]See OECD (2002).

features regarding equity markets within the euro area will be analyzed in section 3.

Despite the results already achieved, there are other important sources of segmentation. For example, retail banking, cross-border payments, mortgage and insurance markets are still highly segmented and strongly confined within national frontiers. Liberalization has to be pushed further and perfect integration of European financial markets is far from being a reality. In response to the need of increasing integration, the European Commission established, in January 1999, a Financial Service Policy Group and published, in May 1999, the Financial Services Action Plan. This plan consists of more than 40 measures, some already adopted and some to be adopted by mid 2004 and then translated into national laws by 2005. The three crucial objectives of the plan are: 1) creation of a single EU market for financial services; 2) creation of a secure and open retail market; 3) creation of a set of prudential rules and supervision. With respect to this last point, it is undoubtable that financial markets cannot function properly cross-border without coordinated regulation and supervision for banking, insurance and securities markets. Regulation is mainly structured by sector and run at the European level, which implies problems of coordination. For this reason, the Economics and Finance Ministers of the European Union established, during 2000, a Committee of Wise Men on the Regulation of European Securities Markets, chaired by Lamfalussy[9].
Supervision is also structured by sector but mainly organized at the national level. Consequently, it is necessary to increase cross-border cooperation between national supervisors and the convergence in supervisory practices. Given the relevance of the issue, the debate on changing the current structure of supervision is still a hot one.

In conclusion, we can say that world financial markets have been interested by important changes in recent years. Developments have been particularly relevant within the euro area, where the architecture of the financial system is still changing and the expected result is the creation of an efficient European single market. These structural changes in financial systems create new opportunities but also impose the necessity of higher coordination of cross-border regulation and supervision, to avoid the insurgence of instability.

[9]The main function of the Lamfalussy Committee was to discuss the best ways to implement the rules of the Action Plan and to increase cooperations between regulators. The Committee published its final report in 2001 and proposed a four-step approach to change the legislative process on security market regulation. This approach also included the creation of two new Committees, European Securities Committee (ESC) and Committee for European Securities Regulators (CESR).

3 Financial market integration in Europe: the effects on equity markets

We now restrict our attention to European equity markets and briefly discuss how their structure has changed over the last twenty years. This discussion is aimed at underlying the main events that have interested individual European stock exchanges and have created the bases for an increase in their interdependence, especially within the euro area.

3.1 Changes in the structure of European equity markets

3.1.1 In the '80s and early '90s...

The reform of European equity markets has started well before the introduction of the single currency, even though recent years have witnessed an acceleration of integration processes. Until 1985, the stock exchange of each European country was a closed membership organization with high barriers to potential enters. Additionally, each exchange was protected from competition by national regulation, restriction to capital mobility and high costs of telecommunication[10]. The situation started to change in mid '80s, as a result of increasing capital mobility, significant progresses in telecommunications and a rapid augment in cross-border trading to improve portfolio diversification.

The London Stock Exchange was the first in Europe to adjust to these new opportunities introducing a screen-based system, called SEAQ-I[11], where dealers could post their bid/ask quotes. The City of London started to attract a large number of international investors, from both the US and Continental Europe. Following the example of London, the main Continental exchanges also underwent a radical restructuring. The immediate impact of these reforms was to create a competitive market for retail customers, and, after a few years, a reversal of trading volume from London towards Continental Europe. Therefore, in the early '90s, the share of Continental Europe stocks traded in London declined considerably[12].

[10] Pagano (1997).

[11] Stock Exchange Automated Quotation System-International.

[12] In addition, the London market for British stocks had to face the new competition of the EUROCAC, a segment of the French Bourse specializing in British and other Continental Europe stocks, and of Tradepoint, a new system based in London and modelled on the Continental electronic auction markets. As a consequence of these events, and of the higher competition arising from Continental exchanges, in 1996 the majority of Lon-

If at the beginning the reform of the London exchange provided an incentive for changing the microstructure of European stock markets, later other factors boosted competition among European exchanges even further[13]: the new regulatory framework of the EU Investment Services Directive, effective since January 1996, aimed at facilitating cross-border access for investment firm and cross-border branching by the electronic networks of the European exchanges; the increasing pressure to cut trading costs (commissions and bid-ask spreads) from institutional investors; more recently, the creation of the European Monetary Union (EMU).

3.1.2 ...and in the recent past up to date

Looking at more recent years, we observe that relevant changes have especially interested the euro equity markets. Obviously, a direct impact of Stage Three of EMU is the elimination of currency risk, which has led euro area investors to shift from a domestic to a more international orientation, favoring pan-European investments. As a matter of facts, the home bias of investors within the euro area has decreased since the introduction of the euro. In 1999 and 2000, for example, investment funds with a domestic orientation lost market share while those with a pan-European or euro area orientation gained market share[14].

In terms of the size of the euro area equity market, the ratio of market capitalization to GDP has widely increased over the last years. Indeed, from 1990 to 1995 the ratio was 25%, and was much lower than in both Japan and the US, but the same ratio reached almost 90% in 2000, becoming higher than in Japan, 68%, even though still lower than in the US, 152%[15]. Additionally, new issuance in recent years has been higher in relative terms than both in Japan and in the US.

Even more striking is the changing attitude of investors within the euro area. Indeed, European investors have strongly increased their demand for equities over the last years. Possibly, this change is due to a combination of

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don Stock Exchange members agreed to replace the quote-driven SEAQ system with an order-driven mechanism, characterized by lower transaction costs. In a price-driven, or quote-driven, mechanism every security is quoted by one or several market makers who display a firm bid and ask price. They are in principles obliged to buy or sell a certain amount of securities at these prices. In an order-driven market, instead, sell and buy orders are centralized in a single order book which collects information such as the limit price, the volume and the time at which the order is registered. Deals are then made at an equilibrium price that results from the confrontation of supply and demand.

[13]Again, Pagano (1997).

[14]ECB, 2001.

[15]ECB, 2001.

factors, among which the fall of yields on bonds, the convergence of interest rates to the lowest level prevailing in Germany and population ageing, which has pushed many European investors to increase investment in equities to secure their income position after retirement. This shift towards equities also concerns institutional investors, which have changed their portfolio strategies for equities quite dramatically since the introduction of the euro. Indeed, the share of assets invested in equity funds in the total assets under management increased from 15% in 1995 to 40% in 2000, growing at a spectacular pace[16]. However, the share remains still low compared with the US (52%) and other EU countries (72%).

To confirm that equity investment has indeed increased within the euro area, we have calculated the ratio of equities to total assets for four European countries, namely France, Germany, Italy and Spain. Results are reported in table 1. Particularly relevant are the cases of Germany and Italy. In Italy, for example, the percentage ratio increased from 3.76% in 1998 to 19.51% in 1999 suggesting that the Italian stock market, traditionally marginal, started to catch up with other European exchanges. Considering that Italy was characterized by traditionally high interest rates before Stage Three of EMU, the convergence of interest rates, combined with lower inflation expectations, seems to be a plausible explanation for this result. Considering the four countries as a whole, the ratio has increased from 4.4% in 1990 to 16.69% in 2000. It is interesting to compare this evidence with evidence for countries outside the EMU. Results for the UK indicate that the ratio has been always high, without experiencing big jumps. Also in Japan the increase has not been so relevant but additionally the ratio has always been low. Finally, the ratio has increased in the US over the years, reaching its peak in 1999. The analysis, although simple, clearly confirms that European investors have sharply increased their preference for equity investment over the last decade and indicate that, on overall, stock markets in Europe and in the US have attracted increasing flows of capital.

The combination of all these events is further affecting the microstructure of the euro equity markets. In particular, we can summarize three main forces shaping the structure of the euro area exchanges. First, the increased demand for equities and cross-border investment has pushed towards a consolidation process between various stock exchanges and towards cross-border mergers between exchanges, the first of which was Euronext in September 2000, formed by the exchanges of Paris, Brussels and Amsterdam. Second, the increasing size of institutional investors and the globalization of companies, which have shown a tendency to expand their international presence,

[16]ECB, 2001.

