European financial integration : the case of stock and bond markets

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Publication Date:
2004

DOI:
https://doi.org/10.26190/unsworks/8170

EUROPEAN

FINANCIAL INTEGRATION:

THE CASE OF STOCK AND BOND MARKETS

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A dissertation submitted to the University of New South Wales in fulfillment of the requirements for the degree of Doctor of Philosophy (PhD)

2004

ORIGINALITY STATEMENT

'I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.'

To my family and Michael

CERTIFICATION

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

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Eliza Wu
20 December 2004

ABSTRACT

This dissertation contains three empirical research projects investigating the development of stock and bond market integration within the European Union (EU) and other major global financial markets. Each of the three stand-alone chapters provides a different perspective on the extent of financial integration and its linkage with the implementation of the European Monetary Union (EMU) in January 1999. Within this context, this thesis makes substantial original contributions to advance the existing knowledge on measuring, documenting and determining financial market integration.

The first inquiry in Chapter 3 focuses on the extent to which the realisation of the EMU has contributed to changes in stock market linkages with the EMU over time. This is determined by comparing the performance of stock markets within the EU and also with the United States (US) and Japan in a bivariate EGARCH (exponential generalised auto-regressive conditional heteroskedasticity) framework. This chapter finds that significant upward trends in aggregate stock market integration have emerged since 1996-97 for the EU countries, with the additional benefit of increased stock market stability - signaling a regime shift in the stock market integration process. Moreover, in a two-step regression approach, the implementation of the EMU has caused the observed stock market integration processes on both the regional and global level. Furthermore, it reveals that stock market integration is a highly persistent process as its main determinants are the existing levels of integration and stock market development, with different economic convergence channels associated with the EMU also playing a significant role. There are implications of diversification reductions from these findings.

Chapter 4 is an exposition on the extent to which government bond markets in the new EU countries are integrated with the pre-enlargement EU markets. Interdependence in daily returns from a sample of Central and Eastern European (CEE) markets and the established EU bloc is empirically modelled over time, using a set of complementary dynamic methodologies. This chapter finds that Poland and Hungary are more integrated with the established EU markets than the Czech Republic, which shows no tendency towards financial convergence. The main implication of the findings in this chapter is that financial markets in the new CEE members are not fully ready for EMU membership.

Chapter 5 examines the time-variations in inter-market integration dynamics between daily government bond and stock market returns for EMU and non-EMU members. Stock and bond returns are modelled within an EGARCH framework and conditional correlations between the two asset returns are used to empirically measure inter-market integration, as it indirectly reflects the extent to which common information are priced. The major findings of this chapter are twofold: Firstly, inter-stock-bond market integration in Europe has decreased during the past decade, coinciding with the formation of the EMU; and secondly, the implementation of the EMU has caused and determined this phenomenon. To investigate the latter, a secondary regression involving principal components for macroeconomic convergence channels is employed. The main conclusion from this research is that investors' uncertainty about the future of the EMU and the macroeconomic fundamentals under the new currency regime may have induced a prolonged flight to quality and this has implications for both asset allocation decisions and policy making within Europe.

ACKNOWLEDGEMENTS

I am indebted to my co-supervisors, Professor Fariborz Moshirian and Associate Professor Suk-Joong Kim for guiding and supporting my journey through to the completion of my doctoral thesis, for being esteemed mentors and lastly, for being inspiring researchers. I could not have asked for more intellectual freedom and healthy criticism than what they gave me in the course of writing this thesis.

I am also grateful for the guidance and peer-support from staff members (especially Associate Professor Toan Pham who has been a great mentor for me) and fellow research students at the University of New South Wales' School of Banking and Finance. The feedback from participants in the School's weekly seminar series and annual Australasian Finance and Banking Conference was much appreciated.

In addition, I would like to acknowledge the financial support from the Faculty of Commerce and Economics at the University of New South Wales, the Australian University Europe Network at the Australian National University and the European Central Bank and Centre of Financial Studies whilst undertaking this PhD. Without their funding, I would not have had the opportunities to attend worthwhile European conferences and this dissertation has benefited substantially from all the feedback received from participants during various international conference presentations. Moreover, I was able to visit, present in a conference and work on a publication with Dr. Brian Lucey at the Institute for International Integration Studies (IIIS) at Trinity College, University of Dublin. Brian Lucey helped me with developing the motivations and direction for Chapter 4 as our collaborative work (also with Suk-Joong Kim) formed the basis for the research work in this chapter.

I would also like to thank my dearest friends for their encouragement and consistent support. Lastly but most importantly, I thank my beloved Michael for being immensely considerate and understanding of the demands of completing a timely PhD and for bringing out the drive and optimism that helped me to complete this thesis and to look forward to life beyond PhD. To my family, I thank them for their unfaltering love, belief and moral support shown over the years. Without Michael and my family, I would have certainly crumbled under the arduous task of completing this dissertation and it is to them that I dedicate my dissertation. Personally, it has been a rewarding and enriching journey of discovery and I am grateful to all those who have motivated and sustained me to pursue and fulfill my academic aspirations. I have gained invaluable experiences that have prepared me for taking on independent research in my academic career.

"The best way to have a good idea is to have lots of ideas"

Linus Pauling

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List of Abbreviations used

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
AR	Auto-Regressive
ARCH	Auto-Regressive Conditional Heteroskedasticity
ARMA	Auto-Regressive Moving Average
BIS	Bank for International Settlements
CAPM	Capital Asset Pricing Model
CBOE	Chicago Board of Options Exchange
CEE	Central and Eastern European
CEEC	CEE Country
CIP	Covered Interest Rate Parity
DCC	Dynamic Conditional Correlation
DW	Durbin Watson
EBRD	European Bank For Reconstruction and Development
ECB	European Central Bank
ECSC	European Coal and Steel Community
ECU	European Currency Unit
EEC	European Economic Community
EGARCH	Exponential GARCH
EGARCH-M	Exponential GARCH-in-Mean
EMI	European Monetary Institute
EMS	European Monetary System
EMU	European Economic and Monetary Union
ERM	Exchange Rate Mechanism
ERM II	ERM Stage Two
EU	European Union
EUR	Euro
FSAP	Financial Services Action Plan
GARCH	Generalised ARCH
GDP	Gross Domestic Product
ICAPM	International CAPM
IID	Independent and identically distributed
MA	Moving Average
MCC	Maastrict Convergence Criteria
MGARCH	Multivariate GARCH
OCA	Optimal Currency Area
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
PHARE	Poland-Hungary aid for economic restructuring
RIP	Real Interest Rate Parity
SEMA	Single European Market Act
SPARCH	Semi-Parametric ARCH
SUR	Seemingly Unrelated Regression
SURE	Seemingly Unrelated Regression Estimate/Estimation
UIP	Uncovered Interest Rate Parity
US	United States
VECM	Vector Error Correction Model

List of Journal Publications from the Dissertation

1. A condensed version of Chapter 3 is in-press with the *Journal of Banking and Finance,* 2005.

2. A shorter version of Chapter 4 is forthcoming in a Special Issue on International Bond and Debt Market Integration in the *Journal of International Financial Markets, Institutions and Money,* 2005.

3. A shorter version of Chapter 5 is forthcoming in the *Journal of Banking and Finance.*

Chapter 1

Introduction

1.1 Motivation and Objective

In the past two and a half decades, Europe has undergone an extraordinary period of economic, monetary and financial integration, with the introduction of a single currency as part of the European Economic and Monetary Union (EMU) in January 1999 and the recent acceptance of ten new members into the European Union (EU) being the most tangible results of this process. There is general agreement in the international finance community that as a result of these developments, the European financial system has gradually moved from a bank-based (intermediated) to a market-based (non-intermediated) one and that different asset markets have became increasingly integrated across the region.

Financially integrated markets can potentially have important benefits on the economy. In more integrated and developed financial markets, corporations have access to a larger pool of financing, at a lower cost (Stultz, 1995, 1999). Similarly, investors and risk managers have access to a larger number of financial assets which enable them to construct investment portfolios with a better risk-return trade-off to suit their specific needs. Indeed, a pan-European investment and financing paradigm has emerged as reflected by the increasing proportions of non-domestic securities in investment portfolios (for instance, see Brookes, 2000 and Baele et al. 2004). For policy makers, increasing financial market integration provides many opportunities and challenges. Policy initiatives like the European Commission (1999)'s Financial Services Action Plan (FSAP) have worked to increase competition, liquidity and efficiency within financial markets. However, there is also a concern that financial integration may not benefit all agents in the financial system, and can potentially contribute to financial instability from heightened systemic risks. Clearly, financial market integration is an important topic for research in international finance because there are significant economic ramifications for all financial market participants.

The main objective of this thesis is to empirically investigate the development of financial market integration in European and other international markets against the backdrop of the implementation of the EMU in recent history. Specifically, this thesis examines three separate aspects of stock and government bond market integration. In doing so, it presents three stand-alone chapters that provide different perspectives on the extent of financial market integration and the linkage to changing macroeconomic fundamentals and political commitments prescribed by the realization of the EMU. Importantly, this thesis uniquely questions the role of currency unions in financial market integration.

The remainder of this chapter will set the context and background for these three main aspects of the thesis. The historical developments of the EU are discussed in section 1.2, followed by an outline of the set of economic convergence criteria that must be fulfilled by EU countries for participation within the EMU in section 1.3. Section 1.4 highlights the importance of the EU and EMU in both economic and financial terms before moving the discussion onto their impacts on financial markets in section 1.5. Section 1.6 introduces the specific focus of this thesis on stock and bond market integration and this is followed by a brief outline of the thesis' structure in section 1.7.

1.2 Historical developments of the EU

The historical roots of the large-scale EU developed during the Second World War. More than half a century ago, Robert Schuman and Jean Monnet - the founding fathers of modern day Europe envisioned political and economic unification would transcend the preceding national conflicts. The notion of European economic integration was conceived to prevent the conflicts and destruction which had long marked European history. They initiated a jointly managed market in coal and steel under the control of an independent authority on 9 May 1950 and this became known as the European Coal and Steel Community (ECSC). As coal and steel formed the backbone of the industrial world at the time, this became a significant project on economic integration.

Pressing forward on the path to further integration, the European Economic Community (EEC) was established in the Treaty of Rome on 25 March 1957 to realise a genuine Europe-wide common market by abolishing customs duties and quantitative limits on trade. The signing of the Single European Market Act (SEMA) in 1986 eliminated more regulatory and fiscal restrictions obstructing the realisation of a single market and set 1 January 1993 as the date by which a full internal market was to be established. The single market called for a single currency. This final step was made on 7 February 1992, with an agreement on the implementation of an economic and monetary union (see Table A.1 in the Appendices for the key events in the EMU process). This marked the formal transition from the troubled, three-staged Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) to monetary unification in Europe.[1] The completion of the internal European market and initiation of the EMU was ratified within the Treaty on European Union (also known as the Maastrict Treaty). This was a quantum leap for Europe and it gave European integration a whole new financial dimension. In its recent arrangement the EU has been described

[1] On the crisis of the ERM, see Chapter 7 of Eichengreen (1997).

as "an advanced form of multisectoral integration, its competence extending to the economy, industry, politics, citizens' rights and foreign policy ... " (Fontaine, 1998, p.6). The eventual introduction of the Euro as the common currency for EMU members on 1 January 1999 culminated the long process in the European integration movement towards a monetary union and integrated financial markets. The new supranational European Central Bank (ECB) was set up to assume responsibility for a common monetary policy for all members that had irrevocably fixed their exchange rates to the Euro. The EMU is without precedent in the history of the civilized world and this exchange rate regime has been adopted under uncertainty about its impacts on international financial markets and system stability.

EU Enlargement

In the mid 1990s, the EU received membership applications from twelve Central and Eastern European Countries (CEECs). The EU welcomed this opportunity to expand and strengthen the EU and accession negotiations were launched in Luxembourg in 1997 and Helsinki in 1999. The EU provided pre-accession aid to enable reforms required for EU membership to be carried out in the group of former socialist (transition) economies from CEE. In particular, the PHARE program was designed to promote economic and social cohesion. This program was first created in 1989 to assist Poland and Hungary with restructuring their economic and political conditions with the weakening state of the Soviet Union (hence PHARE was named with these two candidates in mind). However, over the mid 1990s, PHARE support was re-orientated towards pre-accession priorities for other EU candidates as well (including Bulgaria and Romania).

The recent enlargement of the EU from fifteen to twenty-five members in May 2004 was finally agreed to in a Copenhagen Summit in December 2002, after a decade of accession negotiations (see Table 1.1 for the existing and new members of the EU). The EU candidates were deemed to have fulfilled the set of economic and political conditions for accession (known as the Copenhagen Criteria). Subsequently, a new European Constitution has been ratified to account *inter alia* for an enlarged EU. The new Central and Eastern European (CEE) transition members are at a very different stage of political and economic development to the existing members. The success or failure of the EU's expansion will have significant ramifications for present and aspirant memberships of the EU and EMU.

Table 1.1 Categories of EU members

Established EU members	New EU members
EMU members	***New members***
Austria	Cyprus
Belgium	Czech Republic
Finland	Estonia
France	Hungary
Germany	Latvia
Greece	Lithuania
Ireland	Malta
Italy	Poland
Luxembourg	Slovakia
Netherlands	Slovenia
Portugal	
Spain	
Non-EMU members	***Potential future members***
Denmark	Bulgaria – likely to join in 2007
Sweden	Romania – likely to join in 2007
UK	Turkey – accession talks yet to officially begin

1.3 Maastrict Convergence Criteria for EMU membership

Rule based economic management governed by the set of Maastrict Convergence Criteria (MCC) was established at the Maastrict Inter-Governmental

Conference in February 1992, where the implementation of the EMU was finally agreed to. These MCC were designed to prevent countries whose economic performance was out of line with all other countries from joining and destablising the currency union. Thus, each potential member state was required to manage its economy in order to meet the following five requirements:

1) Rate of inflation must be no more than 1.5 per cent above the average of the lowest three inflation rates in the EMS;
2) Long-term interest rates must be within 2 per cent of the same three countries under condition 1;
3) Been a member of the narrow band of fluctuation of the ERM for at least 2 years without a realignment;
4) Budget deficit must not be regarded as 'excessive' by the European Council – defined by Article 104c(2) of the Treaty, to be where deficits exceeded 3 per cent of GDP for reasons other than those of a temporary or exceptional nature;
5) National debt must not be 'excessive' – defined by the same Article as for condition 4) to be where it exceeds 60 per cent of GDP and is not declining at a 'satisfactory' pace.

These requirements are not a once off entry qualification but are to be maintained once a country has qualified for EMU membership. The Stability and Growth Pact (1997) implemented fiscal regulation and fines to be levied upon member states if their budget deficits exceed the specified targets in all but the worst periods of recession. This was acted upon in November 2003 when Germany and France (two of the largest countries in the EMU) had budget deficits exceeding 3 per cent of their GDPs.

The new EU countries are also required to participate in these convergence procedures for coordinating their macroeconomic policies. The clear incentive for new EU members (to satisfy these economic criteria) is the qualification for EMU participation, and hence, the range of economic and political benefits associated with that.

1.4 The EU and EMU in Economic and Financial terms

On the global level, the EU has emerged as a dominant economic and financial bloc to challenge the dominance of the US in the 21st Century. As can be seen in Table 1.2, with a combined population that is one and a half times that of the US, the economic magnitude of the enlarged EU is now rivaling that of the US in terms of nominal GDP. The new EU members have increased the EU's geographical size by 25% and its population by 20%. However, the group of ten new EU members added only 4 per cent to the EU's enlarged economy. Thus, they provide only a marginal economic contribution to the pre-enlarged EU structure. Furthermore, the need to assist with the economic and political transition of these new members will continue to divert economic resources from the established EU members.

Table 1.2 Population and Nominal GDP in 2003

	Population (in millions)	GDP (in EUR trillions)
Established EU-15	382	9.3
New EU-10	74	0.4
EMU-12	309	7.3
US	291	9.9
Japan	128	3.2

Sources: ECB Statistics Pocket Book October 2004 at http://www.ecb.int/pub/spb/html/index.en.htm

The Euro has predictably emerged as a strong international currency. The Euro was the second most actively traded currency globally in April 2004 according to the Triennial Central Bank Survey coordinated by the Bank for International Settlements (BIS) (with the US dollar being the most traded and the Japanese Yen being the third most traded). Moreover, Eastern European and Asian central banks are increasingly purchasing Euro denominated reserve assets to diversify their holdings, thus further enhancing the Euro's status as a safe and reliable reserve currency in the world. Detken and Hartmann (2000) found the Euro immediately became the second most widely used currency for international financing and investment upon its introduction in 1999.

These developments have also spurred growth in European debt and equity markets, indicating the increasing importance of market-based securities for the EU. Total outstanding amounts of debt securities were 11.6 EUR trillions for the enlarged EU (8.7 EUR trillions for EMU) which is almost double the 6.5 EUR trillions for Japan and only 30 per cent below the United States' 16.4 EUR trillions in 2003. Remarkably, the ratio of stock market capitalisation to GDP has doubled from the mid-1990s to the end of 2003, far exceeding the pace of market growth for both the US and Japan. In 2003, stock market capitalization was 6.0 EUR trillions for the EU (3.6 EUR trillions for the EMU) compared with 10.7 EUR trillions for the US and 2.4 EUR trillions for Japan. This clearly demonstrates the dynamic nature of the Euro market development.

1.5 Impacts on International Financial Markets

The historical developments in economic and political integration within Europe and the recent enlargement of the EU have had important repercussions on international financial markets. This has been evidenced by the explosion in both academic and non-academic literature evaluating the impacts of the Euro on various financial markets during the course of writing this thesis. However, in these early days of the Euro's existence, the world still finds itself in unchartered territory with regards to the full-scale economic and financial implications of this historical currency unification. This makes research on this topic very timely and challenging and the results of the investigations presented in this thesis are valuable for both policy makers and international investors alike.

A general consensus amongst existing empirical studies assessing changes in the main European financial markets is that the introduction of the Euro and the creation of the EMU have accelerated the pace and process of financial integration (for example, Prati and Schinasi, 1997 and Reszat, 2003 offer general assessments across the financial system; Santillan et al. (2000) provides evidence of full convergence in bond and money markets; Hau et al. (2002) identifies the specific impacts on foreign exchange markets; Kleimeier and Sander (2000) find convergence in the retail lending market and Harm (2001) reveals integration in private sector bonds and syndicate loans). Clearly, the advent of the common currency triggered important integrative and competitive forces on financial markets because they are, in essence, where money and financial assets are traded. Hence investors now tend to take a regional perspective in their portfolio allocations instead of the traditional domestic focus (Galati and Tsatsaronis, 2003). Jacques Delors, former president of the European Commission, and whom the 'Delors Report' was named after, supported the notion that a common currency is an objective that can help discipline and deepen the integration process in national financial markets. Denominating financial securities in the same currency has eliminated intra-union exchange rate risk and increased the degree of substitutability between national securities.

The financial landscape of Europe has changed substantially with capital markets having undergone remarkable transformations in the late 1990s in preparation for the currency unification. In the London Economics' (2002) study of the macroeconomic benefits of the EMU commissioned by the European Commission, it was found that European financial integration had progressed extensively in the years following the adoption of the single currency and the gradual implementation of the European Commission (1999)'s Financial Services Action Plan (FSAP). The FSAP aims to incorporate different sets of laws based around national sets of standards and traditions and to establish a single market for financial services in the EU by allowing banks, fund managers and insurers to operate on an EU-wide basis. Other initiatives to promote greater integration in European financial markets continue to be negotiated.

Although complex changes have taken place in European financial markets, a single integrated market is not guaranteed as the Euro was introduced to the EMU as a single currency without a single area financial market. Despite the elimination of intra-

European exchange rate risk, financial assets have not become perfect substitutes because of differences in financial systems, structures and institutions (Hartmann et al., 2003). Consequently, some financial markets seem to have made greater progress in terms of financial integration than others. For example, money and government bond markets are more integrated than equity markets (in which cultural and structural obstacles remain). The single monetary policy associated with the EMU has naturally created substantial integration in money and government bond markets. Both elimination of exchange rate risk and budgetary consolidation in the EMU have led to yield convergence in government bond markets. Increased competition for government debt financing within Europe has led to an increase in liquidity and allowed governments to issue larger individual debt issues. Despite this, government bonds are still issued by separate national agencies with different financing needs, strategies, procedures, practices and instruments. As many smaller issuing member states cannot provide the necessary volume of issuance in all maturities across the yield curve, the government bond market is unlikely to fully converge. Even for the larger member states, there remain small differences in yield spreads due to the decentralized management of the government debt market.

The impact of the Euro has been far more extensive than the relatively superficial fact that all transactions are now undertaken in a single currency. Of far more importance has been the change to economic policies. Financial markets remain segmented although less than before due to the forces of economic convergence. Complete integration will only emerge when barriers like differences in default risk, tax treatments and investor perceptions and practices become unified. It has also been recognized that the Euro zone does not exist in a vacuum and its integrative effects impact upon non-Euro zone markets. The extent of this external influence is of clear importance for other EU Countries remaining independent of the Euro, due to their regional trade and geographical linkages. Furthermore, the forces of globalization have inevitably carried European financial integration onto the international stage.

The recent enlargement experience of the EU will also have ramifications for European financial markets due to the development gap between established and new EU markets. These new EU members and other EU aspirants are also queuing to join the EMU and to thence, adopt the Euro. The construction of a single financial market will continue to be a major enterprise of the EU, enabling Europeans to share the potential benefits generated by regional financial integration.

Continental Europe is often considered a bank-based system as bank lending is the main source of financing for investments. However, traditional bank financing for European companies has become less dominant as markets for tradable securities like bond (corporate and government) and stock markets in particular, have grown to become deeper, broader and more liquid (see Galati and Tsatsoronis, 2003). However, assessments on the direct effects on the banking sector and the process of financial disintermediation are not the focus of this thesis. Instead, this thesis concentrates on the integrative changes within the two other major developing market-based financial segments: government bond and stock markets.