Table 1: Equity securities/total assets

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Germany	4.14	5.08	8.07	8.96	10.18	9.98	11.03	13.8	16.76	21.19	22.8
France	5.46	5.88	5.23	5.72	4.55	4.27	5.00	5.96	7.13	8.52	8.21
Italy	4.13	3.57	2.96	2.60	2.71	2.34	2.33	3.29	3.76	19.51	23.36
Spain	1.41	1.39	1.19	1.07	1.55	1.39	1.53	2.97	5.01	7.74	12.30
Total	4.40	4.83	5.91	6.34	6.47	6.21	6.74	8.30	10.17	15.45	16.69
UK	11.2	13.5	12.1	14.3	13.89	14.06	14.64	13.62	14.62	17.03	14.28
US	8.61	11.3	12.7	17.8	19.13	20.05	22.05	22.88	24.35	28.12	25.30
Japan	na	na	na	na	na	5.56	5.84	5.80	7.01	9.47	8.71

Comments: The table reports the percentage ratios of equity securities to total assets from 1990 through 2000 for all countries but Japan, where data are only available from 1995. The source for data is International Financial Statistics, IMF, Yearbook 2002. Equity securities assets include shares, stocks, participation and similar documents that usually denote ownership of equity. Original data are expressed in billions of US dollars and represent assets for residents of each country. 'Total' refers to the ratio for the four euro area countries as a whole. Namely, it is calculated as the sum of equity securities of Germany, France, Italy and Spain over the sum of total assets of the same four countries.

have incremented the degree of concentration of equity brokerage and advisory work.

Third, trading hours have been expanded to attract investors from other time zones. This need is particularly strong in the field of derivative instruments, where after-hours trading systems have already been fully implemented. Stock exchanges are moving in the same direction, and this, given the high cost of extending local trading hours, leaves room for further co-operation between exchanges on continuous trading.

These changes and developments are important in the measure they enhance further integration and growth of the euro equity markets. A larger capital market promotes the accumulation of capital and a more efficient allocation of resources to investment projects, consequently boosting economic growth. Despite these relevant developments, there are still some sources of segmentation. Economic agents are interested in deep and liquid markets and in low transaction costs. This requires full integration of trading systems, further harmonization of rules (national tax systems are different and so are security market legislation and supervision) and measures to increase market efficiency. But full integration also requires further changes in investment culture, especially among retail investors.

Finally, it should be clear from this analysis that the nature of the changes in the structure and integration of the euro equity markets is quite complex and poses some questions which need to be answered: How effectively integrated are stock exchanges inside the euro area? Which factors have mainly boosted integration?

The remainder of this work addresses these questions with an empirical

analysis, which is preceded by a short review of previous work on measuring financial integration.

4 Measuring equity market integration: theoretical motivations and empirical results

As Bracker *et al.* (1999) point out[17], "the term 'international stock market integration' represents a broad area of research in financial economics that encompasses many different aspects of the interrelationships across equity markets". Broadly speaking, in a financially integrated equity market, economic agents are free to invest in any assets, independently from their location, and expected local returns depend only on non-diversifiable international factors, according to the capital asset pricing model (CAPM). Many attempts and many econometric methodologies have emerged over the years to test for international linkages between equity markets and to interpret them in terms of financial integration.

Existing empirical works on this aspect of international integration generally focus on how the stock markets of different countries are interrelated, finding that countries in proximate geographical areas tend to show greater co-movement than countries far apart; that the relationship tends to be significant within a period of 24 hours; that stock markets have become more integrated in the last years.
Even though the relationship 'high co-movements-high integration' is widely accepted, it should be interpreted with some caution. Indeed, two countries could be completely integrated but their industry sectors may be sufficiently specialized to justify a low correlation. Moreover, before concluding that, as correlations have increased markets are becoming more integrated, one should control for the degree of correlation of economic fundamentals[18].

We now briefly discuss two works that provide a good example of econometric methodologies to test for integration and then consider some very recent works more directly related to the case of the euro equity markets, which is our primary interest.

The paper by Bracker *et al.* (1999) uses a two-step approach which explores two related issues. First, how the degree of co-movements for a given pair of markets varies over time. Second, why this interdependence varies over time. The analysis is run on a sample of 9 countries. In the first stage, the authors estimate contemporaneous and lead/lag relationships among eq-

[17]Bracker, Docking and Koch (1999), p.2.
[18]Dumas, Harvey and Ruiz (2003).

uity returns and find that significant inter-market responses across the 9 markets are mostly completed within 24 hours, throughout the 22-year sample period, indicating a high degree of both market efficiency and integration. Additionally, the level of integration has increased over time. In the second stage, they try to understand, using two different regression models, which macroeconomic factors can explain estimated pair relationships on the same day and lead/lag relationships across days. They find that the extent of integration on the same day is affected by many factors, such as the geographic distance between markets, measures of bilateral import dependance, the size differential across markets, a time trend used as a proxy for the many changes which have boosted integration of capital markets over the years. Instead, lead/lag relationships across days are only affected by real interest rate differential between markets and the market size differential.

Chelley-Steeley and Steeley (1999), instead, focus on European equity markets and refer their analysis to the period 1975-1991, when most European countries eliminated bilateral exchange controls. They first use a VAR analysis that provides impulse responses that allow to identify the strength with which shocks to one stock market are transmitted to other stock markets. In particular, they compare the transmission of shocks before and after the removal of exchange controls finding that market segmentation is reduced after the removal of these controls. A problem with their methodology is that the authors completely ignore the volatility clustering generally observed in financial time series, especially when used with high frequency. As they are using daily stock returns, we believe that the use of a multivariate GARCH model would have been more appropriate for their scope. Second, as the period they investigate is also characterized by an acceleration of economic harmonization, they want to investigate whether higher equity market interdependence is only caused by these closer macroeconomic links or effectively by the removal of exchange controls. The removal of exchange controls is proxied by a dummy variable for each country while macroeconomic links are proxied by a linear combination of 7 economic variables obtained with a principal-component analysis. They then regress the series of pair-correlations between European countries on the dummy and on the linear combination of the seven macroeconomic variables and find indeed that the removal of exchange controls has a positive and significant impact on correlations.

4.1 Previous work on the euro equity markets

Considering empirical studies on the integration of the euro equity markets, a common feature they show is that, despite the great importance attributed

to the monetary unification, they try resisting the temptation to focus exclusively on this event. In fact, the launch of the euro has been preceded by a long convergence process, started in 1979 with the creation of the European Monetary System, which is also crucial to explain increasing integration. The general conclusion of these works is that integration within the EMU has indeed increased through a gradual process.

We start considering a theoretical work by Adjaouté and Danthine (2002). The authors argue that "full financial integration implies that the law of one price applies to financial assets available across the euro-area"[19]. In their view, financial integration should lead to the convergence of interest rate levels and to a reduction of the risk premium on risky assets. In the attempt to assess the integration of equity returns, they first verify whether, inside the euro area, the variances of national equity indexes are higher than the variance of the global portfolio. Under this condition, which is a necessary condition, financial integration should result in a lower risk premium, compared to segmented markets, which in turn should lead to a lower cost of capital and therefore stimulate economic growth. The evidence is unambiguous for the euro area, where the standard deviation of the national markets, measured by Morgan Stanley Capital International (MSCI) indexes, is always higher than the corresponding EMU index. Secondly, they use a multi-factor approach to the equity risk premium. This approach allows equity returns to be affected by several factors, such as sectors, countries, global (euro area/world). Many empirical studies have estimated the relative importance of these various factors showing, in most cases, that country factors traditionally dominate industry factors. This gives support to the traditional 'top-down' approach to asset allocation[20] and is coherent with the existence of segmented markets. Oppositely, inside an integrated area, like the euro area, the industry or sector orientation should prevail. Evidence obtained by Adjaouté and Danthine confirms indeed this expectation for the euro area and the authors associate this finding to the change in asset allocation paradigm. Finally, they obtain very similar results using standard mean-variance models, which indicate that, since 1995, Sharpe ratios[21] of optimal portfolios constructed from sector indices have been constantly higher than those constructed from country indices, again confirming the change in asset allocation paradigm.

[19] Adjaouté and Danthine (2002), p. 9.

[20] This approach includes two steps. The first one consists in deciding on a country allocation grid, giving priority on an adequate geographical diversification of portfolios. The second step consists in choosing the best securities, given the geographical allocation. Therefore, the standard result that country factors are dominant supports the geographical importance of the top-down approach.

[21] Mean divided by standard deviation.

Fratzscher (2001) reaches very similar conclusions using a much more empirical approach, i.e. using a trivariate GARCH model. In particular, he analyzes changes in the integration of European equity markets since the '80s. The processes entering the GARCH model are individual countries' returns, euro area returns and US returns. This allows him to evaluate the relative importance of regional shocks originating in the euro area with respect to global shocks coming from the rest of the world (proxied by the US). His results are quite striking. First, equity markets in Europe are highly integrated[22]. Second, while the US remains the dominant market outside the euro area, it is no longer the only dominant market within the euro area. Third, the degree of integration has strongly increased within the euro area since the announcement of the euro members in May 1998. Finally, the transmission of shocks has become stronger and asymmetric and threshold effects have become larger over time. In other words, not only shocks in one equity market raise volatility in other markets more than before, but also the transmission of large and negative shocks has increased more proportionally than the spillover of small and positive innovations. Obviously, this has implications for contagion patterns, financial instability and ultimately economic growth. Fratzscher then investigates whether the EMU is a driving force behind the integration process and the importance of the reduction and then elimination of exchange rate volatility and uncertainty through the Exchange Rate Mechanism (ERM) and the euro. His idea is that when exchange rates are uncertain and volatile markets are more segmented and correlations across markets lower. Therefore, he interprets correlations as a proxy for integration, in line with many theoretic and empirical studies. Results show that exchange rate volatility has a lot of power in explaining changes in integration. In particular, reduced exchange rate volatility, as well as monetary policy convergence of interest rates and inflation rates have boosted the financial integration process in Europe. European equity markets have become much more integrated with each other and have gained importance in world financial markets since 1996[23]. Moreover, in line with Adjaouté and Danthine (2002), results seem to support a shift from diversification across

[22]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%.

[23]Also Frankel (1996) investigates whether currency integration has an impact on equity market integration. The 'neutrality view' states that the exchange rate regime is irrelevant to equity markets. However, this view does not accord with the facts. Indeed, there is evidence of investors' home-country bias, which can be due to the fact that they feel safer with domestic equities but also to 'currency myopia'. This would explain the increase in correlations in Europe in coincidence with a greater degree of intra-European exchange rate stability. Running some experiments, Frankel finds indeed support for this hypothesis.

countries to diversification across sectors.

This result partly contrasts with the result obtained by Morana and Beltratti (2002). Their analysis suggests indeed that stock market volatility tends to be very sensitive to general macroeconomic conditions. Consequently, it is still more convenient for investors to diversify their stock holding across countries rather than across sectors or industries. In their work, the authors analyze whether the stabilization of fundamentals and the introduction of the euro have decreased traditionally high variance of European stock returns and reach conclusions which in part differ from those of the other works revised in this survey. Their sample is composed by France, Germany, Italy, Spain, plus, for comparison, UK and USA. They use three different methodologies of increasing complexity: 1) a test for equality of unconditional variances before and after the euro; 2) a test for equality of variances performed in the context of a GARCH model; 3) a Markov switching model, with three volatility regimes, namely low, medium and high volatility. Using the first methodology, the null of equal unconditional variances in the two subsamples is rejected for all countries apart from Italy. In the case of the GARCH model, to test for the presence of a volatility shift they introduce a dummy variable taking the value of one starting from 1 January 1999. The evidence arising from this methodology suggests that, in the period following the introduction of the euro, volatility in the European stock markets has not declined. However, the dummy variable used is not very accurate. Indeed, even though the moment of the introduction of the euro is known with certainty, stock price movements tend to anticipate future events. This justifies the use of a multiple regime model, such as the Markow switching model, where a decrease of unconditional variance of stock returns is interpreted as the consequence of a stabilization of fundamentals and expectations. Estimated results are very different from those obtained using the GARCH model as the authors find that the correlation coefficients are significantly different among the three regimes. There is a general increase in correlations in the high volatility regime and there are signs of stabilization of the Italian and Spanish stock markets. Indeed, after an initial burst of volatility common to all European markets, the Italian and Spanish stock markets have experienced a long-lasting reduction in volatility. Therefore, from the point of view of stock market efficiency, European stock markets have reacted in the way predicted in terms of volatility, and the euro seems to have brought a net benefit in terms of reduced volatility.

5 Integration of the euro equity markets: methodology and results

As just explained in section 4, international co-movements are generally interpreted as a measure of equity market integration. In line with this idea, we now investigate whether the euro equity markets have become more integrated over the last ten years. This result is partly anticipated by previous work on the topic. However, as we have discussed, different methodologies can be used to measure the level of interdependence among markets, therefore estimated results tend to be sensitive to the model used and consequently the conclusion that markets are less segmented is not always robust.

To overcome this limit, we use a different methodology, namely we investigate pair-correlations between the euro stock exchanges, and, more importantly, we provide three different measures of pair-correlations and compare estimated results to see whether they show ambiguous evidence or whether they all confirm our expectation. Namely, we refer to unconditional pair-correlations, ex-post rolling estimates of pair-correlations and dynamic conditional pair-correlations.

The analysis includes four countries, Germany, France, Italy and Spain, which are a good proxy for the euro equity market as a whole, and covers the period January 1, 1994 through June 25, 2003[24].

Once obtained support for our hypothesis of higher integration within the EMU, we address a related issue: which forces can explain changes in correlations? To answer this question, we develop an econometric model which includes both macroeconomic variables, as a proxy for the harmonization process of the last years, and a dummy variable for the monetary unification.

5.1 Summary information and unconditional correlations

We begin our analysis providing summary information for the return indexes of the four countries considered. To better identify the changes occurred within the area, we divide the sample period into four sub-periods: 1994-1996; 1997-1998; 1999-2000; 2001-2003.

From table 2, we observe that mean daily returns reached their peak between 1997 and 1998, right before the introduction of the euro. This might reflect expectations related to the launch of the single currency. However,

[24]Data for the MIB30 are only available from October 18, 1994. Consequently, summary information for the MIB30 and unconditional pair-correlations between Italy and any other given country all start from this date.

Table 2: STOCK MARKET RETURN SUMMARY STATISTICS

Index	Average Return	Standard Deviation	Kurtosis	Skewness
4/01/1994 - 31/12/1996				
$Dax30(Germany)$	0.031	0.890	4.653	-0.458
$Cac40(France)$	0.001	0.989	3.216	-0.010
$Mib30(Italy)$	0.012	1.240	4.415	0.123
$Ibex35(Spain)$	0.044	0.951	4.598	-0.387
1/01/1997 - 31/12/1998				
$Dax30$	0.105	1.659	5.632	-0.743
$Cac40$	0.102	1.497	4.765	-0.235
$Mib30$	0.154	1.798	4.439	-0.232
$Ibex35$	0.124	1.650	5.649	-0.488
1/01/1999 - 31/12/2000				
$Dax30$	0.048	1.429	3.703	-0.003
$Cac40$	0.078	1.334	3.448	-0.202
$Mib30$	0.042	1.381	3.970	-0.027
$Ibex35$	-0.015	1.405	4.818	-0.132
1/01/2001 - 25/06/2003				
$Dax30$	-0.107	2.226	4.002	0.058
$Cac40$	-0.100	1.940	4.318	0.107
$Mib30$	-0.083	1.675	5.016	-0.028
$Ibex35$	-0.044	1.751	3.562	0.142

Comments: The table reports summary statistics for daily equity returns of Germany, France, Italy and Spain over the period January 1, 1994, through June 25, 2003. Percentage daily returns are denominated in euro and obtained from daily price index series downloaded from Datastream. Mean and standard deviation are quoted in percent.

mean returns started to fall in the period immediately after the introduction of the single currency and became negative, for all the countries, between 2001 and 2003. Table 2 also shows that volatility for the four markets sharply increased between 1997 and 1998 with respect to the period 1994-1996, slightly fell between 1999 and 2000, to increase again from 2001. Finally, there is evidence that negative shocks are more frequent than positive shocks (negative skewedness) and that excess kurtosis is present in the series. This in part reflects the dispersion of the extreme values in the return series (fat-tails).