1.6 Focus on Stock and Bond Market Integration

The main objective of this thesis is to empirically investigate the development of financial integration in European and other international stock and government bond markets against the backdrop of the implementation of the EMU in recent history. It achieves this by analyzing stock and bond market integration from the perspective of intra-regional vs inter-regional and intra-market vs inter-market comparisons using a range of sophisticated dynamic econometric methodologies. Whilst financial market integration is identified with conditional return correlations across borders and markets, it is also complemented with assessments on the dynamic interaction (spillover) effects that can yield market dependence - even with non-correlated unpredictable return shocks. Moreover, this thesis seeks to improve the current understanding on the role of convergence in macroeconomic fundamentals associated with currency unification on the process of stock and bond market integration on a regional and global dimension. It does so by analysing both *ex ante* and *ex post* financial and macroeconomic conditions to assess the long-term role of currency unification in financial market integration.

The innovation of this thesis is in the exploratory analyses of dynamic financial integration in stock and bond markets within countries at varying stages of economic integration towards a currency union. This natural experimental setup provided by the EU project enables the discernible roles of prescribed convergences in macroeconomic fundamentals and political commitment on stock and bond market integration to be better understood. This knowledge has obvious implications for both policy makers in shaping policies and for investors in devising investment and risk management strategies in response to an increasingly interdependent global financial architecture.

This thesis presents three stand-alone chapters that provide different perspectives on the extent of financial integration in international stock and government bond markets and the linkage to the implementation of the EMU.

Stock Market Integration

The first inquiry is on the dynamics of stock market integration within Europe. The chapter focuses on the extent to which the realisation of the EMU has contributed to changes in the patterns of stock market linkages both inside and outside of the EMU. This has been determined by comparing the performance of stock markets of the twelve EMU member countries with those of other EU countries and the United States (US) and Japan in a multivariate exponential GARCH (generalized auto-regressive conditional heteroskedasticity) framework. The results reveal that a statistically significant upward trend in aggregate stock market integration has emerged since 1996-97 for EU member countries, with the additional benefit of increased stock market stability. These results signal a clear regime shift in the stock market integration process. Moreover, using a two step regression approach, the implementation of the EMU is shown to Granger-cause the observed stock market integration process on both the regional and global level. It is also revealed that stock market integration is a highly persistent process as its main determinants are the existing levels of integration and stock market development, with different economic convergence criteria associated with the EMU also playing a significant role.

Government Bond Market Integration

The next aspect of European financial integration provided is an exposition of the extent to which government bond markets in the new EU countries are integrated with the established core EU markets. Interdependence in daily government bond market returns from a sample of CCE markets and the established EU bloc is empirically modelled over time using a set of complementary dynamic cointegration and conditional correlation methodologies. This chapter finds Poland and Hungary to be more integrated with the established EU government bond markets, in line with the development of the pre-accession Poland-Hungary Aid for Economic Restructuring (PHARE) program. However, the Czech Republic benefited later from this program and shows no tendency towards financial convergence and is not likely to in the near term. The main implication of the findings in this chapter is that financial markets in the new EU members are not fully ready for EMU membership and the adoption of the single currency.

Inter-Stock-Bond Market Integration

The final aspect concerns the time-variations in inter-market integration dynamics between daily government bond and stock market returns for EMU members along with the UK, US and Japan. Stock and government bond returns are modelled using an exponential GARCH framework. The conditional correlations between the two asset returns are interpreted as an empirical measure of inter-market integration as it indirectly reflects the extent to which common information is priced into the two asset markets. The major findings of the chapter are twofold: Firstly, cross-market integration has decreased during the past decade associated with the formation of the EMU; and secondly, there is evidence that the introduction of the EMU has determined this phenomenon. To investigate the latter, a unique secondary seemingly unrelated regression (SUR) is estimated with principal components for macroeconomic convergence channels through which the EMU may have influenced conditional volatility across stock and bond markets and their correlation dynamics. The main conclusion from this chapter is that investors' uncertainty about the future of the EMU and macroeconomic fundamentals under the new currency regime has induced a prolonged flight to quality phenomenon and this has implications for both asset allocation decisions and policy making within Europe.

This thesis makes substantial contributions to the literature on measuring, documenting and determining the dynamic process of financial market integration. In particular, this thesis advances the current understanding on the role of currency unions in influencing the process of regional and global stock and bond market integration. The main contributions of this thesis are in:

1) Comprehensively assessing financial market integration in EU members at different stages of economic integration towards the EMU to better understand the fundamental relationship between currency unification and financial integration;
2) Providing an improved understanding on the macroeconomic roles of a currency union in promoting stock and bond market integration;
3) Extending the current selection of dynamic econometric methodologies for examining financial market linkages and

integration processes over time with a unique sequential two-step regression framework.

1.7 Thesis Outline

The structure of this thesis, partitions six main chapters, as follows. To set the thesis within context, a literature review on the developments in financial market integration and currency union research is presented in Chapter 2. In contributing to the existing literature, first, the role of the EMU in driving European stock market integration is empirically examined in Chapter 3. Second, an exposition on the extent of government bond market integration between new and established EU members is presented in Chapter 4. Third, an assessment of the role of the EMU on the developments of inter-market integration is made in Chapter 5. Lastly, Chapter 6 offers conclusions and directions for further research in the area of financial market integration.

Chapter 2

Literature Review

of

Financial Market Integration

2.1 Testing for Financial Market Integration

In the literature, researchers have approached financial market integration from many different perspectives, hypothesized many different causes and developed many different models to define and test for financial market integration.[1] In essence, the primary difference between the practice of domestic and international finance lies with the segmentation of international financial markets and this makes research on financial market integration integral to the field of international finance. Thus, it is extremely important to monitor the extent and understand the process of financial market integration in various financial segments.

Empirical tests for financial market integration have relied mainly on two related theoretical frameworks in both international finance and international macroeconomic domains. The literature has either focused on the development of international variations on established asset pricing models or evaluations of equilibrium international parity conditions. An apparent divergence has emerged between theoretical and empirical research developments on financial market integration. The theoretical models are generally static models of long-run financial integration but empirical researchers have recognised that the true process towards financial integration is dynamic and much more complicated than what has been theoretically modelled to date. Hence, the range of theoretical and empirical developments in financial market integration will be discussed separately in the following two sub-sections.

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[1] See Kearney and Lucey (2004) for a comprehensive literature review focused on stock market integration.

2.1.1 Theoretical Developments

The most commonly accepted definition of financial integration used in the existing literature is the 'law of one price' which states that in equilibrium assets that have identical risks and returns will be priced identically regardless of trading location. A standard direct approach relying on the law of one price is the assessment of the extent to which the rates of return on financial investments with the same risk profiles and maturity are equalized across markets. This direct measure relies on the basic logic that unrestricted international capital flows would (through investors seeking investments that provide the best risk-return tradeoff available) equalize the after transaction cost rates of return on equivalent financial assets across countries or political jurisdictions. Various forms of this measure rely on uncovered and covered interest rate parities (UIP and CIP) as well as the real interest rate parity (RIP). The UIP states that differentials between domestic and foreign nominal returns on capital are roughly equalized by expected exchange rate changes (for the domestic currency against the foreign currency) in the spot market. The CIP essentially differs by using the forward exchange market (assuming that forward rates are unbiased estimates of future spot rates). The RIP explains that real interest rates will be equalized across countries as nominal interest rate differentials will be equalized by anticipated inflation differentials. The weakness of relying on these different variations on interest rate parity is that they are valid only in equilibrium and they do not specify the process towards equilibrium. Nevertheless, in this line of investigation, convergence and covariability of interest rates have been empirically assessed to deduce the extent of financial market integration (for example see, Goodwin and Grennes, 1994 and Phylaktis, 1997 and 1999).

Despite a vast literature testing financial market integration based on the law of one price, a formal definition of integrated financial markets remains contentious (see Chen and Knez, 1995 for a discussion on the different notions of market integration). A notable theoretical development has been the categorical notions of weak-form and strong-form integration in Chen and Knez (1995) and empirically tested by Ayuso and Blanco (2001). The weak measure requires prices to be equal for the same payoff in different markets and the strong measure incorporates the weak-form conditions and it also rules out arbitrage profits across financial markets. Alternatively, Baele et al. (2004) adopt more practical conditions in defining integrated financial markets. They argue that all participants (with similar characteristics) within a given financial market should face a single set of rules, have equal market access, and are treated equally in that market. Alternative definitions in Chen and Knez (1995) and Baele et al. (2004) are more difficult to empirically ascertain.

Two other frameworks utilised in the literature to measure financial market integration from an economic viewpoint, are based on assessments of international capital market completeness and the degree of financing from world savings, respectively. The former approach is devised by Stockman (1988) who asserts that financial market integration is perfect when there exists a complete set of international financial markets that allow risk-averse financial market participants to insure against the full set of anticipated states of nature (perfectly hedge risks). The latter approach relies on the Feldstein–Horioka (1980) definition in the field of open macroeconomics and requires that for a country that is small in world financial markets, exogenous changes in national savings can be financed from abroad with no change in real interest rates. These definitions are not relied upon in international finance Studies on financial market integration.

2.1.2 Empirical Developments

A wide range of empirical methodologies have been used over time for analysing financial market integration. In international finance there are two distinct categorical measures for quantifying the state and evolution of international financial market integration. The first relies on quantity-based indicators whereas the second involves price-based measures. In addition, dynamic methodologies are increasingly employed to describe the developments of financial market integration over time.

2.1.2.1 Quantity-based Studies

Quantity-based studies generally focus on identifying the asymmetric effects of frictions existing within financial markets. They focus on assessing the ease of market access based on cross-border activities and security holdings or listings. For example, some studies like Tesar and Werner (1995), Lewis (1999) and Ayuso and Blanco (2001), have examined the intensity of cross-border financial flows via the biased share of domestic or non-domestic securities in a well diversified portfolio (in order to gauge the extent of 'home bias' – first noted by French and Poterba, 1991). In this setup, deviations from full integration can be identified based on the existence of barriers to foreign investments. In a similar vein, Galati and Tsatsaronis (2003) find a significant increase in cross-border inter-bank lending within the Euro zone. Alternatively, Bekaert et al. (2002) look for endogenous structural breaks in the relative size of international capital flows and Portes and Rey (2000) examine the timing and complexity patterns of cross-border equity flows. However, there are several drawbacks of the quantity-based approach. First, the classifications used in the available data differ across asset types and countries. Second, the data can be of poor quality and short-spanned, particularly for emerging economies. Third, the data are only available at low frequencies, typically quarterly, and can be quite lumpy. It therefore does not lend itself easily to econometric analysis.

2.1.2.2 Price-based Studies

In the second line of investigation into financial market dynamics, prices and asset returns (including yields and interest rates) are evaluated for discrepancies via cross-market correlations, lead/lag relationships and tests for common stochastic trends. This volume of research invokes the law of one price and Cho et al. (1986) argues that integrated asset markets must be priced in a unified manner. For that to happen, it is reasonable that returns must also move closely together. Since the primary interest in Finance is in the rates of price change (returns) of financial assets (rather than their prices), returns have been a more widely used measure to assess financial market integration. The implication here is that financial asset prices move in conjunction but are not necessarily at the same levels due to differing levels of risks involved. Hence, extensive work has revolved around testing for the extent and the determinants of changes in the comovements of returns across financial markets (see for example, Bodart and Reding, 1999 and Bracker et al., 1999). The general premise of this line of research is that if the correlation/covariance structure demonstrates an upward trend over time, this indicates a greater degree of financial integration.

A common problem with the focus on comovement in asset returns is that they may be exaggerated by common exogenous shocks, heteroskedasticity in underlying return series or similarities in industrial structure, resulting in artificially high comovement levels and potentially wrong conclusions being drawn on the nature of market integration. In the closely related literature on assessing financial contagion, Forbes and Rigobon (2002) argued that high correlation coefficients can be a statistical artifact of time-variations in the volatility of the underlying return series. To further complicate matters, the debate on the relative importance of industry and country-specific effects in explaining cross-market correlations (and volatility) has not yet been resolved (see Roll, 1992 and Heston and Rouwenhorst, 1994).

Despite this, it is generally agreed by a significant number of empirical researchers that return correlations are not constant over time and are determined mainly by real economic linkages between countries (see for example, Arshanapalli and Doukas, 1993, Bachman et al., 1996, Bodurtha et al., 1989, Campbell and Hamao, 1992, and Bracker et al., 1999). In this way, comovements in asset returns over time do capture some aspects of the interrelationships across financial markets, which is integral to the notion of financial market integration. Most empirical studies using correlation dynamics to measure financial market interdependence reject no change(s) in return correlations over time, thus supporting the need for appropriate dynamic methodologies to model return comovements. Such studies include Longin and Solnik (1995), Karolyi and Stulz (1996), Koutmos (1996), Christofi et al. (1997), Bodart and Reding (1999) and more recently, Cappiello et al. (2003)'s use of Engle (2002)'s Dynamic Conditional Correlation (DCC) model.

Other empirical researchers have specifically examined the lead/lag relationship between returns to better understand potential linkages in international financial markets – particularly stock markets. Atheoretical vector auto-regressive models (VARs) proposed by Sims (1980) have been used by Eun and Shim (1989), King and Wadhwani (1990) and others. Gradually, variants on Engle (1982)'s auto-regressive conditional heteroskedasticity (ARCH) model have also been used due to the higher frequency data available to researchers to model financial market dynamics. For example, Hamao et al. (1990) examined stock market linkages and spillovers using daily returns whilst Susmel and Engel (1994) used hourly data to analyse major stock markets in London, New York and Tokyo. However, it is now known that ARCH is less useful for the non-normal distributions exhibited by financial (in particular, emerging) market returns. Instead, semi-parametric ARCH (SPARCH) has been used by Bekaert and Harvey (1997) to capture the fat tails and skewness in emerging market returns. More recently, multiple classes of univariate and multivariate generalized ARCH (GARCH and MGARCH) models have been the technique of choice for research into linkage across financial markets. Bollerslev (1986)'s generalization to the GARCH specification is advantageous for capturing the high degree of persistence in the conditional means and variances of asset returns at high frequency levels and also their fat-tailed distributions (see French et al., 1987). It is also well accepted in the empirical finance literature that the volatility of rising and falling (especially during recessions and/or financial crises) financial markets differ and that negative shocks (bad news) have a greater impact than positive shocks (good news).[2] Hence, the standard GARCH model has been

[2] The theoretical explanation for this is unclear – the two main competing theories are the *leverage effect* and the *risk premium effect* but it is not clear which effect dominates. See Bekaert and Wu (2000) and Wu (2001) for recent developments in stock market studies.

comprehensively extended to accommodate the possibilities of non-normalities and asymmetries in the variance of asset returns (*inter alia* Glosten, Jagannathan and Runkle, 1993, Lin et al., 1994, Bae et al., 1994, Bekaert and Harvey, 1997, Ng, 2000, Darbar and Deb, 2002, Fratzscher, 2002 and Koutmos and Booth, 1995). The two most established approaches are Nelson (1991)'s exponential GARCH (EGARCH) and Glosten, Jagannathan and Runkle (1993)'s GJR-GARCH specification with an additional indicator function for the sign of past return shocks. In particular, previous studies have found that logarithmic specifications in an EGARCH model with a suitable distributional assumption fits financial data well (Bollerslev, 1987 and Hamilton, 1994).

On a parallel front, the cointegration framework has been intuitively used by researchers in financial market integration. In this, a necessary condition for complete integration is the existence of *n-1* cointegrating vectors in a system of *n* indices over a given sample period and this has been tested on various financial markets by Arshanapalli and Doukas (1993), Chan et al. (1997), Chen et al. (2002), Gilmore and McManus (2002), Kanas (1998), Kasa (1992), Kearney (1998), Kleimeier and Sander (2000), Manning (2002), Ratanapakorn and Sharma (2002), Smith (2002), Zhou (2003), Yang et al. (2003) and Tahai et al. (2004), among others. Generally, one or more of the Engle-Granger (1987), Johansen (1988) or Johansen and Juselius (1990) methodologies are employed. For testing interest rate parity conditions, a closely related methodology is used to assess the speed of adjustment of real interest rates from their long-run equilibrium in impulse response analyses within a cointegrated methodology (see Phylaktis, 1999). A key weakness of the cointegration framework is that the existence of long-run stable equilibrium relationships assumed provides an incomplete picture of financial market integration as the true process exhibits strong variations over time. Furthermore, only the existence of an equilibrating process and not the driving forces behind the long-run equilibrium are investigated in standard cointegration analyses.

The spirit of using returns to assess financial market integration has also been maintained within asset pricing contexts. In the well-established asset pricing literature, researchers have been testing for the segmentation of financial markets using various extensions from the international capital asset pricing model (ICAPM) and other multifactor asset pricing models. Traditionally, these models implicitly assume that all of the world's capital markets are perfectly integrated and thus the covariance of the domestic market returns with the world market portfolio of risky assets can represent the major source of asset risk. In this context the price of market risks should be equal across integrated markets. Such studies include those testing the international versions of the CAPM (see Grauer et al., 1976, Korajczyk and Viallet, 1989, and Dumas and Solnik, 1995), the conditional CAPM (Harvey, 1991, Chan et al., 1992), the consumption-based asset pricing models (see Wheatley, 1988), the arbitrage pricing theory (see Solnik, 1983, Gultekin et al., 1989, Cho et al., 1986, Naranjo and Protopapadakis, 1997), the multibeta models (see Ferson and Harvey, 1993), and the latent factor models (see Campbell and Hamao, 1992 and Bekaert and Hodrick, 1992). At the other extreme, the standard CAPM is used for the asset returns from a single country (mainly the US) and this implicitly assumes either the market is perfectly segmented from the world market or that it is a good proxy for the broader world market portfolio. In this vein, Barr and Priestley (2004) also used the CAPM framework to assess whether different types of asset markets (stocks and bonds) are segmented. Many researchers have expressed concerns on the stability and validity of these underlying asset pricing models in testing financial market integration (for example, see Naranjo and Protopapadakis, 1997). Empirical results from these models have been unsatisfactory as they invariably involve joint tests of the model specification, market efficiency and segmentation.

However, a notable development in the asset pricing context has been the ICAPM with partial segmentation used in Errunza and Losq (1985) and subsequently Errunza et al. (1992). However, the major weakness in their mild segmentation model is that the degree of segmentation is assumed to remain time invariant when it is intuitive that markets become more (or less) integrated through time. This is overcome by Bekaert and Harvey (1995) and Bekaert et al. (2005) and they provide a significant improvement in the assessment of time-varying financial market integration.

2.1.2.3 Dynamic Studies

In all the different lines of inquiry discussed above, more recent works have recognised the need to inquire into the evolution (time history) of international integration in asset markets rather than comparative statics alone. Earlier methods failed to provide a complete description of the financial integration process. Based on Campbell (1987) and Harvey (1989, 1991), time-variation in the risk premia has been well accepted and an increasing number of empirical researchers in financial market integration are finding ways to accommodate this. To address variations in financial market integration over time, researchers have performed regressions on sequential sub-sample periods (Koch and Koch, 1991) and also on different sub-sample periods to gain insight into long-term changes in financial market integration dynamics (see Longin and

Solnik, 1995 and Bodart and Reding, 1999). More recently, in studying European financial market integration, Hardouvelis et al. (2005) estimated various ICAPMs with an explicit time-varying measure of integration conditional on the forward interest rate differential with Germany whilst Fratzscher (2002) used time-varying coefficients in a trivariate GARCH model and also rolling and recursive estimation windows. Similarly, Rangvid (2001) and Aggarwal et al. (2003) used dynamic recursive cointegration methodologies to better understand the dynamics of financial market integration. Kim, Lucey and Wu (2005) and Kim, Moshirian and Wu (2005) use time-varying conditional correlations estimated from bivariate GARCH type models and dynamic cointegration techniques. The Kalman Filter technique has also been applied on interest rates to capture the changes in the degree of integration over time by Reisen and Yeches (1993). Furthermore, the asset return generating process has also been remodelled to vary over time using regime-switching models devised by Hamilton (1989, 1990) (see Bekaert and Harvey, 1995, De Santis and Imrohoroglu, 1997, Carrieri et al., 2001, Hardouvelis et al., 2005, Morana and Beltratti, 2002 and Baele, 2004). Conditional Markov regime-switching models extended to allow time-varying transition probabilities for different regimes can potentially capture periods when national financial markets are segmented and when they are integrated. However, a shortcoming of this framework is the reliance on probabilistic assumptions to define regimes.

Regardless of methodology, the bulk of the empirical evidence points to increasing international financial market integration over time, consistent with the broader trend of globalization. The next section will provide the rationale behind this development.

2.2 Rationale for Financial Market Integration

Researchers generally agree that international asset markets have become more integrated in recent times as there is a substantial degree of interdependence in asset prices (for example, see Frankel, 1994, Longin and Solnik, 1995 and Ayuso and Blanco, 2001). There have been various explanations provided for this global phenomenon – relaxation of capital controls, advancements in computer and communication technology that have lowered the cost of international information flows and cross-border financial transactions to name a few (see Grundfest, 1990 for an exposition). Traditionally, differences in transaction costs and tax rates as well as currency risks for investors create barriers to financial market integration as they tend to create different effective prices for financial securities. As cross-border differences are pulled into line, the degree of integration with other financial markets naturally increase. Other barriers identified in the literature are restrictions on foreign security ownership (Errunza and Losq, 1985) - which is a form of capital control - and asymmetric information when investors lack sufficient information to invest (Dumas, 1994 and Bekaert and Harvey, 1995) leading to home bias (see French and Poterba, 1991 and Tesar and Werner, 1995). The problem is that these barriers are difficult to distinguish. Existing frictions in the financial intermediation process invariably continue to exert asymmetric effects on financial markets preventing complete integration.