For our scope, more revealing and interesting than univariate statistics are unconditional pair-correlations of daily equity returns for the four countries. In line with our expectations, we observe that correlations tend to increase over the period of our interest. Considering for example pair-correlations between Germany and France, we observe that they have substantially augmented in each sub-period, rising from 0.496 in the period 1994-1996 to 0.854 in the period 2001-2003. It is interesting to notice that the most dramatic rise has occurred between 1997 and 1998. This seems to confirm the view that stock markets anticipate future events, such as the introduction of the euro. After January 1, 1999, pair-correlations between Germany and France have still increased, suggesting that the single currency has further impacted

Table 3: STOCK MARKET DAILY RETURN CORRELATIONS

	Germany	France	Italy	Spain
4/01/1994 - 31/12/1996				
Germany	1	0.496	0.362	0.453
France	0.496	1.000	0.446	0.603
Italy	0.362	0.446	1.000	0.405
Spain	0.453	0.603	0.405	1.000
1/01/1997 - 31/12/1998				
Germany	1.000	0.717	0.623	0.676
France	0.717	1.000	0.755	0.755
Italy	0.623	0.755	1.000	0.736
Spain	0.676	0.755	0.736	1.000
1/01/1999 - 31/12/2000				
Germany	1.000	0.781	0.692	0.684
France	0.781	1.000	0.755	0.769
Italy	0.692	0.755	1.000	0.737
Spain	0.684	0.769	0.737	1.000
1/01/2001 - 25/06/2003				
Germany	1.000	0.854	0.830	0.777
France	0.854	1.000	0.893	0.873
Italy	0.830	0.893	1.000	0.850
Spain	0.777	0.873	0.850	1.000

Comments: The table reports unconditional pair-correlations of daily equity returns across the four countries listed, namely Germany, France, Italy and Spain. Percentage daily returns are denominated in euro and obtained from daily price index series, downloaded from Datastream. The analysis covers the period January 1, 1994, through June 25, 2003.

on international linkages between the two stock markets, but proportionally less than during the previous sub-period. Therefore the launch of the euro, although a historic event, has been well anticipated by stock markets and it seems plausible to argue that the increase in correlations is better explained by the harmonization process which has preceded the Monetary Union than by Stage Three of EMU itself. In other words, once the monetary unification has been achieved, pair-correlations have started to increase more slowly. Table 3 displays similar patterns for all other country pair-correlations, confirming the idea of a positive trend in correlations within the euro area over the last ten years and consequently of a reduction of market segmentation.

5.2 A comparison between rolling estimates of pair-correlations and dynamic conditional correlations

To strengthen the evidence arising from the statistical analysis, we now provide two different methods to estimate daily pair-correlations and then analyze whether they both confirm that equity markets within the euro area have become more integrated.

First, we consider ex-post 'rolling estimates' of daily pair-correlations. Namely, given the original series of percentage daily returns, we calculate, for each pair of countries, Germany and France for example, the series of daily pair-correlations as the result of the correlation between returns of each day with the previous 21 days, assuming that 21 is the length of the financial month[25]. Therefore, if the series of daily returns start from October 18, 1994[26], the new series start with a lag of 21 days. Once obtained daily pair-correlations, we consider a transformation of the series, namely the 'hyperbolic tangent', defined as:

$$y = \ln((1+x)/(1-x)) \tag{1}$$

where y is the hyperbolic tangent and x is the ex-post rolling estimate of pair-correlations. While correlations are defined between -1 and 1, and suffer of high volatility in proximity of the bounds, the hyperbolic tangent is defined between $-\infty$ and ∞ and this should solve the volatility problem. With this procedure, we obtain six new variables called *tgerfra, tgerita, tgerspa, tfraita, tfraspa, titaspa*, where t stands for hyperbolic tangent and the two countries are indicated by their initials, *gerfra* for example.

Second, we estimate daily pair-correlations using the Dynamic Conditional Correlation (DCC) model[27]. The DCC model is an extension of the CCC (Constant Conditional Correlations) model proposed by Bollerslev (1990). The hypotheses by Bollerslev are: 1. D_t is the $n * n$ diagonal matrix with all conditional variances h_{iit} on the diagonal; 2. R_t is the $n * n$ correlation matrix, such that each correlation coefficient satisfies the relationship: $\rho_{ijt} = h_{ijt}(h_{iit}h_{jjt})^{-1/2}$; 3. As the generic element of Ω_t is defined as $h_{ijt} = \rho_{ijt}(h_{iit}h_{jjt})^{1/2}$, its time variation can depend either on the variation of the correlation coefficient or on the variation of single conditional variances. Since in the CCC model R is constant, the structure of conditional covariances over time only depends on conditional variances. Given

[25]Ex-post refers to the fact that pair-correlations between returns are calculated for each day with the previous 21 days. Alternatively, ex-ante correlations between returns are calculated for each day with the following 21 days.

[26]Data for the MIB30 are not available before.

[27]See Engle and Sheppard (2001) and Engle (2002).

these hypotheses, in the CCC model the conditional variance and covariance matrix is defined by: $\Omega_t = D_t^{1/2} R D_t^{1/2}$. Assuming that the conditional variance of the returns of each asset follows a GARCH(p,q) model, and that the covariance for each pair of assets is given by the standard deviation of the returns of the two assets multiplied by constant coefficients of correlation, we have a model defined by the following equations:

$$h_{iit} = \alpha_{0i} + \sum_{r=1}^{q} \alpha_{ir} \epsilon_{it-r}^2 + \sum_{r=1}^{p} \beta_{ir} h_{iit-r} \tag{2}$$

$$h_{ijt} = \rho_{ij} (h_{iit} h_{jjt})^{1/2} \tag{3}$$

By hypothesis, conditional correlation coefficients do not vary over time. Such a model has two main advantages. First, it reduces the number of parameters to estimate with respect to traditional multivariate GARCH models[28]. Second, it simplifies the procedure to obtain the determinant of the Ω_t matrix in the log-likelihood function.

With respect to this model, in the DCC model, given a n-dimension vector y_t of returns, which can be either mean zero or the residuals from a filtered time series, the conditional variance and covariance matrix is defined by the following relationship:

$$\Omega_t = D_t^{1/2} R_t D_t^{1/2} \tag{4}$$

The correlation matrix R_t is now not constant over time and this leads to a two-step estimate of the whole process.
The first step implies the estimation of n ARMA(p,q) processes with residuals specified by n GARCH(p,q) models[29]:

$$h_{iit} = \alpha_{oi} + \sum_{s=i}^{Q_i} \alpha_s y_{it-s}^2 + \sum_{s=i}^{P_i} \beta_s h_{iit-s} \tag{5}$$

where h_{iit} are the elements of the diagonal matrix D_t and Q_i and P_i are the number of lags in the GARCH model and vary for each series of returns. This step provides the estimation of the elements of the diagonal matrix D_t avoiding the estimation of a multivariate GARCH. Once estimated D_t, standardized residuals can be calculated as:

$$u_{it} = y_{it} / h_{iit}^{1/2} \tag{6}$$

[28] See Palm (1996).

[29] As Engle and Sheppard (2001) point out, any univariate GARCH model can be used to model the variances. Using asymmetric GARCH type models, for example, allows to capture asymmetries in variances.

The second step implies the estimation of the matrix Q_t, defined by a GARCH(p,q) model[30]:

$$Q_t = (1 - \sum_{r=1}^{q} \alpha_r - \sum_{r=1}^{p} \beta_r)\overline{Q} + \sum_{r=1}^{q} \alpha_r u_{t-r} u'_{t-r} + \sum_{r=1}^{p} \beta_r Q_{t-r} \qquad (7)$$

where $\overline{Q} = E(u_t u'_t)$ is the non conditional correlation matrix of y_t. This specification comes directly from the definition of a standardized process. Indeed, for a standardized process conditional correlations coincide with conditional covariances, i.e. $\rho_{ijt} = E_{t-1}(u_{it}u_{jt})$. Therefore, the variance covariance matrix of standardized residuals coincide with R_t. The Q_t matrix can be reparameterized to obtain the true correlation matrix[31] R_t:

$$R_t = \tilde{Q}_t^{-1} Q_t \tilde{Q}_t^{-1} \qquad (8)$$

where $\tilde{Q}_t$ is a diagonal matrix with the squared root of the elements on the diagonal of Q_t. In this way, R_t is the correlation matrix for standardized processes, with all elements on the diagonal equal to one. The two-step process leads to less efficient estimates, but, as proved by Engle and Shepperd (2001), they are consistent and asymptotically normal. The biggest limitation of the DCC model is that all conditional correlations, ρ_{ij}, are described by the same process and consequently their time-varying evolution is restricted.

Using the DCC model, we obtain six daily series of dynamic conditional pair-correlations. As before, also in this case we consider a transformation of these series, namely the hyperbolic tangent. The final series are called *tdgerfra, tdgerita, tdgerspa, tdfraita, tdfraspa, tditaspa*, where again t stands for hyperbolic tangent and d stands for DCC.

Finally, we use a graphical analysis to compare estimated results provided by the two different methods. Figure 1, for example, plots *tgerfra* and *tdgerfra*, i.e. the two transformed series of pair-correlations between Germany and France calculated as explained above. The graph clearly shows that the two series have a positive trend and that the correlation between the German equity market and the French equity market has increased over the last ten years. Moreover, *tgerfra* and *tdgerfra* have a very similar path and a surprising coincidence of troughs and peaks. The main difference between the two series is that *tgerfra*, obtained using rolling estimates of pair-correlations, is much more volatile than *tdgerfra*, estimated with the DCC model. Figure

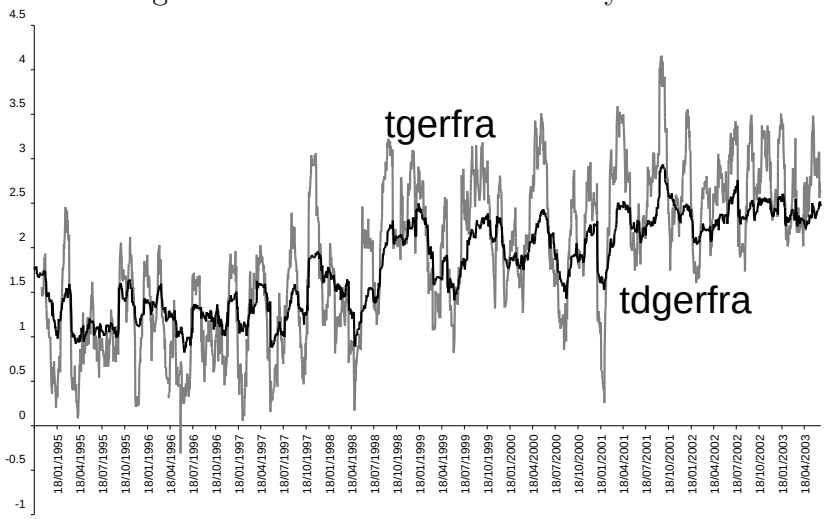
[30]Recently, Sheppard (2002) has extended the DCC model to allow for asymmetric dynamics in the correlation in addition to the asymmetric response in variances already possible in the original DCC model.

[31]Billio *et al.* (2003).

1 also shows that correlation between the two markets sharply increased in 1998, right before Stage Three of EMU, fell in coincidence with the launch of the euro and then started to rise again.

Similar considerations also hold for all other pair-correlations and the main result to retain from this analysis is that correlations within the euro area, in line with our expectations, have increased over the last decade suggesting a reduction of market segmentation. Additionally, we can be confident that this conclusion is robust as it supported, for all pair of countries, by three different methods, unconditional correlations, ex-post rolling estimates of correlations and dynamic conditional pair-correlations.

Figure 1: Pair correlations Germany-France



Comments: The figure plots *tgerfra* and *tdgerfra*, respectively the 'hyperbolic tangent' transformation of ex-post rolling estimates of daily pair-correlations and the 'hyperbolic tangent' transformation of daily dynamic conditional correlations between Germany and France, over the period 1994-2003.