2.2.1 Link between Economic and Financial Integration

In the past decade, researchers in international finance began to consider the role of macroeconomic forces on financial market integration (see Campbell and Hamao, 1992, Bekaert and Harvey, 1995, Bracker et al. 1999, Dickinson, 2000, Ragunathan et al., 1999, Fratzscher, 2002, Phylaktis and Ravazzolo, 2002 and Bekaert et al., 2002). These researchers in financial market integration have identified that what drives time-variations in the integration process may not only be a country's own economic performance but also the degree of real and financial economic links with other economies. Hence, economic integration appears to provide a channel for financial market integration and there is ample empirical evidence that macroeconomic activity and business cycle conditions are significantly linked to asset prices (for example, see Chen et al., 1986, Fama and French, 1989, Schwert, 1990, Roll, 1992, Rouwenhorst, 1995, Kearney, 1998 and Flannery and Protopapadakis, 2002). Bekaert and Harvey (1995) stated that "whether a market is integrated with world capital markets or segmented is greatly influenced by its government or other regulatory institutions". Thus, it is generally accepted that financial market integration and economic integration go hand in hand. There are two main threads in the literature developed to better understand this relationship.

First, to shed light on the link between economic and financial integration, researchers like Campbell and Ammer (1993), Ammer and Mei (1996), Engsted and Tanggaard (2001), Morana and Beltratti (2002) and Phylaktis and Ravazzolo, (2002) have utilised the theoretical framework of Campbell and Shiller (1988)'s approximate present discounted value model. Within this framework, innovations in excess asset returns (risk premia) between different countries can be decomposed into news about excess returns, future dividend growth rates, interest rates and real exchange rate risk borne by domestic investors for owning assets denominated in foreign currencies. Hence, the role of these individual components on comovements between asset market returns can be identified. However, these studies generally recognise that observed covariance levels can not be fully accounted for by these economic fundamentals.

Second, the literature has largely focused on the significance of real economic integration in determining financial integration and this has been mainly assessed on the basis of international trade links between economies (see Bracker et al., 1999 and Phylaktis and Ravazzolo, 2002). The idea here is that through trade interdependencies, business cycles and consequently expected cash flows in different countries will become more similar. Essentially, the more economies are linked, the more they will be exposed to common exogenous shocks and the more information-sharing there will be.

Extending from this literature strand, the impact of economic integration on financial markets can also be studied within the context of Optimal Currency Area (OCA) theory (see for instance, Artis and Zhang, 1998, Bayoumi and Eichengreen, 1997 and Fratzscher, 2002). Robert Mundell (1961)'s seminal theoretical work on common currency areas posed the OCA framework to evaluate the economic costs and benefits for countries adopting a common currency.[3] Although OCA theory has undergone multiple revisions since the 1960s, it is noteworthy that a central part of this analysis continues to be highly relevant in the 21st Century.

The predominant concern of OCA theory is on the impact of adverse exogenous shocks on individual economies when exchange rates cannot adjust to avoid unemployment and inflationary costs. More generally, the OCA literature has focused

[3] See Engle and Rose (2000) and Hawker and Masson (2003) for the literature on currency unions and economic integration.

on the similarity of economic shocks and business cycles, trade links (or broader real economic linkages), wage and price flexibility, factor mobility and the extent of risk-sharing in assessing whether countries are suitable for forming currency unions or not (see Mongelli, 2002 for an exposition on the OCA literature and its relevant properties). It should be noted that the initial development of OCA theory was improved in McKinnon (1963)'s work. The crux of his follow up paper is that the more open an economy, the stronger the case for a fixed exchange rate. This leads to the general conclusion from OCA theory that the smaller the country or region, the less suitable it will be for an OCA. Interestingly, whilst Kenen (1969) subsequently theorized that the more diverse is the product mix and exports of a country, the less likely it is to suffer from adverse economic shocks; Krugman (1993) argues that currency unions can in fact exacerbate asymmetric shocks to individual member states by inducing regional specialization in production on the basis of comparative advantages. Today, the balance of opinions has shifted in favour of currency unions given the preliminary success and sustainability of the European experience.

Researchers have studied financial markets in the context of exchange rate regimes because they have recognised that the prevailing currency regime within a country necessarily characterizes and influences macroeconomic conditions (especially monetary conditions) (see Bodart and Reding, 1999, Fratzscher, 2002, Morana and Beltratti, 2002 and Baele, 2004). Moreover, currency risk is priced in most international asset pricing models (for example, see Dumas and Solnik, 1995), and it is commonly viewed as an impediment to financial integration across regimes with different currencies.

For Europe, there is already much evidence that the introduction of the single currency has accelerated the pace of financial market integration. Galati and Tsatsaronis (2003) and Reszat (2003) highlight the general impacts of the Euro across European financial markets. In other financial segments, Hau et al. (2002) identify the specific trading effects on foreign exchange markets; Kleimeier and Sander (2000) find convergence in retail lending markets; and Harm (2001) reveals financial integration in the markets for private sector bonds and syndicate loans. European stock markets have received attention in Fratzscher (2002), Morana and Beltratti (2002), Yang et al. (2003) and Hardouvelis et al. (2005), amongst others. Furthermore, Santillan et al. (2000), Barr and Priestley (2004), Clare and Lekkos (2000) and Christiansen (2003) have focused on the experiences of European government bond markets.

2.3 Implications of Financial Market Integration

The premise of financial market integration is that "assets of identical risk command the same expected return, regardless of trading location, Bekaert et al. (2002)." Financial market integration is an important issue as both economic theory and empirical findings suggest that it is beneficial on the whole. It is also likely that there are less positive implications like reduced diversification benefits and welfare losses for some financial market participants.

Various interrelated benefits of financial integration are found in the existent literature. Many financial researchers have suggested that integrated financial markets underpinned by some form of currency union, with a single unit of account to standardise pricing of financial assets will not only reduce transaction costs and hedging losses for major corporations (from the elimination of national currency trading) but also mobilise considerable amounts of capital from speculative purposes (see Moshirian, 2002, and Hooper, 2001). Indeed, leveling of the playing field for financial market participants (in that they can search for their preferred risk-return profiles) and the elimination of country-specific preferences and home bias will reduce information asymmetries and enhance efficiency in financial markets. Subrahmanyam (1975) has shown that the enlargement of the investment opportunity set can unambiguously benefit investors. He utilised three different utility functions to show that integration of capital markets invariably leads to pareto-improvements.

Martin and Rey (2000) demonstrate the impact of financial integration on economic and corporate conditions in the context of a theoretical model. Consistent with Hardouvelis et al. (2005) and Stulz (1995, 1999), they argue that financial integration leads to a reduction in the cost of capital and higher prices for financial assets on average. Corroborating with Subrahmanyam (1975), this body of research also suggests an increase in the investment opportunity set as the number of risky projects accepted is increased. Furthermore, Bekaert and Harvey (2000), Henry (2000a, b) and Kim and Singal (2000) present similar interpretations for the cost of capital in studying emerging markets' integration experience with world financial markets.

Financial market integration has far-reaching consequences. It is fundamentally linked to financial development and in turn economic growth, and this relationship has already been explored internationally by Bekaert and Harvey (1995), Edison et al. (2002), King and Levine (1993), Levine (1997), Pagano (1993) and Guiso et al. (2004), among others. It is well accepted in international macroeconomic theory that investors will shift to high-risk, high expected return projects because of risk-sharing benefits from financial market integration (see Obstfeld, 1994). Moreover, financial market integration is expected to stimulate economic growth through risk-sharing benefits (Edison et al., 2002). It is also well supported that global integration of financial markets contributes to an improvement in capital allocational efficiency (see Baele et al., 2004). The better use of world resources contributes to global financial stability and prosperity. This is also helped by reductions in macroeconomic volatility, for instance, in consumption growth and output (Prasad et al., 2003). This sentiment is succinctly put as "the potential benefits to financial integration are enormous, Rogoff (2003)".

The more practical implications are of particular relevance for investors, risk managers, corporate managers and policy makers. It is well-accepted in the Finance discipline that as integration proceeds, arbitrage opportunities will decline. The benefits of international portfolio diversification will also decline as the correlations in international financial market returns become increasingly higher. Investors and risk managers need to be aware of this when formulating their strategies. In addition, as argued by Baele et al. (2004), financial market integration may not increase the welfare of all economic agents if markets remain incomplete and risk-sharing opportunities do not improve in the financial system. For instance, incumbent financial institutions can be harmed through consolidation activity or the loss of market share. Fortunately, the homogenization of monetary policy transmission mechanisms resulting from financial market integration can facilitate the effective implementation of policy decisions and financial system stability management. Overall, the benefits of a well-monitored financial market integration process should outweigh the potential costs.

2.4 Context and Contributions of this thesis to the Literature

In the context of the relevant literature developments discussed in this chapter, this thesis makes significant contributions on a number of levels. The collection of studies in this thesis contributes to the empirical literature on measuring, documenting and explaining the state and evolution of financial market integration. This thesis is in the vein of those existing empirical studies that employ price-based measures on the principle of the law of one price to assess financial market interdependence (through return comovements and market linkages) in order to make inferences on the pattern of financial market integration across countries. However, it distinguishes itself by also using this type of measure to assess integration *across* different types of asset markets – namely stock and bond markets – in Chapter 5. In doing so, it improves current understanding on inter-market volatility interdependencies and comovements in the Financial Economics literature. Moreover, it specifically examines the integration of EU stock and bond markets within the region and with world markets as represented by the US and Japan.

Inspired by recent developments in time-series econometrics, this thesis provides new applications of dynamic econometric methodologies that can monitor and better understand financial market integration. It employs recent innovations like the EGARCH model with alternative distributional assumptions in Chapters 3 and 5; and Engle (2002)'s DCC-Multivariate GARCH model and also Dynamic Cointegration techniques in Chapter 4. These different modelling approaches reveal trends of financial market integration that are broadly consistent with existing empirical studies yet enable a better understanding on the time-varying properties of financial market integration.

Fundamentally, this thesis also builds on the extant literature linking economic and financial market integration as the implementation of the EMU has had considerable macroeconomic implications. Hence, it specifies and evaluates macroeconomic factors which represent the most relevant and critical channels through which the EMU has changed the macroeconomic environment and consequently acted upon financial market integration. It assesses the influence of currency union developments within the EU to better understand the role of monetary unification in the process of financial market integration. It specifically focuses on the European experience in strengthening economic and monetary integration and the gradual implementation of a single currency and the effects of these macroeconomic channels on integrating European stock and bond markets.

Traditionally, discussions on alternative exchange rate regimes would have involved mainly a discussion on the degree of wage or price rigidity, factor mobility, the relative importance of common versus local shocks and real versus nominal shocks. This thesis has shifted focus to a largely different issue that is financial market integration but still within a well-corroborated and frequently revisited theoretical framework to assess currency areas - Optimal Currency Area (OCA) theory (as previously discussed in section 2.2.1).

It does so by relying on the fact that EMU members knew in advance that they were required to meet the various Maastrict Convergence Criteria (MCC) (as discussed in section 1.3) in order to qualify for entry into the EMU and so intense efforts had already been aimed to integrate previously separate European economies. In essence, the effectiveness of the Maastrict convergence conditions (established by the Maastrict Treaty) in facilitating the process of financial market integration are evaluated via assessment criteria commonly used in the OCA literature. In doing so, this thesis advances existing knowledge on the role of currency unions in influencing the process of regional and global financial market integration.

This role is intuitively driven by investors' reaction to policy changes and adaptation of their future expectations. Stock and government bond markets in particular are asset markets with streams of payments spread out over time. As such, small changes in beliefs about the future of the macroeconomic environment can have substantial effects on the present value of the assets concerned. Asset prices are dynamic and volatile because they are inherently wagers on the long-term future. Clearly, expectations on future macroeconomic conditions can exert integrative or segmentary forces on these two financial segments.

In chapters 3 and 5, a novel two-step estimation incorporating a secondary seemingly unrelated regression (SUR) has been utilised to improve the current menu of dynamic econometric methodologies to investigate the impacts of the Euro and economic integration on international financial markets. This empirical framework makes use of the additional information on the financial integration process that can be captured in linear systems estimation. In addition, the Granger-causality test has also been applied to ascertain the causal relationship between financial market integration and the implementation of a currency union. This is a significant contribution of this thesis to the existing literature as previous studies in this area have not explicitly tested for this and have merely *associated* the two processes with each other.

Given the past and present enlargement experiences of the EU, this thesis also contributes a comprehensive comparative study on the extent of financial market integration for members at various stages of EU membership. Chapter 4 is timely and important for future policy direction of the EU in the interests of both established and new EU members.

Developments within the EU present a natural learning model for researchers in international finance. This thesis investigates the progress of financial market integration *ex post* with a view to evaluating the role of currency unification and economic convergence, in its promotion. The focus is circumscribed to the developments of integration in equity and government bond markets.

Chapter 3*

Dynamic Stock Market Integration Driven by the European Monetary Union

* A condensed version of this chapter is forthcoming in the *Journal of Banking and Finance*.

3.1 Introduction

There is no doubt that capital market integration was one motivation for the European Economic and Monetary Union (EMU). The Euro was introduced as the single currency for the EMU on January 1st, 1999 following an economic convergence process that had spanned over two decades from the initial creation of the European Monetary System (EMS) within the European Union (EU). The political creation of the Euro as the single currency of the EMU presents a learning model for understanding the financial effects of currency unions given that the Euro was introduced without a single Euro area financial market. The concept of financial market integration is central to the international finance literature. It is well accepted in the theoretical literature that integration of financial markets is fundamentally linked to economic growth through risk sharing benefits and reductions in macroeconomic volatility (see Pagano, 1993, Obstfeld, 1994, Prasad et al., 2003). As there are significant potential benefits from financial market integration, the purpose of this chapter is to investigate the nature and the determinants of stock market integration with a view to evaluating the effectiveness of the EMU in its promotion.

First, this chapter discusses how European stock market linkages and integration dynamics have evolved over the past fifteen years on both a regional and global scale in response to the economic convergence process associated with the introduction of the Euro. Second, it addresses the causality issue between currency unions and financial market integration to improve the current understanding on the sequencing of financial market integration. Finally, it identifies the factors that determine these integration patterns in a new empirical context and assesses whether they are consistent for both regional and global stock market integration. The research questions addressed in this chapter have obvious implications for policy makers in an increasingly interdependent global financial architecture and for investors' asset allocation decisions[1]. There is a clear need to better understand how and why the Euro has affected stock markets because of their important role in facilitating financing and investment decisions. This analysis on the existing members of the European Union (EU) is also important for ensuring that the process of currency unification governed by the EMU is beneficial for both present and future members from a financial perspective.

In principle, it is reasonable for investors to view a single currency zone as a single area of financial opportunity. To a large extent, financial market integration is driven by market forces but constrained by regulatory barriers and the level of integration is not uniform across market segments nor across time. Hence, financial markets and investment returns should be driven to some time-varying degree of convergence.[2] There has already been some compelling empirical evidence on the effect of the Euro in accelerating the process of financial integration in European financial markets. For example, Galati and Tsatsaronis (2003) and Reszat (2003) discuss the general impacts across Europe's financial markets; Santillan et al. (2000) provide evidence of full convergence in bond and money markets; Hau et al. (2002) identify the

[1] The covariance matrix of international stocks is a key determinant of asset allocation in investment portfolios. Modern portfolio theory asserts that international diversification of equity portfolios improves the risk-return tradeoff if there is a low correlation between national stock markets (Solnik, 1974).

[2] The time-varying nature of financial market integration is well established in the literature. See Bekaert and Harvey (1995), De Santis and Gerard (1997), Longin and Solnik (1995), and Errunza et al. (1999).

specific impacts on foreign exchange markets; Kleimeier and Sander (2000) find convergence in the retail lending market and Harm (2001) reveals integration in private sector bonds and syndicate loans.

In relation to stock market integration, recent studies by Hardouvelis et al. (2005), Fratzscher (2002), Morana and Beltratti (2002), Aggarwal et al. (2003), Yang et al. (2003) and Baele (2004) provide empirical evidence on the impacts of the introduction of the Euro on European stock markets. In particular, Morana and Beltratti (2002) find that daily volatility of stock index returns decreased for Italy and Spain in the period from January 1988 to May 2000 using a three-regime Markov switching model and Fratzscher (2002), using a trivariate GARCH model over a similar sample period from January 1986 to March 2000 provides empirical evidence of rapid integration in daily stock market index returns with the EMU in the two years prior to the formal introduction of the Euro. However, existing studies remain incomplete and have the following shortfalls: i) They are confined to stock market changes up to early 2000-2001 *and* cover only a few selected countries. Thus longer term, post-Euro impacts on international stock markets from the European currency unification are not well documented or understood. Convergence towards the weighted average of the twelve members of the EMU has never been fully assessed. It is not even clear whether the introduction of the Euro has fundamentally changed the integration process of European stock markets.[3] ii) These studies have merely associated the changes in European stock markets to various aspects of the currency union without addressing the

[3] On a minor point, an assessment of Greece's late entry and integration into the EMU since 2001 has never received academic attention despite the important implications for the next stage of EU enlargement to begin in May 2004.

fundamental causal relationship between the two. iii) European stock market integration has only ever been assessed on a country by country basis and rarely as a group or system of member states which are similar by nature of their common convergence towards the EMU in complying with the Maastrict convergence criteria. iv) Although some researchers have attempted to explain why European stock markets have changed with the introduction of the Euro, their findings are conflicting especially with respect to the reduction in exchange rate risk. Fratzscher (2002) finds a key role for exchange rate stability together with real and monetary policy convergence in explaining time-varying coefficients from his trivariate GARCH model whilst on the basis of a theoretical variance-covariance decomposition, Morana and Beltratti (2002) attribute changes in stock market volatility to the unification of interest rates and stabilization of macroeconomic fundamentals and *not* to the elimination of exchange rate risk; and v) specific stock market measures of liquidity have not been explicitly controlled for in previous studies and seasonal effects (especially January effects) have not been examined despite their presence in other stock market studies (see for example, Longin and Solnik, 1995, Karolyi and Stulz, 1996 and Carrieri et al., 2001).

To address these gaps and disparities in the existing literature and to contribute an updated analysis on the extent to which stock market integration has been driven by the EMU, in this chapter a bivariate daily exponential generalised auto-regressive conditional heteroskedasticity (EGARCH) model is constructed for individual and value-weighted regional stock index returns. The focus is primarily on documenting and explaining the time- varying conditional correlations between these time-series during the lead up to the establishment of the European currency union and beyond. The contributions to the literature are in: i) Providing more comprehensive evidence from *all*

EU15 members as well as Japan and the US on the evolution of stock market integration at the regional and global level over a longer post-Euro period; ii) illustrating a two step estimation methodology that is suitable for empirical research on European financial market integration; iii) providing quantitative estimates on national and regional linkages between international equity markets during the different phases of European stock market integration; iv) addressing the fundamental causal relationship between the EMU and stock market integration; and v) using additional information captured in linear systems estimations to find the determinants of stock market integration, including seasonal effects.

The main findings with the benefit of a longer post-Euro sample period are: i) a clear regime shift in stock market comovements within the EU; ii) deeper stock market linkages with the introduction of the Euro; iii) the EMU has *caused* stock market integration between member states and vis-à-vis Japan and the US; iv) stock market integration is primarily a persistent and seasonal process where stock market development and existing levels of integration are vital; v) the January effect is significant but contrary to Karolyi and Stulz (1996)'s study on the comovements between Japanese and US stock market returns, no day of the week effects in comovements with stock markets in the EMU are found and v) whilst the EMU has fostered stock market integration, the reduction in exchange rate volatility has only been important for the smaller member states with historically different economic structures and that economic convergence within the region has had differing impacts on the integration of European stock markets.

The rest of the chapter is organized in the following way. Section 3.2 of this chapter will focus discussion on the data and methodology used as well as the findings emanating from the documentation of time-varying stock market integration. Section 3.3 will discuss potential explanatory variables before exploring the causality issue between currency unions and financial market integration to aid the main investigation into the determinants of the stock market integration process. Finally, concluding remarks are presented in Section 3.4.

3.2 Documenting time-varying Stock Market Integration

This section reveals the extent to which international stock markets have been integrated with the EMU over the past one and a half decades. It first discusses the data used and their statistical properties before moving onto the empirical model used. Following this, the results are presented and closely examined.

3.2.1 Stock market data

The current state of the EU provides a natural setting for analysing the differential impacts on stock market performance from idiosyncratic developments between constituent members within a currency union. The empirical analysis is therefore conducted for a sample set of countries that fall into two distinct groups: 1) The twelve Euro zone members that have adopted the Euro as a common currency (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain) [4] and 2) The non-Euro zone countries which include the three remaining EU states that opted to stay out of the EMU (Denmark, Sweden, the UK) and Japan and US being the other two major stock markets in the world.

The national stock market (continuously compounding) returns examined in this study are measured as the log of changes in closing price levels from one trading day to the next such that, $R_{it} = \ln\left(P_t / P_{t-1}\right) \times 100$ for stock market *i* on day *t*. The national share price indices used are from Thompson Datastream International and are in local currency units with daily frequency from 2 January 1989 to 29 May 2003 (amounting to 3760 usable observations).[5] Local currency returns are needed in this study to explicitly investigate the impact of changes in exchange rate risk induced by the introduction of the Euro. Also, daily frequency is important given that comovements in the equity return generating process may often change on a rapid basis. The stock market returns for the entire Euro zone is calculated as the (market) value-weighted average return of those twelve EMU markets that have already adopted the Euro. However, the value-weighted Euro zone returns used for bivariate estimations with each individual EMU market *i,* is *exclusive* of that market itself in order to filter out idiosyncratic market shocks in the regional return index and thus avoid spurious integration results. The Euro zone return index $R_{E,t}$ (excluding each individual market *i*) is calculated as

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[4] Greece had failed to meet the economic (convergence) criteria required under the Stability and Growth Pact (1997). These convergence criteria were first set out in the 1992 Maastrict (EU) Treaty and aimed at forcing reductions in inflation, fiscal deficits and public debt in the EU member states. Greece adopted the Euro on 1st January 2001.

[5] Datastream's total market indices typically cover at least 80 per cent of the toal market capitalization of a country and tend to be more homogeneous than other stock market indices.

$$R_{E,t} = \sum_{k \neq i} w_{k,t} R_{k,t} \tag{3.1}$$

where w_k is the weight reflecting the market capitalization of each of the other k markets in the Euro zone as a proportion of the total Euro market comprising those k members.

The statistical properties of the stock market index returns are shown in Table 3.1. The descriptive statistics on the daily stock market index returns for each individual EMU country and for the Euro zone (excluding that country) are shown in panel A of Table 3.1. In turn, those for each country in the sample outside of the Euro zone are paired up with the total Euro zone in panel B of Table 3.1. As is evident from the summary statistics shown in this table, the distributions of all these national and regional daily stock market returns are non-normal. Both the skewness and the excess kurtosis statistics for these return series are significantly higher than for comparable normal distributions at all meaningful significance levels. The higher excess kurtosis in national stock index returns relative to regional returns is to be expected given the law of averages but it appears that stock market returns for Portugal and Luxembourg are the most volatile and sensitive to external shocks. The univariate test results of the Ljung-Box Q tests for linear and non-linear serial correlation in each daily return series for up to 20 lags are also shown in Table 3.1. All return series exhibit highly significant linear and non-linear serial dependence and point to the presence of high persistence and time-varying volatility (heteroskedasticity). Finally, the reported joint i.i.d. (independent and identically distributed) test statistics between each national and regional stock index return reported in Table 3.1 are for a bivariate version of the

Ljung-Box portmanteau test (Hosking, 1980) of joint white noise properties for these returns series, r_t defined as:

$$Q = T^2 \sum_{i=1}^{p} \frac{Tr\left(\hat{C}_i \hat{C}_0^{-1} \hat{C}_i \hat{C}_0^{-1}\right)}{(p-i)}, \tag{3.2}$$

where

$$\hat{C}_i = \frac{1}{T} \sum_{t=i+1}^{T} \left(\hat{r}_t \hat{r}_{t-i}\right), \quad r_t = \begin{bmatrix} r_{1t} \\ r_{2t} \end{bmatrix},$$

and T = number of observations, p = number of lags, Q ~ χ^2 with *df* = 4p. The test statistics for joint linear and non-linear independence are all rejected at conventional significance levels, indicating that the first and second moments of the national and regional equity returns move closely together. Henceforth, modelling of these return series must address the bivariate and leptokurtic nature of these distributions in addition to the high degree of linear and non-linear serial correlations.

An appropriately specified GARCH model with a non-normal conditional density function for the residuals is suitable for modelling these daily compounding return series to capture the significant levels of excess kurtosis exhibited. Thus, bivariate *t* densities are used to model excess kurtosis in the standardised residuals from the model and a bivariate version of Nelson (1991)'s exponential GARCH (EGARCH) approach is adopted to address the well-known asymmetric nature of volatility responses in the stock return series. As mentioned in Chapter 2, there is a well-established need in the volatility literature to look at the effects of asymmetric shocks and previous studies (like Bollerslev, 1997) have found that the logarithmic specification in EGARCH models with a suitable distributional assumption fits financial data very well. It will be shown in the following section how the EGARCH framework has been used to model the dynamics of stock market returns.

Table 3.1

Statistical properties of daily equity returns (per cent), 2/1/1989-29/5/2003

This table presents in panel A, the summary statistics on daily continuously compounding stock market index returns for the 12 countries belonging to the Euro zone and the respective regional returns for the Euro zone (*excluding* that country) weighted by stock market capitalization. In panel B, summary statistics for the three EU countries *not* belonging to the Euro zone as well as Japan and the US are reported. The single regional return is for the total Euro area weighted by stock market capitalization. Asymptotic p-values are shown in the brackets. *,**,*** denote statistical significance at the 10, 5 and 1% level respectively. Test results for H_0:Skewness=0 and H_0:Excess kurtosis=0 are indicated. Q(20) is the Ljung-Box test statistic for serial correlation up to the 20^{th} order in the standardised return series; $Q^2(20)$ is the Ljung-Box test statistic for serial correlation up to the 20^{th} order in the squared returns. $Q_b(20)$ and $Q^2_b(20)$ are the bivariate Ljung-Box tests for joint white noise in the linear and squared national and regional stock market returns up to the 20^{th} order.

	National Stock Index Return				Test of univariate i.i.d.		**Regional Stock Index Return**				Test of univariate i.i.d.		Test of bivariate i.i.d.	
	Mean return	Variance	Skewness	Excess Kurtosis	Q(20): $\chi^2(20)$	$Q^2(20)$: $\chi^2(20)$	Mean return	Variance	Skewness	Excess Kurtosis	Q(20): $\chi^2(20)$	$Q^2(20)$: $\chi^2(20)$	$Q_b(20)$: $\chi^2(80)$	$Q^2_b(20)$: $\chi^2(80)$
Panel A: Euro zone														
GER	0.021	2.167	-0.429***	5.868***	38.482*** {0.008}	1512.131*** {0.000}	0.020	1.189	-0.287***	4.624***	87.712*** {0.000}	3471.027*** {0.000}	256.341*** {0.000}	3546.256*** {0.000}
FRA	0.019	1.568	-0.207***	3.692***	69.661*** {0.000}	2916.583*** {0.000}	0.020	1.313	-0.428***	5.496***	66.605*** {0.000}	2127.954*** {0.000}	118.373*** {0.003}	3185.987*** {0.000}
ITA	0.016	2.044	-0.151***	2.422***	65.952*** {0.000}	1208.035*** {0.000}	0.020	1.334	-0.385***	5.288***	73.595*** {0.000}	2700.775*** {0.000}	115.566*** {0.006}	3931.573*** {0.000}
BEL	0.011	0.975	0.209***	7.141***	202.783*** {0.000}	2343.524*** {0.000}	0.020	1.339	-0.424***	5.327***	72.197*** {0.000}	2386.435*** {0.000}	249.010*** {0.000}	3384.443*** {0.000}
NET	0.023	1.563	-0.214***	5.627***	87.180*** {0.000}	5568.123*** {0.000}	0.019	1.323	-0.437***	5.460***	71.713*** {0.000}	1872.402*** {0.000}	148.439*** {0.000}	5717.393*** {0.000}
IRE	0.028	1.392	-0.413***	6.590***	66.336*** {0.000}	557.308*** {0.000}	0.019	1.314	-0.396***	5.304***	75.106*** {0.000}	2575.747*** {0.000}	172.565*** {0.000}	2832.559*** {0.000}
SPA	0.023	1.742	-0.195***	3.669***	41.734*** {0.003}	2000.760*** {0.000}	0.019	1.315	-0.414***	5.404***	76.168*** {0.000}	2495.642*** {0.000}	99.108* {0.073}	3026.535*** {0.000}
POR	0.022	0.834	-0.770***	14.332***	222.748*** {0.000}	354.056*** {0.000}	0.019	1.314	-0.396***	5.303***	75.722*** {0.000}	2585.584*** {0.000}	288.342*** {0.000}	3335.936*** {0.000}
AUS	0.020	1.153	-0.448***	7.383***	184.670*** {0.000}	1042.343*** {0.000}	0.020	1.308	-0.398***	5.335***	75.384*** {0.000}	2554.098*** {0.000}	204.305*** {0.000}	4004.139*** {0.000}
FIN	0.045	4.734	-0.229***	6.892***	41.354*** {0.003}	1011.389*** {0.000}	0.019	1.262	-0.429***	5.601***	76.325*** {0.000}	2491.692*** {0.000}	105.219** {0.031}	3251.184*** {0.000}
LUX	0.022	0.949	-0.028	13.082***	94.641*** {0.000}	694.916*** {0.000}	0.019	1.305	-0.401***	5.338***	75.553*** {0.000}	2536.346*** {0.000}	192.518*** {0.000}	3228.246*** {0.000}
GRE	0.049	3.203	0.120***	5.193***	127.703*** {0.000}	662.149*** {0.000}	0.019	1.317	-0.395***	5.336***	74.655*** {0.000}	2585.554*** {0.000}	163.823*** {0.000}	3344.325*** {0.000}

Panel B: Non-Eurozone														
DEN	0.030	0.885	-0.451***	5.290***	89.261***	650.460***	0.019	1.027	-0.480***	5.304***	82.397***	1999.688***	195.123***	2274.888***
					{0.000}	{0.000}					{0.000}	{0.000}	{0.000}	{0.000}
UK	0.023	0.914	-0.160***	3.195***	81.346***	2947.509***							128.465***	3448.464***
					{0.000}	{0.000}							{0.000}	{0.000}
SWE	0.027	2.130	0.139***	4.404***	71.322***	1085.047***							130.191***	2426.712***
					{0.000}	{0.000}							{0.000}	{0.000}
JAP	-0.026	1.490	0.162***	4.152***	76.992***	580.898***							222.113***	2556.963***
					{0.000}	{0.000}							{0.000}	{0.000}
US	0.035	1.057	-0.179***	4.338***	46.424***	1295.261***							165.289***	3316.050***
					{0.001}	{0.000}							{0.000}	{0.000}

3.2.2 Econometric modelling

The aim of this chapter is to examine whether the establishment of a currency union has induced a dynamic change in stock market integration by making inferences from the behaviour of daily conditional volatility of stock index returns and their conditional correlations. There is much evidence to support the notion that financial market integration changes the conditional return generating process (for example, see Bekaert and Harvey, 2003). Markets are permanently in motion and comovements fluctuate on a daily basis, and so by allowing for asymmetric response characteristics in stock returns, the integration process of a member state with the currency union region as a whole is better captured. In recent times, multivariate GARCH models have been extended to incorporate time-varying correlations and this feature is theoretically appealing for assessing dynamic financial market integration. Thus, pairs of national and regional stock index returns are jointly modelled in a parsimonious bivariate EGARCH(1,1)-*t* model. The flexibility of this form is to allow for well-documented asymmetric effects as well as the magnitude effects of shocks to stock market returns and also their fat-tailed distributions. A joint student-*t* conditional density function is used to accommodate leptokurtosis in the data.

While time-varying coefficients on return spillovers have been estimated by Fratzscher (2002) in a trivariate GARCH to measure stock market integration, the orthogonality condition required for unbiased estimates (with multiple shock components modelled) may be difficult to ascertain. Instead this chapter uses time-variations in conditional correlations from the EGARCH model.[6] This provides a more direct indication of interdependence over time between individual stock markets and the entire EMU. It is also more meaningful than the arbitrary classification of volatility states required by alternative regime switching models (for example, see Baele, 2004).

Specifically, the model used in this chapter has the conditional first moments (means) of the stock index returns estimated as a parsimonious restricted bivariate Auto-Regressive Moving Average ARMA(p,q)[7] process in order to capture the dynamics between mean stock market returns for each individual country and the Euro zone (excluding individual EMU markets):

$$\begin{aligned} R_{N,t} &= \alpha_{CN} + \sum_{i=1}^{p_E} \alpha_{rE,i} R_{E,t-p_E} + \sum_{j=1}^{q_N} \alpha_{mN,j} \varepsilon_{N,t-q_N} + \varepsilon_{N,t} \\ R_{E,t} &= \alpha_{CE} + \sum_{i=1}^{p_N} \alpha_{rN,i} R_{N,t-p_N} + \sum_{j=1}^{q_E} \alpha_{mE,j} \varepsilon_{E,t-q_E} + \varepsilon_{E,t} \end{aligned} \tag{3.3}$$

with

---

[6] The concerns of Forbes and Rigobon (2002) with using correlation coefficients to measure stock market comovements in the closely related financial contagion literature is not relevant to this study as reductions in European stock market volatility have already been shown by Morana and Beltratti (2002). Hence, one can be confident that the estimated conditional correlations are not a by-product of increasing volatility (that is, heteroskedasticity) in stock returns.

[7] A bivariate exponential GARCH in mean (EGARCH-M) estimation was also conducted with no improvements in the qualitative results. Furthermore, a risk premium adjustment does not fundamentally change the results given that most EMU stock markets are similarly well-developed.

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{N,t} \\ \varepsilon_{E,t} \end{bmatrix} = \varepsilon_t | I_{t-1} \sim t(0, H_t, d),$$

$$H_t = \begin{bmatrix} h_{N,t} & h_{NE,t} \\ h_{EN,t} & h_{E,t} \end{bmatrix}$$

I_{t-1} = Information set available at *t-1*

In essence, $R_{N,t}$ is the national conditional mean return that is a function of past returns in the rest of the Euro zone and past idiosyncratic shocks, $\varepsilon_{N,t}$ and $R_{E,t}$ is the regional conditional mean return for the Euro zone that is a function of past returns in country *N* and its own past shocks, $\varepsilon_{E,t}$. To provide a parsimonious specification and to minimise non-convergence in estimation, the bivariate ARMA has been restricted such that past EMU regional (national market) performance and past own national market (EMU regional) performance are only captured by auto-regressive (AR) and moving average (MA) terms respectively. In doing this, the regional and country mean spillover effects can be quantified by the sign and magnitude of the estimated coefficients for the lagged Euro zone and national returns respectively. Note that p_N and p_E are the number of AR terms and q_N and q_E are the number of MA terms needed to eliminate joint linear and non-linear serial correlation in the standardised residuals, $\frac{\varepsilon_{N,t}}{\sqrt{h_{N,t}}}$ and $\frac{\varepsilon_{E,t}}{\sqrt{h_{E,t}}}$ which are jointly *t* distributed.

The conditional second moments (variances) of the estimated model also incorporate interdependencies in the innovations of national and regional stock market returns as shown below:[8]

[8] In the EGARCH-*t* model the conditional variance equation is defined in terms of $z_t \sim t(0,1,d)$:

$$\ln h_{N,t} = \beta_{CN} + \beta_{hN} \ln h_{N,t-1} + \left[\beta\varepsilon_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta\varepsilon_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] +$$

$$\left[\beta_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right], \tag{3.4}$$

$$\ln h_{E,t} = \beta_{CE} + \beta_{hE} \ln h_{E,t-1} + \left[\beta\varepsilon_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta\varepsilon_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] +$$

$$\left[\beta_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] \tag{3.5}$$

which assumes that the conditional variance is determined by its own past variance, its own negative and positive past unanticipated shocks as well as those from the other stock index return. In this context, the regional and country volatility spillover effects (both asymmetric and volume effects) can be explicitly measured by the magnitude of the estimated coefficients for the negative and positive lagged external innovations in the latter part of equations (3.4) and (3.5). Another advantage of this specification is that by formulating the conditional variances in logarithmic terms, the EGARCH model

---

$$\ln \sigma_t^2 = \omega + g(z_{t-1}) + \beta \ln \sigma_{t-1}^2$$

where g(.) is the asymmetric response function defined by

$$g(z_t) = \lambda z_t + \varphi\left(|z_t| - \sqrt{\frac{2}{\pi}} \right)$$

where z_t is the standardised unexpected return ε_t/σ_t. The second term in the asymmetric response function is the mean deviation of z_t since $E(|z_t|) = \sqrt{\frac{2}{\pi}}$. Hence, when $\varphi > 0$, and $\lambda < 0$ negative return shocks ($z_{t-1} < 0$) will induce larger conditional variance responses than positive return shocks (These are known as the *asymmetric* and *volume* effects).

overcomes the need for non-negativity constraints to ensure positive definite covariance matrices. The stationarity condition for the conditional variance is $\beta_{hN}<1$ and $\beta_{hE}<1$.

Instead of assuming constant correlation between the national and regional stock index return series, as in Bollerslev (1990) and many others, it is allowed in this study to vary across time to capture the time-varying nature of the stock market integration process. The conditional covariance equation is shown below: [9]

$$h_{NE,t} = \delta_0 + \delta_1\sqrt{h_{N,t}.h_{E,t}} + \delta_2 h_{NE,t-1} \tag{3.6}$$

where the dynamics of the conditional correlation coefficient have been modelled based on the cross-product of standard errors of the national and regional stock index returns and past conditional correlations. Hence, the time-varying conditional correlations can be computed as the standardised conditional covariance:

$$INT_t = \frac{h_{NE,t}}{\sqrt{h_{N,t}.h_{E,t}}} \tag{3.7}$$

---

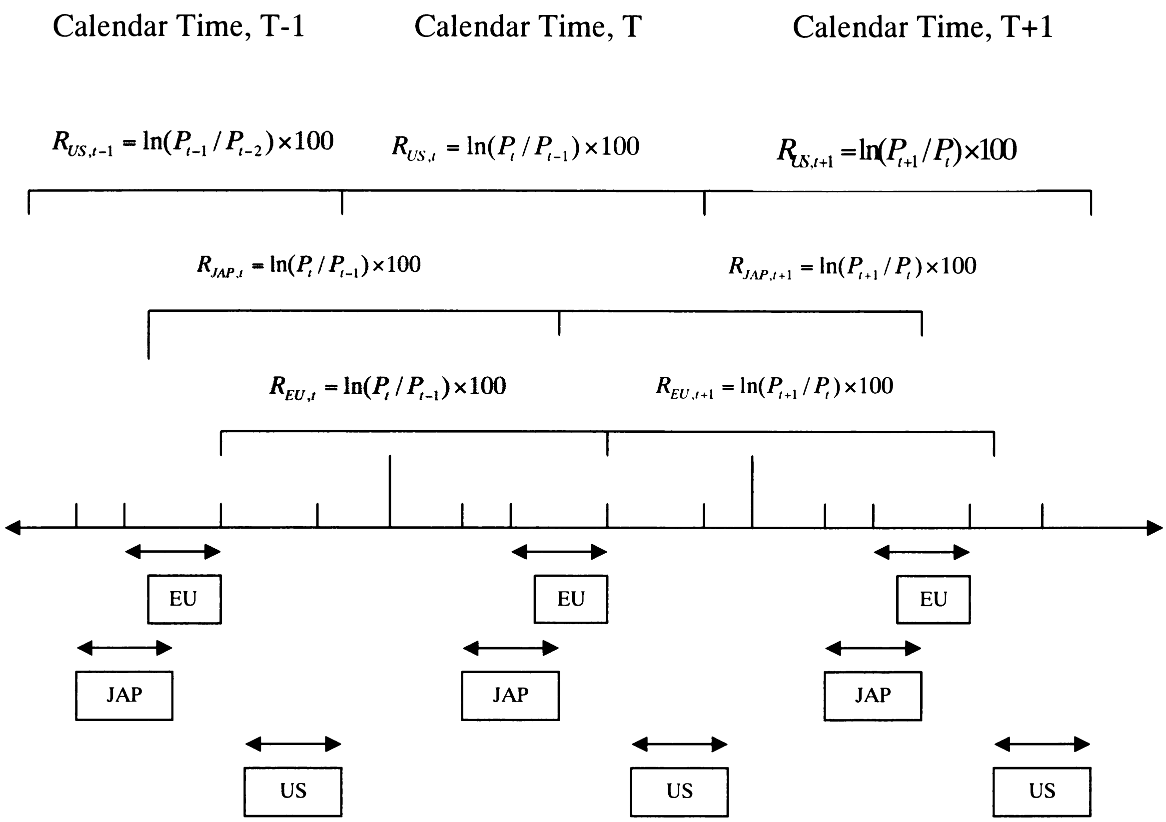
[9] Alternative covariance structures such as $h_{NE,t} = \delta_0 + \delta_1\sqrt{h_{N,t}.h_{E,t}}$ have been estimated to ensure that the results obtained are robust to different functional forms for the conditional covariance equation. Darbar and Deb's (2002) logistic EGARCH has also been estimated to explicitly constrain the range of conditional correlations to between -1 and +1. Alternative specifications made no major differences to the parameter estimates for the bivariate EGARCH model. The cross-product of the mean-deviated unexpected returns (shocks) has been omitted due to the complexity of these shock terms in the bivariate EGARCH framework and maximum likelihood convergence considerations.

and can be used to indicate the level of comovement between national and regional stock index returns. Specifically, this measures the contemporaneous conditional correlation between the two stock market return series and has been used in this chapter to proxy the degree of integration between national stock markets and other stock markets in the Euro zone[10].

This model has also been used to gauge the extent of inter-regional integration between stock markets in Europe and Asia (represented by Japan) and also Europe and the USA. This second application of the empirical model provides invaluable insight into the globalisation phenomenon of the past decades. To minimize the errors resulting from non-synchronous stock market trading across different time zones, US returns from the previous day are modelled with contemporaneous Euro zone weighted market returns as the US market opens and closes *after* European stock markets and therefore affects the Euro zone only on the following day. For the Japanese stock market, same day returns are modelled with the Euro zone. As highlighted in Figure 3.1, this approach maximizes the overlap in stock market trading times and thus, the pricing of common information across different regions.

[10] Typically, time-varying conditional correlations have been used more in the domain of risk management for calculating short-term hedge ratios to reflect current market conditions. However, time-varying conditional correlations have been used in recent macroeconomic research in recognition that static correlations are too simplistic and are blurred by the transition process (see Babetski et al., 2002 and Sarkar and Zhang, 2002).