Figure 2: Pair correlations Germany-Italy

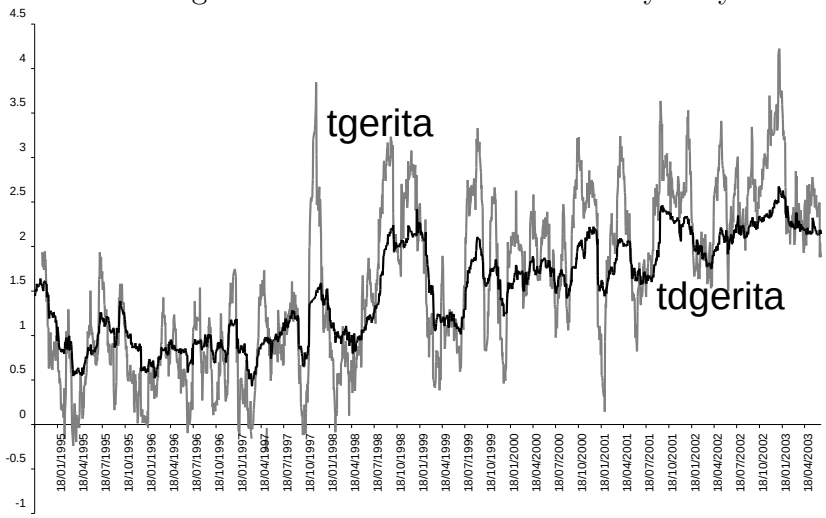


Figure 3: Pair correlations Germany-Spain

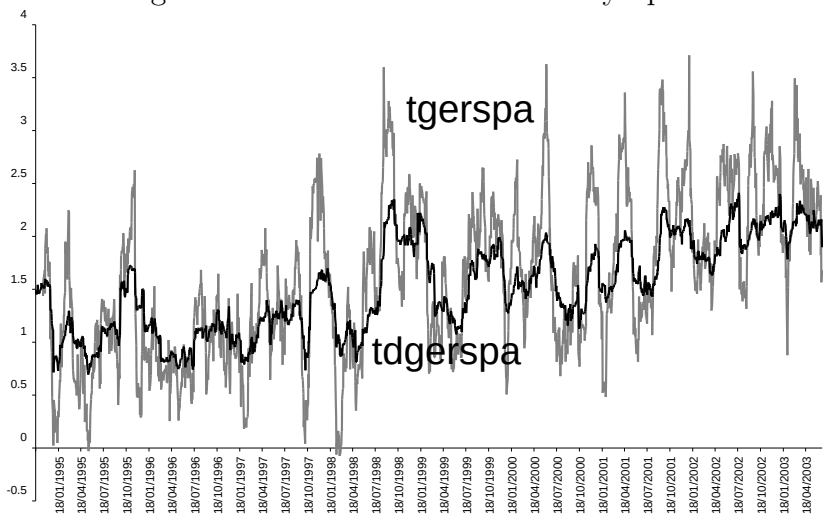


Figure 4: Pair correlations France-Italy

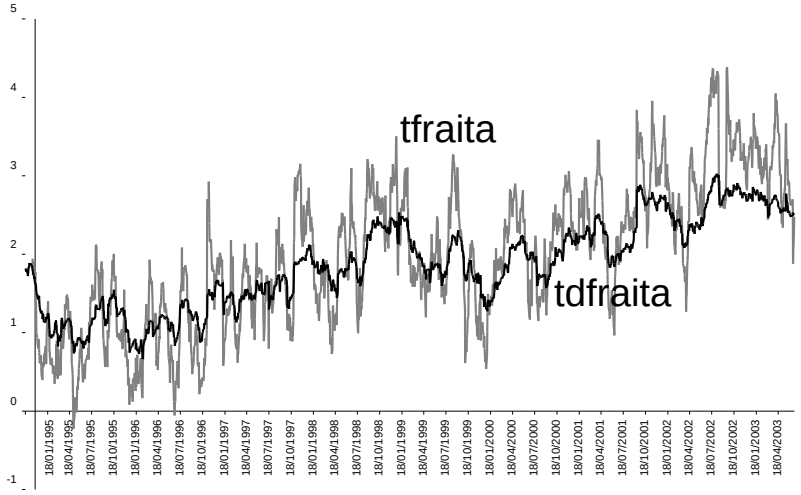


Figure 5: Pair correlations France-Spain

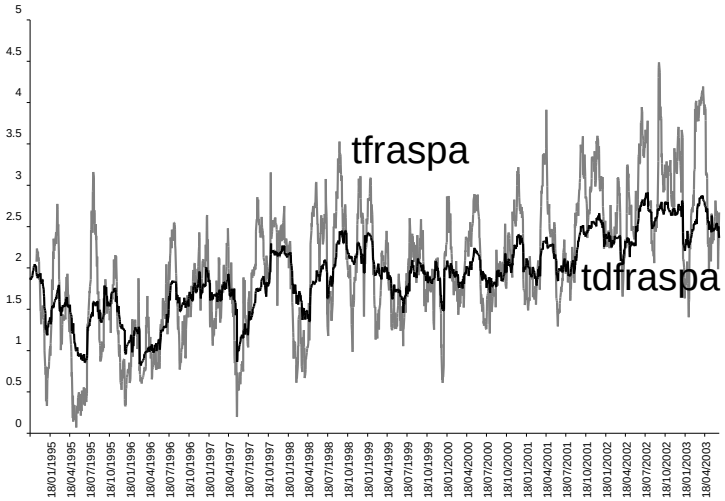
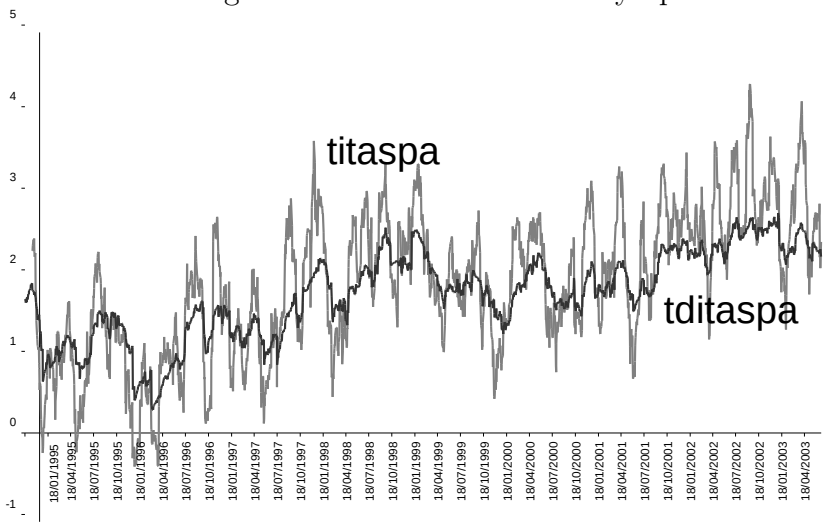


Figure 6: Pair correlations Italy-Spain



5.3 Explaining the trend in correlations

After having obtained robust evidence in favor of higher integration within the euro area over the last years, we want to address the issue of which factors have driven this integration process. Our hypothesis is that the extent of stock market integration may depend upon certain macroeconomic factors that influence the degree of economic integration across countries. We therefore specify the macroeconomic factors which are potentially more significant to describe the economic convergence process in Europe over the last years and, at the same time, are in somehow related to equity market co-movements[32].

Additionally, we test for the impact of Stage Three of EMU to see whether or not it has further boosted the rate of integration between the euro exchanges. Generally, a more volatile exchange rate increases the national risk premium required by investors to be compensated for increased uncertainty, while the reduction or elimination of currency risk may rise the degree of financial integration across countries. According to Fratzscher (2001)[33], "the more volatile and unpredictable exchange rates are and the more costly hedging such uncertainty is, the stronger the degree of market segmentation and the lower the degree of correlation across markets". Therefore, the existence of exchange rate uncertainty can be an important source of segmentation to be considered in a model aimed at explaining financial integration. In the case of the euro equity markets, the complete removal of exchange rate uncertainty coincided with Stage Three of EMU, i.e. 1 January 1999, when irrevocable and fixed bilateral exchange rates were established between the currencies of each pair of countries within the EMU and between each of these currencies and the euro[34]. However, also considering the evidence arising from the analysis in sections 5.1 and 5.2, we have reasons to believe that the euro equity markets moved in anticipation of future events and that they were covered with respect to exchange rate risks before 1 January 1999. Consequently, the impact of Stage Three of EMU on the integration of the euro equity markets should not be particularly strong.

The model we use is described by equation 9:

$$\begin{aligned} td_{ij} = \alpha + \beta_0 trend + \beta_1 eurotrend + \beta_2 ABS(D(ly_{ij}))+ \\ +\beta_3 ABS(D(lp_{ij})) + \beta_4 ABS(s_{ij}) + \beta_5 ABS(sb_{ij}) \end{aligned} \tag{9}$$

[32]Chen *et al.* (1986), p. 384.

[33]Page 25.

[34]This event was preceded by other important steps, such as the adoption of the new Exchange Rate System in June 1997 and the announcement of the countries entering the EMU from the beginning, in May 1998.

where the dependant variable, td_{ij}, is the monthly time series of the hyperbolic tangent calculated from estimated dynamic conditional pair-correlations between country i and country j, as explained in section 5.2[35]. To move from daily series to monthly series, we have calculated the average for each month included in the sample period, which goes from October 1994 through June 2003.

We now provide motivation for the regressors included in the model and explain their construction.

The first variable included is a deterministic trend, which is aimed at capturing all the developments and events occurred over the period of our interest. These developments include innovation in production and communication technology, liberalization of markets and of cross-border transactions, institutional harmonization and increasing cross-listing of stocks. The coefficient of the trend is expected to be significantly positive.

Second, we include a multiplicative dummy variable, *eurotrend*, which is built multiplying the trend by a dummy variable which takes the value of 0 before 1999, and 1 after January 1, 1999. The coefficient of the dummy captures the extra impact of the monetary unification on the general positive trend in correlations and consequently in financial integration. In particular, the coefficient of this dummy captures the increase in the rate of integration. As explained above, we do not expect this coefficient to be strongly significant as the euro equity markets moved in anticipation of the launch of the single currency. For comparison, we have also estimated equation 9 substituting the variable *eurotrend* with a dummy which takes the value of 0 before May 1998 and 1 after May 1998, date of the announcement of the euro countries, and we have tested first for the shift in the intercept and then for the slope effect (again using a multiplicative dummy variable built multiplying the trend by the new dummy). Fratzscher (2001), for example[36], finds that the degree of financial integration has strongly increased within the euro area since the announcement of the euro members in May 1998, being the announcement credible and committing.

The other four variables are macroeconomic factors included, as previously argued, to capture the convergence process in Europe over the last years. Moreover, they are relevant to explain equity returns of firms which represent a national equity market and consequently they also affect return co-movements. In particular, it is the value of a macroeconomic factor in one country relative to its value in another country that influences equity

[35]To build the dependant variable, we use estimated DCC, rather then rolling estimates of pair-correlations, as they are less volatile.