Figure 3.1 Time line of trading hours across regions



The bivariate ARMA-EGARCH-t model is implemented for the stock index returns data via maximum likelihood estimation of the following log likelihood function[11]

[11] The Simplex algorithm was first used to determine appropriate starting values for parameter estimates then numerical optimization was based on the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm.

$$L_T(\theta_f) = \sum_{t=1}^{T} l_t(\theta_f) = \sum_{t=1}^{T} \begin{bmatrix} -\left(\frac{k}{2}\right)\log(2\pi) - \frac{1}{2}\log\left(\frac{d-2}{d}\right) - \frac{1}{2}\log|H_t| - \frac{k}{2}\log\left(\frac{d}{2}\right) \\ +\log\Gamma\left(\frac{d+k}{2}\right) - \log\Gamma\left(\frac{d}{2}\right) - \left(\frac{d+k}{2}\right)\log\left(1 + \frac{\varepsilon_t' H_t^{-1} \varepsilon_t}{d-2}\right) \end{bmatrix}$$

(3.8)

where k = 2 in the bivariate case, θ_f is the vector of parameters to be estimated, T is the number of observations and Γ(.) denotes the gamma function. As previously mentioned, a conditional bivariate student's *t* distribution with variance-covariance matrix H_t and *d* degrees of freedom has been assumed for the joint conditional distribution of the two error processes instead of the standard bivariate normal distribution in order to account for possible leptokurtosis in the joint conditional densities (see Bollerslev, 1987 and Hamilton, 1994). The advantage of employing this distribution is that the unconditional leptokurtosis observed in most high-frequency asset price data sets can appear as conditional leptokurtosis and still converge asymptotically to the standardised Normal distribution as *d* approaches infinity or *1/d* approaches 0 (usually in lower-frequency data). As shown below, this distributional assumption is well suited for the dynamics of the stock market returns employed.

3.2.3 Empirical Results

The bivariate estimation results for all individual market indexes with the Euro zone market indexes are reported in Table 3.2. Estimates for parameters in the two conditional mean and volatility equations are shown followed by those in the covariance equation. The diagnostic results of the estimations are shown in the bottom panel. In general, the bivariate EGARCH model is appropriate for all the stock market index return pairs as significant negative asymmetric effects ($\beta\varepsilon_{N1}$, β_{E1}, $\beta\varepsilon_{E1}$ and β_{N1}) together with positive volume effects ($\beta\varepsilon_{N2}$, β_{E2}, $\beta\varepsilon_{E2}$ and β_{N2}) are present. The coefficients for lagged conditional volatility (β_{hN} and β_{hE}) are fairly close to one for all countries suggesting a high persistence in shocks to the conditional volatility but the conditional variance appears not to be integrated. The insignificant Ljung-Box Q test statistics (for a null hypothesis of joint white noise) indicates that joint linear and non-linear serial correlations in the standardised residuals have been successfully eliminated in the bivariate ARMA-EGARCH-*t* models.

Figures 3.2 and 3.3 illustrate the path of time-varying conditional correlations estimated from these bivariate EGARCH models for the twelve EMU members and the other five non-Euro zone countries. Due to the differences in the industrial structure of the underlying stock market indices, the levels of comovement in stock returns will differ. By construction, countries such as Germany, France and Italy with larger stock market capitalizations will appear to be more integrated with the EMU regional core and this is reflected in the levels of conditional correlations in Figures 3.2 and 3.3. Nevertheless, it is clear that the pattern of stock market integration has varied strongly over time for all EU countries, having been more volatile prior to the mid 1990s. In the aftermath of the severe and costly EMS crisis over 1992-93, stock markets in the region were to some extent heading towards further segmentation (reflecting the general state of uncertainty surrounding the single currency project) but this had stabilized in all EU countries by 1996. Since 1996-97 there has been a clear change in the dynamics of integration amongst stock markets inside the entire EU (that is, not just amongst those members that have adopted the Euro). In fact, there is a statistically significant change in the long-run trend towards both regional and global integration, evident in Table 3.3.

Table 3.2

Bivariate-ARMA-EGARCH-*t* Model Estimations

In this table, the results of the bivariate EGARCH estimations are reported. The bivariate EGARCH model for each country, as defined in equations (3.3)-(3.6), are

$$R_{N,t} = \alpha_{CN} + \sum_{i=1}^{p_E} \alpha_{rE,i} R_{E,t-p_E} + \sum_{j=1}^{q_N} \alpha_{mN,j} \varepsilon_{N,t-q_N} + \varepsilon_{N,t}$$

$$R_{E,t} = \alpha_{CE} + \sum_{i=1}^{p_N} \alpha_{rN,i} R_{N,t-p2} + \sum_{j=1}^{q_E} \alpha_{mE,j} \varepsilon_{E,t-q_E} + \varepsilon_{E,t}$$

$$\ln h_{N,t} = \beta_{CN} + \beta_{hN} \ln h_{N,t-1} + \left[\beta\varepsilon_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta\varepsilon_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right],$$

$$\ln h_{E,t} = \beta_{CE} + \beta_{hE} \ln h_{E,t-1} + \left[\beta\varepsilon_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta\varepsilon_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right]$$

$$h_{NE,t} = \delta_0 + \delta_1 \sqrt{h_{N,t} . h_{E,t}} + \delta_2 h_{NE,t-1}$$

	Eurozone												Non-Eurozone				
	GER	FRA	ITA	BEL	NET	IRE	SPA	POR	AUS	FIN	LUX	GRE	DEN	UK	SWE	JAP	US
Mean: R_N																	
α_{CN}	0.041^{***}	0.048^{***}	0.033^{**}	0.035^{***}	0.043^{***}	0.037^{***}	0.058^{***}	0.020^{**}	0.038^{***}	0.027	0.038^{***}	0.012	0.038^{***}	0.038^{***}	0.080^{***}	-0.036^{***}	0.035^{***}
	{0.003}	{0.000}	{0.029}	{0.001}	{0.000}	{0.008}	{0.000}	{0.047}	{0.006}	{0.156}	{0.000}	{0.598}	{0.002}	{0.001}	{0.000}	{0.002}	{0.000}
α_{rE1}	0.289^{***}	0.013	0.061^{***}	0.035^{***}	0.053^{***}	0.142^{***}	-0.013	0.033^{***}	0.058^{***}	0.143^{***}	0.127^{***}	0.108^{***}	0.230^{***}	-0.006	0.029	0.248^{***}	0.426^{***}
	{0.000}	{0.580}	{0.006}	{0.000}	{0.000}	{0.000}	{0.193}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.793}	{0.222}	{0.000}	{0.000}
P_E	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1
Q_N	7	1	5	3	5	3	3	4	8	5	9	3	0	1	2	1	7
Vol.:R_N																	
β_{CN}	1.485^{***}	1.496^{***}	1.482^{***}	1.415^{***}	1.452^{***}	1.456^{***}	1.464^{***}	1.368^{***}	1.439^{***}	1.518^{***}	1.197^{***}	1.375^{***}	1.422^{***}	1.490^{***}	1.473^{***}	1.436^{***}	1.465^{***}
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{hN}	0.987^{***}	0.983^{***}	0.972^{***}	0.976^{***}	0.983^{***}	0.978^{***}	0.980^{***}	0.966^{***}	0.966^{***}	0.993^{***}	0.921^{***}	0.936^{***}	0.968^{***}	0.983^{***}	0.984^{***}	0.976^{***}	0.979^{***}
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.00}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
$\beta_{\varepsilon N1}$	-0.019	-0.047^{***}	-0.031^{**}	-0.014	-0.049^{***}	-0.003	-0.047^{***}	0.017	-0.021	-0.013	0.012	-0.003	-0.012	-0.051^{***}	-0.027^{**}	-0.076^{***}	-0.042^{***}
	{0.187}	{0.000}	{0.014}	{0.278}	{0.000}	{0.790}	{0.000}	{0.233}	{0.105}	{0.419}	{0.316}	{0.737}	{0.412}	{0.001}	{0.044}	{0.000}	{0.001}
$\beta_{\varepsilon N2}$	0.093^{***}	0.078^{***}	0.129^{***}	0.109^{***}	0.112^{***}	0.096^{***}	0.105^{***}	0.205^{***}	0.166^{***}	0.102^{***}	0.363^{***}	0.329^{***}	0.165^{***}	0.091^{***}	0.134^{***}	0.157^{***}	0.068^{***}
	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.002}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{E1}	-0.032^{***}	-0.018	-0.010	-0.032^{**}	-0.001	-0.026^{**}	-0.006	-0.040^{**}	-0.022^{*}	-0.020^{*}	-0.026^{**}	-0.008	-0.028	-0.015	-0.025^{*}	-0.019^{*}	-0.030
	{0.003}	{0.258}	{0.487}	{0.012}	{0.893}	{0.017}	{0.672}	{0.046}	{0.094}	{0.086}	{0.027}	{0.294}	{0.107}	{0.371}	{0.057}	{0.078}	{0.108}

β_{E2}	0.055***	0.050***	0.036	0.104***	0.071***	0.085***	0.069***	0.054	0.029	0.009	0.101***	0.027***	0.041*	0.034***	0.029***	0.053***	0.087***
	{0.005}	{0.000}	{0.108}	{0.000}	{0.000}	{0.000}	{0.000}	{0.212}	{0.201}	{0.616}	{0.000}	{0.000}	{0.057}	{0.001}	{0.003}	{0.000}	{0.000}
Mean: R_E																	
α_{CE}	0.044***	0.045***	0.043***	0.049***	0.041***	0.044***	0.047***	0.041***	0.046***	0.032***	0.046***	0.042***	0.044***	0.040***	0.055***	0.044***	0.056***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.001}	{0.000}	{0.000}	{0.001}	{0.000}	{0.004}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
α_{rN1}	0.010	0.132***	0.016	0.016	0.019*	-0.054***	0.037***	-0.039***	-0.075***	0.003	-0.016	0.002	-0.095***	0.078***	0.016	-0.048***	-0.075***
	{0.445}	{0.000}	{0.153}	{0.182}	{0.088}	{0.000}	{0.000}	{0.002}	{0.000}	{0.726}	{0.193}	{0.807}	{0.000}	{0.000}	{0.160}	{0.000}	{0.000}
P_N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q_E	6	1	3	0	5	7	1	2	5	2	4	3	4	1	1	4	2
Vol.: R_E																	
β_{CE}	1.472***	1.471***	1.480***	1.468***	1.468***	1.469***	1.452***	1.478***	1.493***	1.482***	1.461***	1.464***	1.456***	1.452***	1.460***	1.439***	1.467***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{hE}	0.986***	0.984***	0.984***	0.981***	0.981***	0.982***	0.982***	0.983***	0.987***	0.980***	0.983***	0.983***	0.983***	0.980***	0.983***	0.979*	0.978***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
$\beta_{\varepsilon E1}$	-0.043***	-0.034	-0.037***	-0.053***	-0.033***	-0.056***	-0.017	-0.063***	-0.062***	-0.062***	-0.051***	-0.060***	-0.061***	-0.022	-0.039***	-0.056***	-0.058***
	{0.000}	{0.117}	{0.000}	{0.000}	{0.000}	{0.000}	{0.234}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.236}	{0.002}	{0.000}	{0.000}
$\beta_{\varepsilon E2}$	0.114***	0.121***	0.161***	0.130***	0.135***	0.150***	0.129***	0.131***	0.140***	0.141***	0.142***	0.148***	0.125***	0.131***	0.133***	0.159***	0.182***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{N1}	-0.009	-0.028	-0.025***	0.007	-0.035***	0.010	-0.046***	0.015	-0.018**	0.010	-0.003	-0.012**	0.016	-0.053***	-0.011	-0.033***	-0.008
	{0.533}	{0.108}	{0.001}	{0.504}	{0.000}	{0.380}	{0.005}	{0.206}	{0.039}	{0.289}	{0.653}	{0.025}	{0.217}	{0.009}	{0.426}	{0.000}	{0.385}
β_{N2}	0.039	0.033**	-0.016	0.029***	0.025*	0.008**	0.050***	0.013	-0.011	-0.001	0.026**	0.015***	0.045***	0.040***	0.030***	0.029***	0.030***
	{0.105}	{0.023}	{0.156}	{0.000}	{0.093}	{0.031}	{0.000}	{0.327}	{0.442}	{0.932}	{0.019}	{0.000}	{0.000}	{0.004}	{0.000}	{0.000}	{0.000}
Covariance																	
δ_0	-0.115***	-0.137***	-0.311***	-0.059***	-0.099***	-0.063***	-0.157***	-0.087***	-0.059***	-0.277***	-0.027***	-0.124***	-0.051**	-0.078***	-0.107***	-0.044**	-0.010
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.015}	{0.000}	{0.000}	{0.010}	{0.662}
δ_1	0.712***	0.836***	0.814***	0.494***	0.806***	0.501***	0.791***	0.464***	0.524***	0.684***	0.140***	0.293***	0.523***	0.797***	0.657***	0.492***	0.347***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
δ_2	0.210*	0.134**	0.145***	0.371***	0.130***	0.130***	0.134***	0.353***	0.131***	0.114***	0.514***	0.124**	0.095	0.091***	0.225***	-0.597***	0.099
	{0.056}	{0.047}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.002}	{0.000}	{0.010}	{0.610}	{0.005}	{0.000}	{0.000}	{0.366}
Diagnostics																	
d	48.410***	45.906***	52.603***	33.048***	47.207***	36.449***	42.039***	24.189***	40.404***	40.966***	25.505***	32.221***	35.929***	41.543***	40.126***	43.781***	48.034***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
-Ln L	9316.048	8706.235	10326.733	8438.382	8461.270	9884.085	9415.108	8443.410	9423.102	11563.618	9185.353	11766.353	8633.881	7761.139	9488.770	9957.465	8791.552
$Q_b(10)$:	42.498	49.011	27.628	50.199	39.153	26.906	34.109	36.701	27.374	40.234	45.905	44.481	49.517	42.593	41.447	21.969	38.839
$\chi^2(40)$	{0.364}	{0.155}	{0.931}	{0.129}	{0.508}	{0.944}	{0.732}	{0.620}	{0.936}	{0.460}	{0.241}	{0.289}	{0.144}	{0.360}	{0.407}	{0.991}	{0.522}
$Q^2_b(10)$:	20.351	17.634	15.406	7.648	18.298	12.358	8.387	1.038	44.963	19.865	15.659	8.700	13.247	12.142	11.275	18.743	6.274
$\chi^2(40)$	{0.996}	{0.999}	{1.000}	{1.000}	{0.999}	{1.000}	{1.000}	{1.000}	{0.272}	{0.997}	{1.000}	{1.000}	{1.000}	{1.000}	{1.000}	{0.998}	{1.000}

*Notes: d is the degree of freedom in a student t distribution for the two joint error processes. -Ln L is the negative estimated value of log-likelihood. P-Values are shown in the brackets.***,*** denote significance at the 10%, 5% and 1% level respectively. $Q_b(10)$ and $Q^2{}_b(10)$ are the bivariate Ljung-Box tests for joint white noise in the linear and squared standardised residuals up to the 10^{th} order.*

From 1996 to late 1998, stock market integration with the Euro zone increased rapidly for most EU members. This period coincided with the final stages of the Treaty of Amsterdam in which political and institutional conditions were created to enable the EU to meet the challenges of the future with amendments to the Maastrict (EU) Treaty.[12] This was a major milestone in the path to financial integration as it eliminated a large amount of uncertainty leading up to the formal adoption of the Euro and consequently kicked off the distinct upward trend in stock market integration for all EU countries. The phase of uncertainty preceding this phase of rapid integration is clearly more pronounced for Portugal, Ireland, the Netherlands and Greece. Interestingly, late entry has not been a major setback for integration of the stock market in Greece into the EMU. As previous European stock market studies have recognised, stock prices move in anticipation of future events and forward looking investors had already factored in the introduction of the Euro into stock prices prior to its formal introduction (see for example, Morana and Beltratti, 2002). A long lasting benefit since the Euro's introduction in 1999, has been the effective stabilization of the integration process as indicated by dampened volatility in all estimated conditional correlation series (see Table 3.3). This is possibly due to the stabilization in macroeconomic fundamentals through the EMU convergence process as shown by Morana and Beltratti (2002). The view of these authors is that the introduction of the Euro was "a macroeconomic news of varying importance for different countries which in no case has brought about a revolution in the economic structure." Although to some extent, the changes in the integration patterns do vary amongst all the EU countries in line with this view, there is further evidence in Table 3.3 to suggest that a stronger regime shift has occurred for

[12] The Maastrict Treaty (Treaty on EU) technically came into force on November 1, 1993 but the Treaty of Amsterdam was concluded on June 17, 1997.

most member states that have adopted the Euro. This has been made clearer with this more recent sample period than that used in past studies. Whilst the mean levels of all the conditional correlations have significantly increased with the EMU, the volatility reduction has been greater for most EMU countries. While Morana and Beltratti (2002) have already focused on the changes in stock return volatility specifically before and after the introduction of the Euro, this chapter focuses on the overall changes in stock market comovements with the Euro zone. It is apparent that a new regime marked by increased stability and higher mean levels of integration, has emerged for EMU countries in the post-Euro era.

In comparison, the group of Central and Eastern European (CEE) stock markets' integration with the EMU is more heterogeneous and at a much lower level than the sample countries considered (see Figure A.1 in the Appendices). The stock market in Cyprus appears to be one of the most integrated with the EMU out of the peripheral new EU group and integration has picked up from late 2001 (earlier in Estonia, Slovenia and Slovakia). As for future EU members, Turkey is already reasonably integrated with the EMU whilst Romania and Bulgaria are further off. Whilst interesting to compare and contrast the financial market integration experience in established, new and future EU stock markets, difficulties with achieving model convergence and limited economic data availability for CEECs constrained the validity of a parallel assessment on their stock markets and will not be pursued any further in this chapter.

Figure 3.2 Time-varying stock market integration – Euro zone countries, 1/1989-5/2003

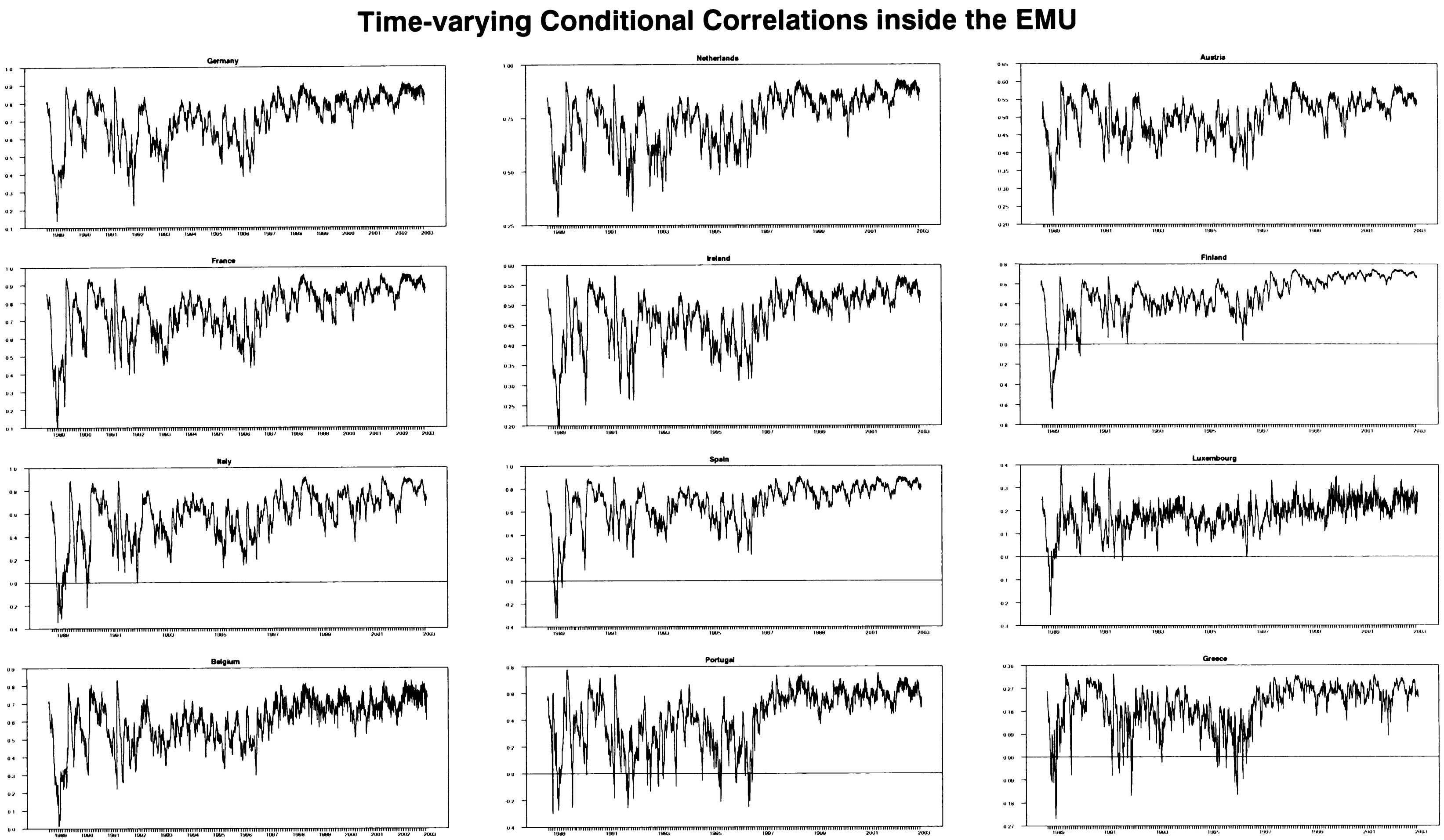
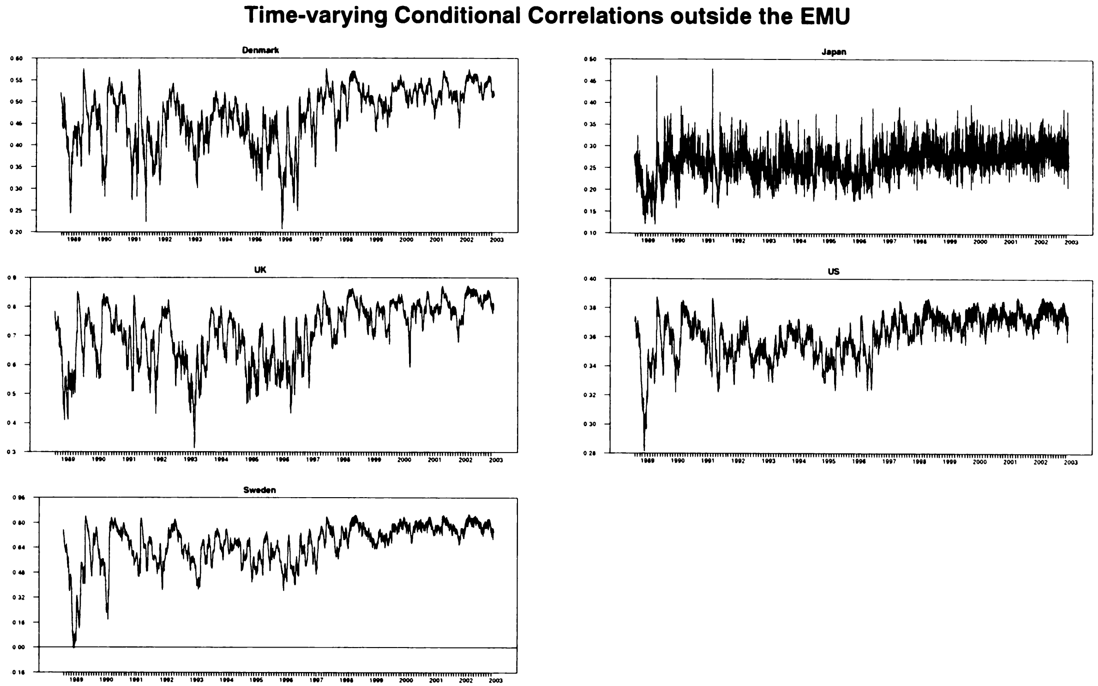


Figure 3.3 Time-varying stock market integration – non-Euro zone countries, 1/1989-5/2003



On the global front, ties between the Euro region and the other two major markets were also strengthened during this period of monetary unification and this is consistent with the general evolution towards more integrated financial markets documented by Ayuso and Blanco (2001) and Carrieri et al. (2001).[13] However, heterogeneity is evident between the Euro zone and non-Euro zone stock markets as there are important differences in their conditional correlation time-series in this sample period. To the extent that investors did update their stock valuations leading up to the macroeconomic "news" regarding the formal introduction of the Euro in the EU market, the anticipation was not as significant outside the EU, particularly in the Japanese stock market where there is much more noise in the conditional correlation series, as seen in Figure 3.3. Specifically, a regime shift in financial integration with the EMU is not obvious although the pattern is consistent with stock market integration inside the Euro zone in that there was also an upward trend preceding the Euro's formal introduction as the uncertainties were reduced and a plateau has also emerged in the post-Euro period. Quantifying the linkages between stock market returns will aid this assessment on the differences in regional and global integration.