[36]See section 4.1.

market correlations. Therefore, we refer to the difference between the variable in country i and the corresponding variable in country j. We would like to stress that the choice of these variables is not easy as they can show a high degree of multi-collinearity. Previous works[37] have related to a principal component analysis to obtain a linear transformation of the variables and so overcome the problem. However, this transformation has the disadvantage of making the interpretation of coefficients poor. Therefore, we have restricted the number of variables included rather than relating to their transformation.

$ABS(D(ly_{ij}))$ stands for the absolute value of the difference in the industrial production growth rate of the two countries. The original series downloaded from Datastream are the industrial production indexes, IP, for each country included in the analysis. We have then calculated the log-difference between the variable in two countries, i.e. $lnIP_i - lnIP_j$, and differentiated this log-difference, i.e. $D(lnIP_i - lnIP_j)$. Given that $D(A-B) = DA - DB$ and that we are referring to log variables, we obtain the difference between the industrial production growth rate in country i and in country j. This variable is called $D(ly_{ij})$ and in the model we consider its absolute value. The idea is that, if changes in industrial production of two countries move together, namely their industrial production growth rate difference falls, then also the performance of their equity markets should be more similar and therefore equity market correlations should be higher. Given this explanation, the coefficient is expected to be negative.

$ABS(D(lp_{ij}))$ is built in exactly the same way and stands for the absolute value of the difference in the Consumer Price Index (CPI) growth rate in country i and in country j. Therefore, $D(lp_{ij})$ is the inflation differential between country i and country j. In this case, the original series downloaded from Datastream are monthly CPI. The inclusion of this variable is relevant to characterize economic convergence in Europe and obviously inflation differentials have decreased over time, given the importance attributed to price stability and low inflation within the EMU. In general, high inflation rises discount rates, reducing the discounted value of cash flows. Consequently, higher inflation has an adverse impact on equity markets and greater divergence in inflation rates is likely associated with less co-movements across capital markets. Therefore, the reduction of inflation differentials should be associated with higher correlation.

Finally, we believe that risk-free interest rate differentials between country i and country j are also relevant to characterize the convergence process in Europe. Greater risk-free interest rate differentials are likely to reduce cross border co-movements. Oppositely, the reduction of these differentials should

[37] Chelley-Steeley and Steeley (1999) and Fratzscher (2001).

increase equity market correlations. Consequently, the expected sign of the coefficient is negative. We have proxied the nominal risk-free interest rate using a three-month money market rate for each country. Then, we have considered the absolute value of the spread between this variable in country i and in country j, namely s_{ij}. Obviously, this difference is zero after January 1, 1999[38]. Additionally, we have considered the absolute value of the spread between the 10-year government bond yield in country i and in country j, sb_{ij}. The government bond yield is also a proxy for the risk-free rate. However, even though much smaller than in the past, spreads in yields are still positive, possibly due to the fact that public bond issuance is still decentralized within the euro area[39].

5.3.1 Estimated results

Results from the estimation of equation 9 are reported in Table 4. In particular, the table reports results of pair-correlations between Germany and respectively France, Italy and Spain; France with respectively Italy and Spain; Italy and Spain. As the models for two given countries are symmetric, we only need to estimate each model once.

In terms of descriptive statistics, the models do not suffer, on overall, of autocorrelation, heteroskedasticity, non-normality and mi-specification problems[40]. Two specifications are however required. First, in all the models we include an autoregressive part to avoid autocorrelation. The number of lags is chosen referring to information criteria. Second, in the model Germany-Italy we do not include $ABS(D(lp_{ij})$ because introducing this variable the matrix becomes almost singular and consequently the estimation of the regression equation is not possible.

Estimated results are quite interesting and not straightforward. First, estimated coefficients of td_{ij-1} are all positive and significant, suggesting that present correlation strongly depends on the correlation the period before. Coefficients of td_{ij-2} are still significant but negative. This result is more ambiguous. We would have rather expected to find insignificant coefficients, suggesting a more independent path of correlations from their previous his-

[38]Previous works rather use the spread between real interest rates. Higher real interest rates may reduce consumer and investment spending and therefore have an adverse impact on equity markets. See Chelley-Steeley and Steeley (1999) and Bracker *et al.* (1999). We prefer using nominal interest rates as they better capture convergence within the EMU. Additionally, given that also inflation rates have widely converged across Europe, the spread between real interest rates is much more closed to the spread between nominal interest rates after 1999.

[39]Refer to section 2.

[40]Descriptive statistics are reported in Appendix B.

tory. Not surprisingly, estimates confirm that the coefficient of the trend is always significantly positive. This supports our idea that changes and developments aimed at reducing different types of barriers restricting capital mobility have impacted on cross-border correlations and consequently on the integration of the euro equity markets. Estimated coefficients of the multiplicative dummy variables are significantly negative in all the models, but the one Germany-France. However, the value of the coefficients is very low, almost zero indeed. In line with our expectations, this result suggests therefore that the introduction of the euro has not further boosted the rate of integration across the euro equity markets confirming that these markets anticipated Stage Three of EMU. Combining this result with the evidence arising from unconditional correlations in section 5.1 and from the graphical analysis in section 5.2, we can say that Stage Three of EMU, although a historic event, has not boosted integration has initially thought.

As for the variables describing economic convergence, they also play a role in explaining pair-correlations. The reduction of the difference between the industrial production growth rate in France and Italy, for example, has a big impact on pair-correlations between the two countries' exchanges. This means that as the changes in the industrial production move together, also the equity markets of the two countries tend to perform more similarly. It is also interesting to notice that the reduction of the spread between the three-month money market interest rate has a significantly positive impact on pair-correlations between Germany and respectively Italy and Spain. Considering that Italy and Spain were traditionally the two countries with highest interest rates, this result suggests that the discipline imposed on weaker economic countries helped to strengthen their linkages with traditionally strong countries, such as Germany. Finally, estimated results show that the reduction of spreads in bond yields has not positively impacted on pair-correlations. To the contrary, the coefficient is significantly positive in the models Germany-France, Germany-Italy and Germany-Spain. Additionally, the variable enters into the model France-Italy at the 5% level of significance, still with a positive coefficient. This result is not straightforward as it implies that the reduction of spreads in bond yields across countries has decreased pair-correlations.

As anticipated, we have also estimated the model using the dummy for the announcement of the euro countries. Without reporting full estimates, we only say that there is no evidence either for an increase in the level of integration or for an increase in the rate of integration associated with this event. Therefore, even though credible, the announcement did not boost integration of the euro equity markets.

Our results seem to indicate that, after important developments and economic convergence have been reached over the last years, perfect integra-

tion can now be achieved only through further harmonization of rules and through measures to increase market efficiency. Additionally, full integration also requires further changes in investment culture, especially among retail investors.

6 Conclusions and final remarks

In this paper, we have first investigated the main changes and developments in financial markets over the last years and then focused on the impact of the integration process in Europe on equity markets within the euro area. In particular, we have obtained empirical evidence for an increase in correlations across the euro equity markets over the last ten years, which, in line with previous work on measuring financial integration, can be interpreted as a sign that these markets are now more integrated than in the past. This result is robust as confirmed by three different methodologies, unconditional correlations, rolling estimates of correlations and dynamic conditional correlations. Additionally, we have proved that a big part of this increase in correlations is explained by the relaxation of restrictions to capital mobility and of institutional barriers, while it seems that Stage Three of EMU has not further boosted integration. Part of the augment in correlations is also explained by macroeconomic factors characterizing economic convergence in Europe.

The findings have important implications.

First, the positive trend in correlations not only denotes higher integration but also higher informational market efficiency. Strong stock market linkages imply indeed that stock price changes better reflect available information on the performance of companies and suggest the existence of an international pattern of transmission of information which supports the notion of informationally efficient equity markets.