3.2.4 Conditional mean and volatility spillover effects

Spillovers in conditional mean return and volatility occur when past information from the national stock markets or the Euro area market has persistent effects on the other. The coefficients of the mean spillover variables (one day lagged cross-market returns) and the spillovers in negative and positive unexpected cross-market shocks

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[13] Although these authors argue that higher correlations of market-wide index returns are neither a necessary nor sufficient condition for greater market integration.

have been isolated in Tables 3.4 and 3.5 respectively. They have been estimated for the full sample period as well as three sub-samples justified on the basis of observed integration patterns. The first sub-sample period goes from the beginning of January 1989 to the end of 1995, indicating the period before major changes took effect in the integration process of these equity markets. The second sub-sample is the short intense pre-Euro integration period between the start of 1996 and the end of 1998. Finally, the third sub-sample from the start of 1999 to the end of May 2003 is the extended post-Euro period. In such an exercise, the econometric model that is suitable for the full sample may not necessarily be a good fit for individual sub-samples. However, a break down of the full sample period contributes to the understanding of the long-term dynamics of the stock market integration process.

First, to aid the analysis of the full sample period, the significant coefficients on cross-market returns from the previous day have been graphed side by side in Figures 3.4 and 3.5. The first result that emanates from a comparison of these two figures is that the sign of the significant coefficients from individual lagged country returns (country spillover effect) may be positive or negative but the coefficient from the Euro zone (regional spillover effect) is always positive. This could simply be attributed to the law of averages in that the idiosyncratic differences in information transmission are more predictable for the value-weighted average of the whole Euro zone. Based on the magnitudes of these significant regional spillover coefficients, for an equal percentage increase in stock market returns for the rest of the Euro zone, stock returns in the US stock market will move the most (0.426%) in the same direction on the next day, followed by the German (0.289%) then Japanese stock market (0.248%) and so on. The sensitivity of the US and Japanese stock markets to information flows from the Euro zone is another indicator that globalization is a key feature of the 21st Century. It should also be noted that of all the countries in the sample, only Luxembourg required more than one lag in the regional mean return to fully eliminate serial correlation in its conditional mean equation. This suggests that this stock market is the most inefficient at incorporating information from the rest of the Euro zone into stock prices. In Figure 3.5, it is revealed that changes in stock market returns for the Euro zone are led by stock market returns in France, the UK, Spain and the Netherlands whilst stock market returns for the Euro region react in an opposite direction to developments in Japan, the US and Denmark, Austria, Ireland, and Portugal.

As is evident in Tables 3.4 and 3.5, regional spillovers in conditional mean returns and unexpected shocks tend to be larger than the country specific spillover effects. This is an intuitive result given the size difference of these indices. In regards to return spillovers reported in Table 3.4, the effects are not constant. The magnitude of these linkages has increased for most countries in line with the three distinct phases in stock market integration. As integration in stock markets proceeded, the interdependencies between national and Euro zone stock markets have strengthened although not always in the same direction. Feedback effects in country and regional returns are apparently asymmetric in that information may spillover unidirectionally from a country into the Euro region or vice versa. As expected, for most countries these feedback effects are bilateral. In regards to the volatility spillovers reported in Table 3.5, there is further evidence that European markets are largely integrated as the regional shocks appear to be relatively larger than the country specific shocks and are becoming increasingly more so. This is consistent with the findings in Baele (2004)'s study of volatility spillover intensities. The asymmetric and volume effect (from the past negative and positive unexpected shock) from each individual country and from the Euro region are mostly significant and of the expected sign over the full sample period but not for all sub-sample periods.

Table 3.3

Sub-sample statistics for time-varying conditional correlations

This table shows the pre- and post-Euro sub-sample means and standard deviations for each sample country. The Z test statistics are computed for a two-tailed, two-sample mean difference test for large samples.

	Pre-Euro sub-sample		*Post-Euro sub-sample*		*2 sample Z test on mean difference*
	Mean	Std. Dev.	Mean	Std. Dev.	($Z_{\alpha/2}$ = 1.96 for α of 5%)
Eurozone					
GER	0.6655	0.1349	0.8156	0.0522	48.98**
FRA	0.7109	0.1400	0.8597	0.0611	45.23**
ITA	0.5190	0.2219	0.7268	0.1101	38.22**
BEL	0.5606	0.1310	0.7023	0.0570	46.10**
NET	0.7107	0.1206	0.8471	0.0486	49.27**
IRE	0.4505	0.0672	0.5246	0.0238	49.54**
SPA	0.6189	0.1890	0.7995	0.0632	43.46**
POR	0.3433	0.2123	0.5873	0.0661	52.96**
AUS	0.4877	0.0581	0.5376	0.0286	35.20**
FIN	0.4080	0.2017	0.6728	0.0479	62.93**
LUX	0.1619	0.0750	0.2358	0.0415	38.53**
GRE	0.1772	0.0894	0.2560	0.0333	39.13**
Non-Eurozone					
DEN	0.4483	0.0636	0.5182	0.0259	47.80**
UK	0.6607	0.1022	0.7801	0.0461	49.32**
SWE	0.6178	0.1378	0.7633	0.0446	48.41**
JAP	0.2562	0.0313	0.2851	0.0118	41.04**
US	0.3566	0.0095	0.3682	0.0032	55.55**

Table 3.4

Bivariate ARMA-EGARCH-*t* results for Stock Market (Mean) Return Spillovers

In this table, the estimated mean return spillovers from the national (α_{rN}) and regional (α_{rE}) stock markets on the previous day are reported for the full sample period and three other sub-sample periods shown. Asymptotic p-values are shown in the brackets. *, **, *** denote statistical significance at the 10, 5 and 1% level respectively. The conditional mean equations, as defined in equation (3.3), are

$$R_{N,t} = \alpha_{CN} + \sum_{i=1}^{p_E} \alpha_{rE,i} R_{E,t-p_E} + \sum_{j=1}^{q_N} \alpha_{mN,j} \varepsilon_{N,t-q_N} + \varepsilon_{N,t}$$

$$R_{E,t} = \alpha_{CE} + \sum_{i=1}^{p_N} \alpha_{rN,i} R_{N,t-p2} + \sum_{j=1}^{q_E} \alpha_{mE,j} \varepsilon_{E,t-q_E} + \varepsilon_{E,t}$$

	From Country i				From Eurozone			
Coefficient	α_{rN1}				α_{rE1}			
	Total	Sub sample periods			Total	Sub sample periods		
	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03
Panel A: Eurozone								
GER	0.010	0.009	-0.065	0.179***	0.289***	0.298***	0.463***	-0.047
	{0.445}	{0.435}	{0.127}	{0.000}	{0.000}	{0.000}	{0.000}	{0.492}
FRA	0.132***	0.125***	0.161***	-0.096***	0.013	-0.016	-0.050	0.183***
	{0.000}	{0.000}	{0.000}	{0.008}	{0.580}	{0.596}	{0.267}	{0.000}
ITA	0.016	0.008	0.035**	0.063***	0.061***	0.199***	-0.051	0.064***
	{0.153}	{0.508}	{0.039}	{0.002}	{0.006}	{0.000}	{0.226}	{0.000}
BEL	0.016	-0.035	0.092	0.032	0.035***	0.107***	0.014	-0.037**
	{0.182}	{0.200}	{0.714}	{0.270}	{0.000}	{0.000}	{0.974}	{0.047}
NET	0.019*	0.049***	0.104	-0.085***	0.053***	0.017	0.008	0.199***
	{0.089}	{0.006}	{0.126}	{0.004}	{0.000}	{0.314}	{0.922}	{0.000}
IRE	-0.054***	-0.027	-0.111***	-0.092***	0.142***	0.159***	0.206***	0.102***
	{0.000}	{0.113}	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
SPA	0.037***	0.002	0.133**	-0.049	-0.013	0.026	-0.017	0.012
	{0.000}	{0.926}	{0.012}	{0.205}	{0.193}	{0.406}	{0.692}	{0.742}
POR	-0.039***	-0.042	-0.003	-0.029	0.033***	0.078***	-0.035	-0.006
	{0.002}	{0.123}	{0.931}	{0.329}	{0.000}	{0.000}	{0.127}	{0.639}
AUS	-0.075***	-0.048**	-0.114***	-0.143***	0.058***	0.188***	0.133***	0.278**
	{0.000}	{0.012}	{0.003}	{0.000}	{0.000}	{0.000}	{0.003}	{0.046}
FIN	0.003	0.015*	-0.075***	-0.005	0.143***	0.164***	0.218***	0.103**
	{0.726}	{0.088}	{0.000}	{0.328}	{0.000}	{0.000}	{0.002}	{0.048}
LUX	-0.016	-0.020	0.041	-0.029	0.127***	0.164***	0.106***	0.131***
	{0.192}	{0.200}	{0.101}	{0.345}	{0.000}	{0.000}	{0.000}	{0.000}
GRE	0.002	-0.001	0.014	-0.020	0.108***	0.074*	0.247***	0.092***
	{0.807]	{0.905}	{0.459}	{0.188}	{0.000}	{0.066}	{0.000}	{0.000}
Panel B: Non-Eurozone								
DEN	-0.095***	-0.072***	-0.180***	-0.065**	0.230***	0.278***	0.221***	0.214***
	{0.000}	{0.000}	{0.000}	{0.017}	{0.000}	{0.000}	{0.000}	{0.000}
UK	0.078***	0.088***	0.069**	-0.014	-0.006	-0.035	-0.019	0.038
	{0.000}	{0.000}	{0.042}	{0.810}	{0.793}	{0.180}	{0.893}	{0.156}
SWE	0.016	0.013	0.079	-0.018	0.029	0.009	0.005	0.151***
	{0.160}	{0.471}	{0.977}	{0.348}	{0.222}	{0.780}	{0.999}	{0.000}
JAP	-0.048***	-0.032***	-0.083***	-0.052**	0.248***	0.153***	0.216***	0.342***
	{0.000}	{0.003}	{0.000}	{0.046}	{0.000}	{0.000}	{0.000}	{0.000}
US	-0.075***	-0.080***	-0.128***	0.004	0.426***	0.250***	0.480***	0.616***
	{0.000}	{0.000}	{0.001}	{0.883}	{0.000}	{0.000}	{0.000}	{0.000}

Table 3.5

Bivariate ARMA-EGARCH-*t* results for Stock Market Return Volatility Spillover

This table presents the estimated spillovers in negative and positive shocks from national (β_{N1}, β_{N2}) and regional (β_{E1}, β_{E2}) stock market returns. Asymptotic p-values are shown in the brackets. *, **, *** denote statistical significance at the 10, 5 and 1% level respectively. The conditional volatility equations, defined in equations (3.4)-(3.5), are

$$\ln h_{N,t} = \beta_{CN} + \beta_{hN} \ln h_{N,t-1} + \left[\beta\varepsilon_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta\varepsilon_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right],$$

$$\ln h_{E,t} = \beta_{CE} + \beta_{hE} \ln h_{E,t-1} + \left[\beta\varepsilon_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta\varepsilon_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right]$$

	From Country i								*From Eurozone*							
Coefficient	β_{N1}				β_{N2}				β_{E1}				β_{E2}			
	Total	Sub sample periods			Total	Sub sample periods			Total	Sub sample periods			Total	Sub sample periods		
	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03	1/89-5/03	1/89-12/95	1/96-12/98	1/99-5/03
Panel A: Eurozone																
GER	-0.009	-0.022	-0.020	-0.090**	0.039	0.043	0.062	0.067	-0.032***	-0.024	-0.064	0.041	0.055***	-0.011	0.187***	0.111***
	{0.533}	{0.377}	{0.599}	{0.013}	{0.105}	{0.214}	{0.236}	{0.238}	{0.003}	{0.116}	{0.134}	{0.374}	{0.005}	{0.703}	{0.000}	{0.005}
FRA	-0.028	-0.051***	-0.163***	-0.021	0.033**	0.047***	0.024	-0.053*	-0.018	-0.017	0.139***	0.002	0.050***	0.023	0.181***	-0.010
	{0.108}	{0.002}	{0.000}	{0.404}	{0.023}	{0.002}	{0.586}	{0.096}	{0.258}	{0.197}	{0.001}	{0.891}	{0.000}	{0.120}	{0.000}	{0.534}
ITA	-0.025***	-0.019	-0.012	-0.019	-0.016	0.015	-0.023	0.104***	-0.010	-0.020	-0.041	-0.064***	0.036	0.008	0.062	-0.045
	{0.001}	{0.312}	{0.461}	{0.210}	{0.156}	{0.627}	{0.543}	{0.000}	{0.487}	{0.212}	{0.198}	{0.000}	{0.108}	{0.716}	{0.171}	{0.277}
BEL	0.007	0.027	-0.017	-0.030	0.029***	-0.005	-0.065	0.107***	-0.032**	-0.052**	-0.041	-0.057*	0.104***	0.134***	0.188	0.004
	{0.504}	{0.187}	{0.977}	{0.193}	{0.000}	{0.783}	{0.972}	{0.000}	{0.012}	{0.042}	{0.897}	{0.070}	{0.000}	{0.000}	{0.363}	{0.932}
NET	-0.035***	-0.039	-0.114***	-0.091***	0.025*	-0.024*	0.176***	0.032**	-0.001	-0.010	-0.006	0.054*	0.071***	0.059***	0.066	0.022**
	{0.000}	{0.265}	{0.001}	{0.000}	{0.093}	{0.095}	{0.000}	{0.042}	{0.893}	{0.695}	{0.908}	{0.052}	{0.000}	{0.005}	{0.342}	{0.036}
IRE	0.010	0.009	0.004	-0.005	0.008**	0.029**	0.021	-0.016	-0.026**	-0.026	0.047**	-0.048*	0.085***	0.074***	0.411***	0.071**
	{0.380}	{0.672}	{0.881}	{0.720}	{0.031}	{0.035}	{0.333}	{0.365}	{0.017}	{0.295}	{0.043}	{0.053}	{0.000}	{0.001}	{0.000}	{0.026}
SPA	-0.046***	-0.038***	-0.105	-0.051**	0.050***	0.064***	0.108	-0.006	-0.006	-0.009	0.027	-0.020	0.069***	0.014	0.199	0.085**
	{0.005}	{0.004}	{0.155}	{0.047}	{0.000}	{0.002}	{0.389}	{0.913}	{0.672}	{0.658}	{0.314}	{0.430}	{0.000}	{0.400}	{0.106}	{0.030}
POR	0.015	0.016	-0.090*	-0.008	0.013	-0.020*	0.099**	0.043***	-0.040**	-0.057**	-0.014	0.001	0.054	0.119**	0.184***	-0.022
	{0.206}	{0.211}	{0.067}	{0.622}	{0.327}	{0.090}	{0.020}	{0.003}	{0.046}	{0.020}	{0.746}	{0.959}	{0.212}	{0.018}	{0.000}	{0.294}
AUS	0.018**	0.023**	0.072**	-0.017	-0.011	0.049***	0.029	-0.033	-0.022*	-0.056***	-0.115***	0.017	0.029	-0.015	0.237***	0.030
	{0.039}	{0.031}	{0.010}	{0.361}	{0.442}	{0.000}	{0.406}	{0.122}	{0.094}	{0.002}	{0.009}	{0.505}	{0.201}	{0.465}	{0.001}	{0.220}
FIN	0.010	0.022	0.032	0.058***	-0.001	0.030***	0.059	-0.064***	-0.020*	-0.011	-0.101***	-0.085**	0.009	0.009**	0.138**	0.003
	{0.289}	{0.171}	{0.375}	{0.002}	{0.932}	{0.005}	{0.242}	{0.006}	{0.086}	{0.554}	{0.002}	{0.023}	{0.616}	{0.023}	{0.027}	{0.936}
LUX	-0.003	-0.001	-0.025	0.033	0.026**	0.025***	0.051***	0.035	-0.026**	0.015	-0.125***	-0.070**	0.101***	0.111***	0.172***	0.009
	{0.653}	{0.944}	{0.186}	{0.179}	{0.019}	{0.000}	{0.000}	{0.265}	{0.027}	{0.475}	{0.009}	{0.027}	{0.000}	{0.000]	{0.007}	{0.612}
GRE	0.012**	0.026***	-0.015	-0.028	0.015***	-0.004	0.034	0.047***	-0.008	-0.014	0.047	-0.033	0.027***	0.027***	0.198**	-0.017
	{0.025}	{0.003}	{0.588}	{0.122}	{0.000}	{0.161}	{0.339}	{0.000}	{0.294}	{0.331}	{0.215}	{0.269}	{0.000}	{0.000}	{0.019}	{0.258}

Panel B: Non-Eurozone																
DEN	0.016	0.012	0.051**	-0.027*	0.045***	-0.017***	0.133***	0.055***	-0.028	0.041	-0.100***	-0.087**	0.041*	0.092***	0.216***	0.060*
	{0.217}	{0.325}	{0.027}	{0.090}	{0.000}	{0.000}	{0.000}	{0.007}	{0.107}	{0.303}	{0.000}	{0.019}	{0.057}	{0.001}	{0.001}	{0.081}
UK	-0.053***	-0.047**	-0.094**	-0.142***	0.040***	0.083**	0.030	-0.020	-0.015	-0.024	-0.001	0.054***	0.034***	-0.015	0.132	0.029***
	{0.009}	{0.046}	{0.028}	{0.000}	{0.004}	{0.025}	{0.477}	{0.328}	{0.371}	{0.376}	{0.938}	{0.000}	{0.001}	{0.590}	{0.192}	{0.000}
SWE	-0.011	-0.018	-0.030	0.010	0.030***	0.040	0.120	0.038	-0.025*	-0.016	-0.062	-0.017	0.029***	0.029	0.149	0.022
	{0.426}	{0.426}	{0.978}	{0.392}	{0.000}	{0.127}	{0.833}	{0.152}	{0.057}	{0.382}	{0.179}	{0.533}	{0.003}	{0.331}	{0.974}	{0.370}
JAP	-0.033***	-0.030***	-0.065***	-0.016	0.029***	0.045***	0.067*	0.003	-0.019*	-0.020	0.001	-0.028	0.053***	0.006	0.102**	0.122***
	{0.000}	{0.009}	{0.003}	{0.331}	{0.000}	{0.000}	{0.099}	{0.616}	{0.078}	{0.270}	{0.955}	{0.287}	{0.000}	{0.620}	{0.014}	{0.000}
US	-0.008	-0.011	-0.040***	-0.016	-0.030***	-0.066***	0.068***	-0.036***	-0.030	-0.008	-0.038	-0.085**	0.087***	0.052	0.147**	0.092***
	{0.385}	{0.191}	{0.002}	{0.394}	{0.000}	{0.000}	{0.000}	{0.000}	{0.108}	{0.593}	{0.638}	{0.020}	{0.000}	{0.101}	{0.020}	{0.000}

Figure 3.4: Size of Regional Feedback Effect

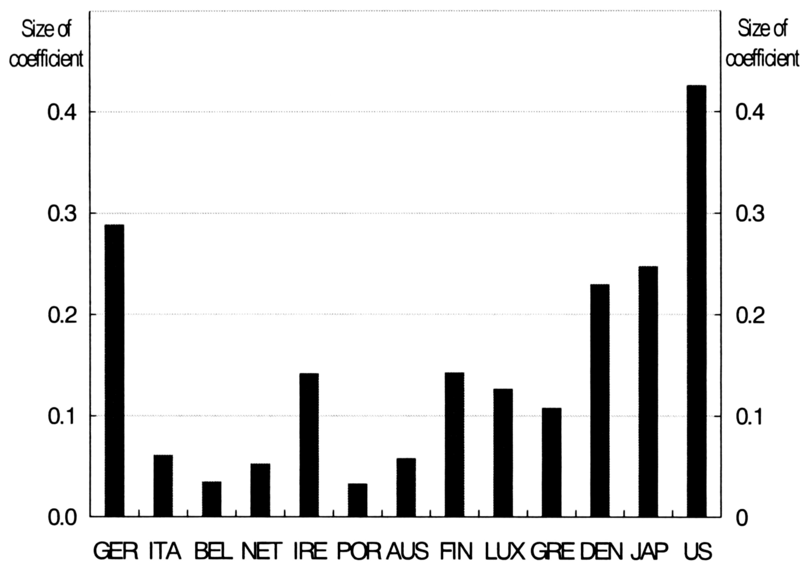
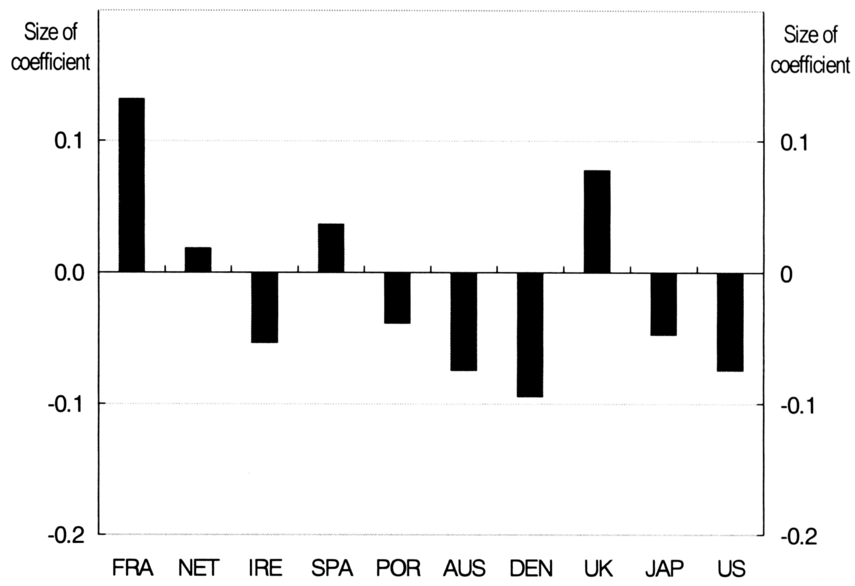


Figure 3.5: Size of Country Feedback Effect



In short, linkages between stock markets inside and outside of the Euro region are clearly present and have strengthened in the wake of currency unification. The significant spillover coefficients indicate the EMU members are crucial both to each other's prosperity and to the stability of the world economy as a whole. It can be inferred from these results that the benefits of portfolio diversification across international stock markets have decreased in recent times. This is not only consistent with the findings of increased correlations in cross-country stock returns documented by Longin and Solnik (1995) but more importantly the findings by Freimann (1998) and Kempa and Nelles (2001) on reduced diversification benefits in European stock markets with the introduction of the Euro. Given so, what are the specific determinants of stock market integration? Are there particular factors related to the EMU that are driving stock markets to be more integrated? If so, a better understanding of these factors would not only assist portfolio risk and investment managers but also guide policy makers in the direction of more efficient financial markets.

3.3 The Determinants of Stock Market integration

This section builds on the work already presented in this chapter and utilises a two-step estimation methodology to find the main determinants of stock market integration within the Euro region and with the US and Japan. First, the arguments for potential determinants selected and tabulated in Table 3.6 are presented. Following that, tests for causality between stock market integration and European currency unification are conducted to facilitate an appropriate modelling strategy. Finally, the empirical methodology and results will be discussed in detail.

Table 3.6 Explanatory Variable Definitions and Data Sources

Category	Variable	Frequency	Source	Definition
Exchange Rate Risk	EX_VOL	Daily	Datastream	Conditional variance from a GARCH(1,1) model for daily local currency to ECU or Euro exchange returns for each EMU member.
	EX_SD*	Daily	Datastream	Rolling standard deviations of daily changes in the foreign exchange rate over the past 3 months (quarter).
Real Convergence	OUTPUT	Monthly	IMF/ Eurostat	Correlations in national and regional growth rates of seasonally adjusted industrial production (IP) – weighted by annual GDP for the Euro area over the past 12 months.
	DIVRATIO*	Daily	Datastream	Ratio of national dividend yield to that for the Euro area weighted by stock market capitalization.
	DIV_CHANGE_ RATIO*	Daily	Datastream	Ratio of changes in national dividend yields to that for Euro area weighted by stock market capitalization.
	COR_DIV_ CHANGE*	Daily	Datastream	Rolling correlations for changes in national and Euro area dividend yields (weighted by stock market capitalization) over the past 3 months (quarter).
Monetary Policy Convergence	IRATE	Daily	Datastream and IMF	Rolling correlations for national nominal short-term interest rates (1 month Eurocurrency rates) and the Euro area weighted by annual GDP over the past 3 months (quarter).
	INFLA	Monthly	Datastream and IMF	Correlations in seasonally-adjusted consumer price inflation with the Euro-area inflation index weighted by annual GDP over the past 12 months.
	SHORT_RATE_ RATIO*	Daily	Datastream and IMF	Ratio of national nominal short-term interest rates (1 month Eurocurrency rates) to that for the Euro area weighted by annual GDP.
Control	Log(VOL)	Daily	Datastream	Logarithm of turnover by volume of trade for each national stock market.
	FIN_DEPTH	Daily	Datastream and IMF	Ratio of stock market capitalization to annual GDP in Euros.
	FRI_DUM	Daily		Indicator is equal to one if that trading day was a Friday, zero otherwise.
	MON_DUM*	Daily		Indicator is equal to one if that trading day was a Monday, zero otherwise.
	JAN_DUM	Daily		Indicator is equal to one if that trading day was in January, zero otherwise.
	EURO_DUM	Daily		Indicator takes a value of one if the Euro has already been introduced on the date ie. from 1st January 1999 onwards. (NOTE: An alternative dummy taking a value of one from 1st January 2001 was also tested for Greece due to its delayed entry into the EMU)

*Note: * These alternative proxies are NOT included in the final specification of the regression models reported in this chapter. They were employed in preliminary model specifications.*

3.3.1 Potential explanatory variables for stock market integration

To substantiate the link between stock market integration and the EMU, first the explanatory power of a Euro dummy for determining the previously estimated conditional correlation time-series (INT_t) is tested. A Euro dummy (taking the value of one from 1 January 1999 and zero otherwise) is the broadest proxy for the formal introduction of the Euro and can be used as a first assessment in regression analyses.

As discussed in Chapter 2, it has been recognised in the literature that what drives time-variations in financial market integration may not only be a country's own economic performance, but also the degree of real and financial convergence with other economies (see for example, Ragunathan et al., 1999, Dickinson, 2000, Fratzscher, 2002 and Phylaktis and Ravazzolo, 2002). The Optimal Currency Area (OCA) literature pioneered by Mundell (1961) and McKinnon (1963) offers several assessment criteria for the suitability of countries for a common currency area. There are three main channels identified in the literature through which a currency union can directly affect financial market integration and this chapter builds on common proxies for these and introduces other variables (as shown in Table 3.6) and uses a linear systems regression approach to determine and differentiate the driving forces behind the regional and global integration of stock markets with the EMU.

Firstly, given that currency risk premia have been priced in most international asset pricing models since the seminal work of Solnik (1974)[14], it has been recognised that currency risk premia can be interpreted as a major impediment to financial market

[14] See Dumas and Solnik (1995) and De Santis and Gerard (1998) for more recent developments.

integration and that the launch of a common currency directly eliminates most intra-union currency risk.[15] Although, the elimination of intra-union exchange rates with the introduction of the Euro has been shown by Morana and Beltratti (2002) in a theoretical variance decomposition of shocks to excess returns to cancel out components of exchange rate risks borne by a domestic investor holding foreign stock under a different currency, they argue that because the covariance between exchange rates and stock returns is empirically small, elimination of intra-union currency risk has not affected European stock markets. However, Fratzscher (2002) and Baele (2004) provide empirical evidence that exchange rate stabilization does significantly explain stock market integration in Europe. This chapter seeks to resolve the disparity on exchange rate risk as this is a vital issue relating to the role of currency unions in stock market integration. Theoretically, interdependent movements (estimated conditional correlations) between the individual national stock market returns should increase as foreign exchange volatility has reduced (inverse relationship).

Secondly, as EMU members knew in advance that they were required to meet various economic convergence criteria for EMU entry from the 1992-1993 Maastrict (EU) Treaty (as discussed in section 1.3), a significant degree of convergence has occurred in their real economies. It has long been found that business cycle conditions are intricately linked with stock returns (for example, see Fama and French, 1989, Rouwenhorst, 1995 and Kearney, 1998) and international equity correlations (see Erb, Harvey and Viskanta, 1994). If countries are in similar phases of the business cycle, the degree to which shocks are transmitted across financial markets will be increased. Thus, one expects *a priori,* increases in real convergence (via growth rates in industrial

[15] A single currency zone is equivalent to a system of irrevocably fixed exchange rates.

production) will stimulate higher stock market integration. The use of contemporaneous movements in output growth between economies is a well-accepted proxy for real economic integration based on the logical transmission of economic activity through trade in business cycle theory. This consequently leads to convergence in expected cash flows of firms and their stock prices.

Finally, the EMU integration process has also been characterized by monetary policy convergence in that independent monetary policies have been replaced by a single one set by the European Central Bank (ECB) for all EMU members. For this reason, Morana and Beltratti (2002) also showed in their variance decomposition that the variance of interest rates have reduced through the convergence of monetary policies and attributed the decline in volatility of European stock markets mainly to the stabilization of fundamentals and expectations thereof. Hence, one anticipates *a priori* that monetary policy convergence (via short term interest rates or inflation rates) has also increased stock market integration.

In addition to these, control variables used in standard asset pricing studies are introduced to ascertain the true importance of these currency union variables. The control variables include country-specific aggregate stock market liquidity and development measures and other seasonal anomalies that might change stock market returns and hence, comovements. Domestic financial market development is included because more developed financial markets are likely to share more common information than less developed ones. Financial market development is commonly measured by stock market capitalization as a proportion of Gross Domestic Product

(GDP)[16] and stock market liquidity as proxied by the logarithm of turnover by volume. In addition, a day of the week effect is tested, using a Friday dummy and the turn of the year effect is tested using a January dummy.[17] Before these variables can be empirically tested, the existence and nature of a causal relationship between the introduction of the EMU and observed stock market integration ought to be investigated.

3.3.2 Direction of Causality: Stock Market Integration and Currency Union

Although this chapter has documented stock market integration in the period characterized by the introduction of the Euro and beyond, this does not explicitly provide evidence of a causal relationship. To one's best knowledge, the causality issue between financial market integration and currency unification has not been previously addressed in the international finance literature. Indeed, questions remain about causality: do currency unions drive financial market integration in that a political decision to form a currency union could anchor exchange rate expectations and create incentives to establish integrated capital markets or does financial market integration create more incentives for joining a currency union, or both? Although logic supports the former, economic theory purports that financial market integration promotes risk sharing benefits through asset markets and this may create economic incentives for countries to join a currency union and give up control of their monetary policy. Optimal currency area (OCA) theory clearly suggests that as integration proceeds, monetary unions will become more desirable as the costs for foregoing an independent monetary

[16] Bekaert and Harvey (1995) and Ng (2000) among others, found that countries with a higher ratio are on average better integrated with world financial markets.

[17] A Monday dummy was also initially included but had no explanatory power for any sample country.

policy are higher for countries that are prone to asymmetric shocks. Given that each member state has unique challenges based upon its own degree of diversification in production (industry mix), economic, cultural, political and social institutions, causality from financial market integration to currency unification is also a reasonable assumption. Alternatively, there may not be causality either way but instead, independence. According to Krugman (1993), currency unions can exacerbate asymmetric shocks by inducing regional specialization of production based on comparative advantage considerations. In this way, a currency union may lead to greater segmentation rather than integration. It is clear that there is a need for deeper understanding of stock market integration in currency unions.

To address this issue, the Granger (1969) Causality test is conducted in the following two regressions using the previously estimated time-varying conditional correlations ($\hat{INT}_t$) and a Euro dummy (EMU_t) which takes a value of one from January 1 1999 and zero otherwise[18]:

$$\hat{INT}_t = \sum_{i=1}^{p} \alpha_i EMU_{t-i} + \sum_{i=1}^{p} \beta_i \hat{INT}_{t-i} + u_{1t} \qquad (3.9)$$

$$EMU_t = \sum_{i=1}^{p} \gamma_i \hat{INT}_{t-i} + \sum_{i=1}^{p} \delta_i EMU_{t-i} + u_{2t} \qquad (3.10)$$

[18] For robustness sake, proxying the implementation of the EMU with correlations in short term interest rates provided qualitatively similar results. The Euro time dummy insulates the causality test from effects on stock market integration prior to the formal introduction of the EMU. However, the drawback is that the causality tests have limited statistical value as they have little power with the dummy variable violating the Gaussian assumption.

Based on the premise that the future cannot cause the present or the past, the coefficients of (lagged) EMU_{t-i} are all tested for significant difference from zero in equation (3.9), ie. H_0: $\sum_{i=1}^{p} \alpha_i = 0$. Similarly, the coefficients of $\hat{INT}_{t-i}$ are tested for significant difference from zero in equation (3.10), ie. H_0: $\sum_{i=1}^{p} \gamma_i = 0$. Results from these cross-country tests are shown in Table 3.7 for p=8 lags but tests for p={2,4,6} lags yielded qualitatively similar conclusions. The first null hypothesis (that the introduction of the EMU has not caused financial integration) was rejected for all Euro and non-Euro countries at the 10% significance level but not for France, Spain, Austria, nor Finland at the 5% level. However, the second null hypothesis (that financial integration has not caused the EMU) could not be rejected for all meaningful significance levels indicating that financial market integration has not preceded formal currency unification in Europe.

This simple analysis provides a better understanding of the sequential path to financial market integration on both a regional and global scale. There is consistent evidence across the sample of Euro zone countries used to suggest that the currency regime is a pre-requisite for financial market integration as the EMU has Granger caused their stock market integration with the EMU region. Furthermore, the EMU has also Granger caused financial integration of the EMU vis-à-vis Japan and the US. These results are not only illuminating but also helpful for finding a suitable model specification to determine the true extent to which the EMU is driving the time-varying integration process in these stock markets. The following section will account for this one-way direction of causality in further regression analyses.

Table 3.7

Granger Causality Test Results for Stock Market Integration

In panel A of this table, results of the Granger Causality tests are reported for all countries in the Euro zone and the results for Japan and the US are reported separately in panel B. The tests involve estimations of equations (3.9)-(3.10), defined as:

$$\hat{INT}_t = \sum_{i=1}^{p} \alpha_i EMU_{t-i} + \sum_{i=1}^{p} \beta_i \hat{INT}_{t-i} + u_{1t} \quad \text{and} \quad EMU_t = \sum_{i=1}^{p} \gamma_i \hat{INT}_{t-i} + \sum_{i=1}^{p} \delta_i EMU_{t-i} + u_{2t} \quad \text{where}$$

$\hat{INT}_t$ are the estimated conditional correlation time-series and EMU_t is the Euro dummy taking a value of one from January 1st 1999. The null hypotheses tested were EMU→INT, H_0: $\sum_{i=1}^{p} \alpha_i = 0$ and INT→ EMU, H_0: $\sum_{i=1}^{p} \gamma_i = 0$. Asymptotic p-values are shown in the brackets. *, **, *** denote statistical significance at the 10, 5 and 1% level respectively. The F-values are for tests using 8 lags, F(8,3722).

	Direction of Causality				Conclusion
	EMU→INT		INT→ EMU		
	F value	{p value}	F value	{p value}	
Panel A: Eurozone					
GER	3.0336***	{0.0021}	0.7606	{0.6378}	EMU Granger-causes INT
FRA	1.8937*	{0.0566}	0.4390	{0.8981}	EMU Granger-causes INT
ITA	2.2789**	{0.0197}	0.3288	{0.9553}	EMU Granger-causes INT
BEL	5.0898***	{0.0000}	0.6032	{0.7759}	EMU Granger-causes INT
NET	3.1323***	{0.0016}	0.6548	{0.7318}	EMU Granger-causes INT
IRE	3.1135***	{0.0017}	0.5064	{0.8524}	EMU Granger-causes INT
SPA	1.7456*	{0.0831}	0.3648	{0.9393}	EMU Granger-causes INT
POR	4.5383***	{0.0000}	1.0468	{0.3980}	EMU Granger-causes INT
AUS	1.9333*	{0.0718}	0.4702	{0.8779}	EMU Granger-causes INT
FIN	2.0010*	{0.0621}	0.3026	{0.9653}	EMU Granger-causes INT
LUX	3.4301***	{0.0006}	0.2946	{0.9680}	EMU Granger-causes INT
GRE	3.0103***	{0.0023}	0.2373	{0.9839}	EMU Granger-causes INT
Panel B: Non-Eurozone					
JAP	3.0024***	{0.0023}	0.2600	{0.9784}	EMU Granger-causes INT
US	3.1116***	{0.0017}	0.3738	{0.9349}	EMU Granger-causes INT

Note: Only the causality test results for 8 lags, F(8,3722) are reported above due to space considerations. However, tests for 2, 4, and 6 lags yielded identical conclusions of unidirectional causality.

3.3.3 Methodology to determine Stock Market Integration

Given the upward trend in most stock market integration (conditional correlation) time- series estimated from the bivariate EGARCH model, tests for non-stationarity were first conducted to determine the appropriate model for this dependent series. The results from unit root tests (Augmented Dickey Fuller (ADF) tests with a constant, trend and using 4 lags) are shown in the bottom of panel A, Table 3.8. The null hypothesis of the presence of a unit root in each of the dependent time-series for the 12 EMU countries and for Japan and the US are rejected at the conventional 5% significance level. However, Ljung-Box Q test statistics reveal these dependent series to be highly autocorrelated, necessitating the inclusion of lags of these series in the econometric models in addition to Newey-West (1987) corrections for heteroskedasticity and serial correlations.[19]

Ordinary least squares (OLS) and seemingly unrelated regression[20] estimations (SURE) in the vein of Zellner (1962) are sequentially applied to determine the drivers of the stock market integration process in the Euro zone countries and the US and Japan and the results are shown in Tables 3.8 and 3.9. The assumption under SURE is that the error terms in a system of equations at any point in time are contemporaneously

[19] Serial correlations of residuals in a regression model with lagged dependent variables can potentially bias the estimators.

[20] The SUR is given by $Y_i = X_i B_i + U_i,\ i = 1,2...k$ where Y_i is the endogenous vector, X_i is the exogenous matrix with full column rank, B_i are the coefficients and U_i is the disturbance vector having zero mean. The covariance matrix of u_i and u_j is given by $\sigma_{ij}I_m$ (i,j = 1,..k and I_m is the identity matrix).

correlated because they are capturing similar effects.[21] This is reasonable for the group of EMU countries and for Japan and the US given that their error terms contain the influences of omitted factors on their respective integration process with the EMU. These may include regulatory barriers, political, institutional, social and cultural factors. Since the Euro zone members are similar in nature due to economic convergence required by the Maastrict Convergence Criteria (discussed in section 1.3), it is conceivable that the effects of the omitted variables on each country's integration will be similar. Hence, additional information normally excluded from separate least squares estimation of equations (3.11 and 3.12) are captured by this assumption. Contemporaneous correlations between error terms have been utilised to produce better estimates by jointly estimating these equations within a generalised least squares (GLS) framework. It can be seen in Tables 3.10 and 3.11 that the correlations between residuals in each equation are fairly high, suggesting that SURE is a more suitable methodology for the evaluation of stock market integration influenced by a currency union than OLS. An average of 0.61 in Table 3.10 and 0.64 in Table 3.11 provides justification for the advantageous and innovative use of SURE in this empirical investigation.

[21] The SUR framework has been previously used in international finance research by Choi et al. (1992) to investigate the currency exposure of US banks.

Table 3.8

Preliminary Regression results with Euro dummy alone

In panel A of this table, the OLS results and Augmented Dickey Fuller (ADF) Statistics are reported for each country. The OLS estimates are corrected for autocorrelation and heteroskedasticity in accordance with Newey-West (1987). In panel B, the seemingly unrelated regression estimates (SURE) are shown. The model estimated by both methods, as defined in equation (3.11) is

$$\hat{INT}_{i,t} = \alpha_{1i} + \alpha_{2i} FIN\_DEPTH_{i,t-1} + \alpha_{3i} Log(VOL)_{i,t-1} + \alpha_{4i} FRI\_DUM_{i,t} + \alpha_{5i} JAN\_DUM_{i,t} + \alpha_{6i} EMU_{i,t} + \alpha_{7i}\hat{INT}_{i,t-1} + \alpha_{8i}\hat{INT}_{i,t-2} + u_{it}$$

where the dependent variable ($\hat{INT}_{i,t}$) is the estimated conditional correlation series for each country *i*, *FIN_DEPTH* = stock market capitalization divided by GDP, *LOG(VOL)* = logarithm of the stock market's turnover by volume, *FRI_DUM* and *JAN_DUM* are the seasonal dummies, EMU is the Euro dummy variable which takes a value of one from 1st January 1999 and $\hat{INT}_{i,t-1}$ and $\hat{INT}_{i,t-2}$ are the first and second lags of the dependent variable.