Second, financial integration generally allows a better allocation of capital resources and this, in turn, should promote economic growth. Until now, European investors have widely invested in America rather than in other European countries. In this way, they have largely financed the US investment spending and contributed to boost American growth. Obviously, they have also suffered losses because of the poor performance of the American market in recent years and this in turn has badly impacted on their spending capability ultimately affecting European growth. Clearly, this is a consequence of financial integration and capital mobility and reflects the fact that European companies traditionally spend less in research and development and invest less than their American counterparts. Additionally, it reflects

the fact that in Europe banks have played an important role in financial intermediation limiting the role of financial markets. However, the situation is gradually changing and, as we have pointed out, the European financial system is moving towards a more market-oriented structure. On one side, structural reforms in Europe are required to boost demand and growth. On the other side, the fact that the euro equity markets are now more efficient and integrated is also crucial to promote economic growth, as this should allow European countries to catch up with the USA in attracting capital. As a matter of facts, European investors have started to invest more in equities and to diversify their portfolio holdings across the euro area without restricting their investment to a single country. To reach full integration, further changes in investment culture in Europe are required, especially among retail investors. These advantages are partly offset by potentially higher financial instability. Indeed, highly correlated stock markets are exposed to domestic as well as international shocks and to cross-border contagion. Ultimately, policy makers and European governments have to increase the quality of prudential supervision and cross-border regulation to make sure that advantages arising from financial integration are not offset by its costs.

Finally, the euro area is now a more attractive place for investors, who, as previously argued, have easier access to equity markets within the euro area. Moreover, facilitated cross-border investments make it less costly to achieve international diversification. However, high correlations erode benefits arising from international diversification and this provides incentive to shift from country diversification within Europe to cross-sector diversification, supporting the change in the traditional asset allocation paradigm, based on geographic diversification and coherent with more segmented markets.

Table 4: ESTIMATED COEFFICIENTS FROM EQUATION 9

	intercept	td_{ij-1}	td_{ij-2}	$trend$	$eurotrend$	$abs(d(ly_{ij}))$	$abs(d(lp_{ij}))$	$abs(s_{ij})$	$abs(sb_{ij})$
					GERMANY				
$FRANCE$	0.241	0.778	-0.268	0.011	-0.001	0.659	-19.208	-0.041	0.346
	(0.083)	(0.000)	(0.006)	(0.000)	(0.148)	(0.723)	(0.196)	(0.370)	(0.044)
$ITALY$	0.048	0.870	-0.358	0.015	-0.006	-2.023		-0.088	0.120
	(0.714)	(0.000)	(0.000)	(0.000)	(0.000)	(0.222)		(0.001)	(0.000)
$SPAIN$	0.056	0.835	-0.310	0.013	-0.004	0.147	1.687	-0.062	0.111
	(0.680)	(0.000)	(0.001)	(0.000)	(0.002)	(0.214)	(0.815)	(0.027)	(0.004)
					FRANCE				
$ITALY$	0.122	0.859	-0.271	0.015	-0.005	-5.745	-2.007	-0.036	0.052
	(0.357)	(0.000)	(0.003)	(0.000)	(0.000)	(0.014)	(0.854)	(0.107)	(0.056)
$SPAIN$	0.316	0.854	-0.297	0.0105	-0.003	0.128	0.132	-0.019	0.029
	(0.046)	(0.000)	(0.003)	(0.000)	(0.018)	(0.269)	(0.986)	(0.490)	(0.392)
					ITALY				
$SPAIN$	0.293	0.682		0.007	-0.004	0.076	9.444	-0.069	-0.134
	(0.028)	(0.000)		(0.005)	(0.028)	(0.538)	(0.313)	(0.336)	(0.189)

Comments: The table reports estimated results of equation 9 for all pair of countries. The probability values of the estimated coefficients are given in parentheses below each coefficient estimate. The dependent variable, td_{ij}, is the monthly time series of the hyperbolic tangent calculated from estimated daily dynamic conditional pair-correlations between country i and j. *trend* is a deterministic trend and *eurotrend* is a multiplicative dummy variable built multiplying the trend by a dummy variable which takes the value of 0 before January 1999 and of 1 after January 1, 1999. $ABS(D(ly_{ij}))$ is the absolute value of the difference in the industrial production growth rate between country i and j. $ABS(D(lp_{ij}))$ is the absolute value of the inflation differential between the two countries. $ABS(s_{ij})$ and $ABS(sb_{ij})$ are respectively the absolute value of the spread between the three-month money market rate in country i and j and the spread between the 10-year government bond yield in country i and in country j.

7 Appendix: Descriptive statistics

Tables 1 to 6 report descriptive statistics relative to estimated results (contained in table 4) of equation 9 for each pair of countries.

Table 1: Descriptive statistics for Germany-France

Test	Statistics	p-value
AR (1-2) test	$F_{2,88} = 1.4966$	0.2295
ARCH (1-1) test	$F_{1,88} = 0.42131$	0.5180
Normality test	$Chi_2^2 = 1.2311$	0.5403
RESET test	$F_{1,89} = 0.025692$	0.8730

Comments: The table reports descriptive statistics from estimate of equation 9 for Germany and France. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Additionally, the model does not suffer of mi-specification problems, as confirmed by the Reset test.

Table 2: Descriptive statistics for Germany-Italy

Test	Statistics	p-value
AR (1-2) test	$F_{2,92} = 1.5823$	0.211
ARCH (1-1) test	$F_{1,92} = 0.038629$	0.8446
Normality test	$Chi_2^2 = 3.4510$	0.1781
RESET test	$F_{1,93} = 0.013736$	0.9070

Comments: The table reports descriptive statistics from estimate of equation 9 for Germany and Italy. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Additionally, the model does not suffer of mi-specification problems, as confirmed by the Reset test.

Table 3: Descriptive statistics for Germany-Spain

Test	Statistics	p-value
AR (1-2) test	$F_{2,91} = 0.92936$	0.3985
ARCH (1-1) test	$F_{1,91} = 0.35844$	0.5509
Normality test	$Chi_2^2 = 1.0392$	0.5948
RESET test	$F_{1,92} = 0.41165$	0.5227

Comments: The table reports descriptive statistics from estimate of equation 9 for Germany and Spain. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Additionally, the model does not suffer of mi-specification problems, as confirmed by the Reset test.

Table 4: Descriptive statistics for France-Italy

Test	Statistics	p-value
AR (1-2) test	$F_{2,88} = 0.56739$	0.5691
ARCH (1-1) test	$F_{1,88} = 1.1009$	0.2969
Normality test	$Chi_2^2 = 2.6261$	0.2690
RESET test	$F_{1,89} = 6.0634$	0.0157*

Comments: The table reports descriptive statistics from estimate of equation 9 for France and Italy. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Find * if the null hypothesis is rejected at 5% level of significance.

Table 5: Descriptive statistics for France-Spain

Test	Statistics	p-value
AR (1-2) test	$F_{2,88} = 1.6217$	0.2034
ARCH (1-1) test	$F_{1,88} = 1.4448$	0.2326
Normality test	$Chi_2^2 = 1.0241$	0.5993
RESET test	$F_{1,89} = 0.13113$	0.7181

Comments: The table reports descriptive statistics from estimate of equation 9 for France and Spain. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Additionally, the model does not suffer of mi-specification problems, as confirmed by the Reset test.

Table 6: Descriptive statistics for Italy-Spain

Test	Statistics	p-value
AR (1-2) test	$F_{2,92} = 1.4556$	0.2386
ARCH (1-1) test	$F_{1,92} = 0.42732$	0.5149
Normality test	$Chi_2^2 = 1.0034$	0.6055
RESET test	$F_{1,93} = 0.67159$	0.4146

Comments: The table reports descriptive statistics from estimate of equation 9 for Italy and Spain. The null hypotheses of autocorrelation, heteroskedasticity and normality of residuals are accepted at any conventional level of significance. Additionally, the model does not suffer of mi-specification problems, as confirmed by the Reset test.

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