	Eurozone												*Non-Eurozone*	
	GER	FRA	ITA	BEL	NET	IRE	SPA	POR	AUS	FIN	LUX	GRE	JAP	US
Panel A: Single Equation Least Squares														
FIN_DEPTH_{t-1}	-0.0004	-0.0003	-0.0728	0.0051	-0.0010	-0.0026*	-0.0053**	0.0088**	-0.0211**	-0.0001	0.0024*	-0.0044***	-0.0001**	-0.0002
	{0.9040}	{0.8617}	{0.4242}	{0.2686}	{0.4087}	{0.0956}	{0.0401}	{0.0126}	{0.0196}	{0.8209}	{0.0877}	{0.0009}	{0.0462}	{0.2746}
$Log(VOL)_{t-1}$	0.0005**	0.0007***	0.0014***	0.0007	0.0018**	0.0006	0.0033***	0.0004	0.0015***	0.0010***	0.0025***	0.0020***	0.0000	0.0003***
	{0.0470}	{0.0065}	{0.0000}	{0.3353}	{0.0282}	{0.3503}	{0.0000}	{0.2440}	{0.0000}	{0.0000}	{0.0001}	{0.0000}	{0.9023}	{0.0044}
FRI_DUM	-0.0009	-0.0012*	-0.0020*	-0.0005	-0.0010	0.0002	-0.0015*	0.0005	-0.0004	-0.0016**	0.0021	-0.0019***	-0.0004**	-0.0002***
	{0.2597}	{0.0702}	{0.0514}	{0.6797}	{0.1545}	{0.7916}	{0.0593}	{0.6946}	{0.2139}	{0.0366}	{0.2058}	{0.0064}	{0.0212}	{0.0032}
JAN_DUM	0.0019*	0.0016	0.0031*	0.0031*	0.0020*	-0.0017*	0.0002	0.0062***	0.0009	0.0032***	0.0010	0.0036***	0.0007**	0.0002*
	{0.0722}	{0.1047}	{0.0899}	{0.0893}	{0.0537}	{0.0686}	{0.8180}	{0.0023}	{0.1151}	{0.0096}	{0.7063}	{0.0028}	{0.0466}	{0.0949}
EMU	0.0023*	0.0008	0.0009	0.0010	0.0003		-0.0009	0.0006	0.0005	-0.0004		0.0005	0.0010***	-0.0000
	{0.0780}	{0.4541}	{0.4698}	{0.6168}	{0.7344}		{0.4394}	{0.7060}	{0.2731}	{0.7005}		{0.5430}	{0.0000}	{ 0.9683}
$\hat{INT}_{t-1}$	1.0611***	1.2365***	1.2197***	0.8823***	1.1641***	0.6800***	1.2094***	1.1749***	1.2260***	1.1972***	0.7474***	1.1287***	0.9772***	0.9882***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\hat{INT}_{t-2}$	-0.0778**	-0.2556***	-0.2393***	0.0822***	-0.1878***	0.2461***	-0.2324***	-0.2083***	-0.2481***	-0.2131***	0.0898***	-0.1808***	-0.0100	-0.0207
	{0.0372}	{0.0000}	{0.0000}	{0.0077}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0031}	{0.0000}	{0.6320}	{0.3219}
INTERCEPT	0.0065*	0.0083**	0.0012	0.0148***	0.0002	0.0361***	-0.0144***	0.0084***	0.0040*	0.0017	0.0269***	-0.0011	0.0090***	0.0085***
	{0.0626}	{0.0163}	{0.8875}	{0.0006}	{0.9688}	{0.0016}	{0.0035}	{0.0035}	{0.0594}	{0.4328}	{0.0000}	{0.5756}	{0.0000}	{0.0003}
ADF Test Statistic	-6.4544	-6.9565	-6.9374	-7.9003	-7.1984	-6.6799	-6.8782	-7.5864	-7.3039	-7.1329	-10.8913	-8.4380	-6.4544	-6.9565
Adj. R^2	0.9796	0.9826	0.9821	0.9512	0.9783	0.8736	0.9781	0.9756	0.9778	0.9892	0.7165	0.9569	0.9527	0.9626
Observations	3612	3600	3614	3578	3635	668	3345	3220	3516	3590	1086	3559	3362	3621

Panel B: SURE

FIN_DEPTH_{t-1}	0.0056***	0.0029***	0.0429	0.0056	0.0009	-0.0048***	0.0034	0.0102***	-0.0091*	0.0012***	0.0003	-0.0021	-0.0001**	-0.0001
	{0.0094}	{0.0049}	{0.4009}	{0.1108}	{0.1201}	{0.0000}	{0.1272}	{0.0004}	{0.0988}	{0.0030}	{0.8839}	{0.2100}	{0.0371}	{0.5091}
$Log(VOL)_{t-1}$	-0.0001	0.0005***	0.0019***	-0.0010**	0.0016***	0.0003*	0.0017***	0.0006***	0.0010***	0.0011***	0.0000	0.0022***	0.0005***	0.0002***
	{0.1980}	{0.0003}	{0.0000}	{0.0288}	{0.0000}	{0.0894}	{0.0000}	{0.0086}	{0.0000}	{0.0000}	{0.9727}	{0.0000}	{0.0000}	{0.0007}
FRI_DUM	-0.0006	-0.0002	-0.0011	-0.0014	-0.0008	0.0002	-0.0008	0.0006	-0.0003	-0.0009	0.0004	-0.0022***	-0.0003	-0.0001
	{0.4890}	{0.7996}	{0.4018}	{0.3056}	{0.3244}	{0.7987}	{0.4475}	{0.6810}	{0.4338}	{0.2929}	{0.8758}	{0.0043}	{0.1554}	{0.1663}
JAN_DUM	0.0010	0.0013	0.0020	0.0004	0.0015	-0.0027***	0.0014	0.0057***	0.0006	0.0020	-0.0038	0.0040***	0.0007*	0.0001
	{0.4675}	{0.2844}	{0.2601}	{0.8494}	{0.1981}	{0.0087}	{0.3292}	{0.0081}	{0.2472}	{0.1200}	{0.2070}	{0.0002}	{0.0519}	{0.6521}
EMU	0.0037***	0.0026***	0.0022*	0.0064***	0.0023***		0.0015	0.0037**	0.0015***	0.0011		0.0003	0.0009***	0.0001
	{0.0005}	{0.0099}	{0.0806}	{0.0004}	{0.0098}		{0.2132}	{0.0285}	{0.0002}	{0.3231}		{0.8236}	{0.0020}	{0.1677}
$\hat{INT}_{t-1}$	1.0791***	1.0981***	1.1389***	1.0519***	1.0860***	0.7135***	1.1336***	1.1392***	1.1450***	1.1059***	0.6664***	1.0988***	0.9444***	0.9514***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\hat{INT}_{t-2}$	-0.1244***	-0.1431***	-0.1792***	-0.1129***	-0.1391***	0.1351***	-0.1792***	-0.1914***	-0.1907***	-0.1427***	0.0777**	-0.1617***	0.0184	0.0101
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0230}	{0.0000}	{0.2293}	{0.5171}
INTERCEPT	0.0316***	0.0276***	-0.0001	0.0405***	0.0230***	0.0818***	0.0137***	0.0134***	0.0171***	0.0107***	0.0629***	-0.0006	0.0046***	0.0112***
	{0.0000}	{0.0000}	{0.9795}	{0.0000}	{0.0000}	{0.0000}	{0.0003}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.7194}	{0.0069}	{0.0000}
Adj. R^2	0.9732	0.9760	0.9754	0.9242	0.9747	0.8665	0.9761	0.9747	0.9734	0.9837	0.5315	0.9576	0.9547	0.9642
Observations	2783	2783	2783	2783	2783	617	2783	2783	2783	2783	617	2783	2747	2747

Notes: P-Values are shown in brackets.,**,*** denote significance at the 10%, 5% and 1% respectively. Due to data limitations, the sample periods available for Ireland and Luxembourg are post-1999 meaning that there is no variation in the EMU dummy time-series. For this reason, the OLS and SURE regressions for these two countries have omitted the EMU dummy as an explanatory variable. The SUR estimates shown for Ireland and Luxembourg are from a 12 equation SURE estimated using fewer observations and no EMU dummy whilst those for the other Euro zone countries are estimated using 10 equations with an EMU dummy. A two equation SURE was estimated separately for Japan and US and the correlation between the two residuals was 0.7112. Critical Value for the Augmented Dickey Fuller (ADF) Test for a unit root at the 5% significance level is -3.4100. The appropriate ADF test included a constant, trend and 4 lags. As a robustness check, an alternative Euro dummy used for Greece took a value of one for dates after 1 January, 2001 (Greece's formal entry into the EMU).*

Table 3.9

Regression results with other currency union explanatory variables

In panel A of this table, the OLS results are reported for each country. The OLS estimates are corrected for autocorrelation and heteroskedasticity in accordance with Newey-West (1987). In panel B, the seemingly unrelated regression (SUR) estimates are shown. The model estimated by both methods, as defined in equation (3.12) is

$$\hat{INT}_{i,t} = \beta_{1i} + \beta_{2i}EX\_VOL_{i,t-1} + \beta_{3i}OUTPUT_{i,t-1} + \beta_{4i}IRATE_{i,t-1} + \beta_{5i}FIN\_DEPTH_{i,t-1} + \beta_{6i}Log(VOL)_{i,t-1} + \beta_{7i}FRI\_DUM_{i,t} + \beta_{8i}JAN\_DUM_{i,t} + \beta_{9i}\hat{INT}_{i,t-1} + \beta_{10i}\hat{INT}_{i,t-2} + u_{it}$$

where the dependent variable ($\hat{INT}_{i,t}$)is the estimated conditional correlation series for each country *i*, *EX_VOL* = exchange rate volatility, *OUTPUT* = correlations in the growth of industrial production rates with Euro area weighted averages, *IRATE* = correlations in nominal short term (30 day) interest rates with Euro area weighted averages, *FIN_DEPTH* = stock market capitalization/ GDP, *LOG(VOL)* = logarithm of the stock market's turnover by volume, *FRI_DUM* and *JAN_DUM* are the seasonal dummies introduced before and $\hat{INT}_{i,t-1}$ and $\hat{INT}_{i,t-2}$ are the first and second lags of the dependent variable. For Japan and the US, the results from an alternative specification with $INFLA_{t-1}$ in place of $IRATE_{t-1}$ are also reported.

	Euro zone													Non-Euro zone		
	GER	FRA	ITA	BEL	NET	IRE	SPA	POR	AUS	FIN	LUX	GRE	JAP	US	JAP	US
Panel A: Single Equation Least Squares																
EX_VOL_{t-1}	0.0022*	0.0015	-0.0516***	0.0254***	0.0002	0.0036***	0.0012	-0.0001**	0.0003	0.0009	0.0101***	0.0019**	0.0003**	-0.0002	0.0001	-0.0001
	{0.0677}	{0.1189}	{0.0000}	{0.0008}	{0.8440}	{0.0023}	{0.3245}	{0.0150}	{0.4819}	{0.3955}	{0.0001}	{0.0152}	{0.0414}	{0.2263}	{0.5194}	{0.5751}
$OUTPUT_{t-1}$	0.0017	0.0000	0.0006	0.0034**	-0.0006	0.0003	-0.0024	0.0039	0.0001	-0.0025	-0.0009	0.0000	0.0002	0.0000	0.0001	0.0000
	{0.3561}	{0.9904}	{0.6958}	{0.0272}	{0.5508}	{0.9270}	{0.2441}	{0.2559}	{0.8701}	{0.1358}	{0.6748}	{0.9917}	{0.3988}	{0.9827}	{0.7905}	{0.7383}
$IRATE_{t-1}$	-0.0004	-0.0022*	-0.0013	-0.0013	-0.0001	-0.0001	0.0004	-0.0010	0.0004	0.0004	-0.0008	-0.0001	-0.0003	0.0000		
	{0.7965}	{0.0634}	{0.5525}	{0.5845}	{0.8987}	{0.9661}	{0.7880}	{0.6019}	{0.4976}	{0.7205}	{0.8499}	{0.8969}	{0.1457}	{0.8702}		
$INFLA_{t-1}$															0.0000	0.0002**
															{0.9070}	{0.0488}
FIN_DEPTH_{t-1}	0.0057*	-0.0001	-0.0009	-0.0027	-0.0011	-0.0078***	-0.0036	0.0008	-0.0035	-0.0005	-0.0009	-0.0081***	0.0000	-0.0001	0.0000	-0.0001
	{0.0730}	{0.9738}	{0.5244}	{0.2836}	{0.3587}	{0.0009}	{0.2762}	{0.9017}	{0.7168}	{0.3444}	{0.6150}	{0.0000}	{0.7604}	{0.3988}	{0.9251}	{0.5363}
$Log(VOL)_{t-1}$	0.0001	0.0031***	-0.0097	0.0184***	0.0036***	0.0007	0.0045***	0.0042***	0.0015***	0.0025***	0.0027***	0.0060***	0.0006***	0.0005***	0.0007***	0.0003***
	{0.8623}	{0.0000}	{0.9331}	{0.0044}	{0.0000}	{0.2998}	{0.0000}	{0.0017}	{0.0001}	{0.0000}	{0.0006}	{0.0000}	{0.0019}	{0.0000}	{0.0000}	{0.0056}
FRI_DUM	-0.0006	-0.0002	0.0055***	0.0013	-0.0010	0.0004	-0.0009	0.0004	-0.0005	0.0000	0.0029*	-0.0009	0.0001	0.0000	-0.0004**	-0.0002**
	{0.5275}	{0.7960}	{0.0000}	{0.2535}	{0.2454}	{0.6214}	{0.3709}	{0.8228}	{0.2892}	{0.9628}	{0.0972}	{0.3126}	{0.5481}	{0.7640}	{0.0417}	{0.0274}
JAN_DUM	0.0017	0.0014	-0.0008	-0.0029*	0.0016	-0.0032***	0.0005	0.0053**	0.0008	0.0021	0.0003	0.0040***	0.0010**	0.0001	0.0007*	0.0000
	{0.2613}	{0.2942}	{0.4804}	{0.0859}	{0.2373}	{0.0082}	{0.7428}	{0.0279}	{0.2654}	{0.1035}	{0.9097}	{0.0063}	{0.0364}	{0.5242}	{0.0650}	{0.7160}
$\hat{INT}_{t-1}$	0.8499***	1.1636***	0.0012	0.0016	1.0443***	0.6692***	1.1788***	1.0858***	1.1169***	1.2003***	0.7474***	1.0378***	0.9793***	0.9815***	0.9730***	0.9568***
	{0.0000}	{0.0000}	{0.5710}	{0.5714}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\hat{INT}_{t-2}$	0.1307***	-0.1922***	1.2649***	0.7511***	-0.0753**	0.2350***	-0.2075***	-0.1257***	-0.1464***	-0.2287***	0.0731**	-0.1154***	-0.0066	-0.0316	-0.0043	-0.0064
	{0.0002}	{0.0000}	{0.0000}	{0.0000}	{0.0160}	{0.0000}	{0.0000}	{0.0001}	{0.0000}	{0.0000}	{0.0225}	{0.0024}	{0.8214}	{0.2917}	{0.8317}	{0.7526}
INTERCEPT	0.0092*	-0.0093*	-0.2905***	0.1786***	-0.0128	0.0475***	-0.0257***	-0.0163**	0.0052	-0.0048*	0.0231***	-0.0268***	-0.0003	0.0116***	-0.0005	0.0136***
	(0.0724}	{0.0998}	{0.0000}	{0.0000}	{0.1207}	{0.0002}	{0.0001}	{0.0360}	{0.1037}	{0.0932}	{0.0012}	{0.0000}	{0.8990}	{0.0001}	{0.8141}	{0.0000}
Adj. R^2	0.9688	0.9789	0.9814	0.9111	0.9732	0.8897	0.9806	0.9757	0.9748	0.9903	0.7363	0.9625	0.9601	0.9674	0.9526	0.9563
Observations	1971	2022	2128	1966	2066	566	2027	2008	2128	1835	984	2028	2011	2017	2999	3005

Panel B: SURE

EX_VOL_{t-1}	0.0010	0.0002	-0.0008	0.0013	-0.0011*	0.0008	0.0002	-0.0001	-0.0002	-0.0006	-0.0080**	-0.0017**	0.0001	-0.0002	0.0000	-0.0001
	{0.1458}	{0.7564}	{0.5375}	{0.3392}	{0.0519}	{0.2701}	{0.8129}	{0.8173}	{0.5905}	{0.3743}	(0.0140)	{0.0276}	{0.4790}	{0.1107}	{0.9503}	{0.2876}
$OUTPUT_{t-1}$	0.0002	0.0007	0.0033**	-0.0011	0.0005	-0.0011	-0.0004	0.0054**	0.0011*	-0.0004	0.0014	-0.0006	0.0005**	0.0000	0.0002*	0.0000
	{0.7374}	{0.3159}	{0.0121}	{0.4674}	{0.2814}	{0.3425}	{0.7678}	{0.0304}	{0.0714}	{0.7109}	(0.7088}	{0.6225}	{0.0500}	{0.8330}	{0.0811}	{0.6947}
$IRATE_{t-1}$	0.00042	0.0006	0.0022**	-0.0004	0.0002	-0.0005	0.0012	0.0014	-0.0002	-0.0003	0.0014	-0.0011	-0.0001	0.0000		
	{0.4598}	{0.3234}	{0.0484}	{0.7792}	{0.7866}	{0.4625}	{0.2211}	{0.3499}	{0.6371}	{0.6490}	(0.7877}	{0.2681}	{0.3264}	{0.7965}		
$INFLA_{t-1}$															0.0001	0.0002***
															{0.5005}	{0.0062}
FIN_DEPTH_{t-1}	0.0103***	0.0048***	0.0749	0.0153***	0.0024***	-0.0062***	0.0053**	0.0074	0.0122*	0.0014***	-0.0023	-0.0065***	0.0000	0.0000	0.0000	0.0000
	{0.0000}	{0.0000}	{0.3159}	{0.0014}	{0.0005}	{0.0000}	{0.0251}	{0.1118}	{0.0827}	{0.0006}	(0.4457}	{0.0002)	{0.7380}	{0.7855}	{0.8684}	{0.8666}
$Log(VOL)_{t-1}$	-0.0003**	0.0003	0.0039***	-0.0006	0.0013***	0.0002	0.0022***	0.0035***	0.0002	0.0015***	0.0006	0.0057***	0.0004***	0.0002***	0.0006***	0.0002***
	{0.0114}	{0.2883}	{0.0000}	{0.4061}	{0.0022}	{0.1970}	{0.0000}	{0.0001}	{0.4299}	{0.0000}	(0.4958}	{0.0000}	{0.0061}	{0.0003}	{0.0000}	{0.0050}
FRI_DUM	0.0002	0.0011	0.0010	-0.0019	0.0003	0.0003	0.0004	0.0005	0.0002	0.0005	0.0014	-0.0014	0.0001	0.0000	-0.0003	-0.0001
	{0.8928}	{0.2527}	{0.4620}	{0.3190}	{0.7885}	{0.6954}	{0.7359}	{0.7801}	{0.6104}	{0.5256}	(0.5721}	{0.1393}	{0.6991}	{0.6072}	{0.1656}	{0.1675}
JAN_DUM	0.0016	0.0020	0.0026	0.0006	0.0017	-0.0033***	0.0022	0.0064**	0.0014**	0.0017	-0.0065*	0.0047***	0.0009**	0.0001	0.0008**	0.0001
	{0.3327}	{0.1456}	{0.1873}	{0.8347}	{0.2310}	{0.0075}	{0.1732}	{0.0155}	{0.0346}	{0.1477}	(0.0894}	{0.0005}	{0.0213}	{0.5851}	{0.0416}	{0.6792}
$\hat{INT}_{t-1}$	0.9663***	1.0418***	1.1658***	0.9568***	1.0128***	0.7211***	1.0690***	1.0874***	1.0485***	1.1295***	0.6487***	1.0293***	0.9678***	0.9734***	0.9477***	0.9510***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	(0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\hat{INT}_{t-2}$	-0.0165	-0.0917***	-0.2017***	-0.0298*	-0.0685***	0.1214***	-0.1212***	-0.1526***	-0.0964***	-0.1637***	0.0753**	0.0205***	0.0001	-0.0100	0.0188	0.0092
	{0.1909}	{0.0000}	{0.0000}	{0.0573}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	(0.0455}	{0.0000}	{0.9948}	{0.5843}	{0.2294}	{0.5644}
INTERCEPT	0.0360***	0.0331***	-0.0316***	0.0428***	0.0276***	0.0867***	0.0112**	-0.0027	0.0220***	0.0061***	0.0577***	-0.0247***	0.0039**	0.0101***	0.0020	0.0121***
	{0.0000}	{0.0000}	{0.0001}	{0.0000}	{0.0000}	{0.0000}	{0.0219}	{0.6149}	{0.0000}	{0.0013}	{0.0000}	{0.0000}	{0.0405}	{0.0000}	{0.1798}	{0.0000}
Adj. R^2	0.9669	0.9763	0.9813	0.9027	0.9717	0.8805	0.9790	0.9737	0.9747	0.9906	0.9026	0.9639	0.9592	0.9682	0.9540	0.9634
Q(20):$\chi^2(20)$	17.9763	16.2852	33.1020**	42.5891***	17.4396	22.4083	31.7102**	27.4462	26.6415	36.3218**	26.0572	30.2269*	30.3326*	28.9051*	14.0247	18.8797
	{0.5890}	{0.6988}	{0.0329}	{0.0023}	{0.6243}	{0.3188}	{0.0465}	{0.1232}	{0.1457}	{0.0141}	{0.1639}	{0.0663}	{0.0646}	{0.0896}	{0.8292}	{0.5297}
Observations	1507	1507	1507	1507	1507	521	1507	1507	1507	1507	521	1507	1909	1909	2653	2653

Note: P-Values are shown in brackets., **, *** denotes significance at the 10%, 5% and 1% respectively. A two equation SURE was estimated separately for Japan and US and the correlation between the two residuals was 0.7243 and 0.7101 for including the $IRATE_{t-1}$ and $INFLA_{t-1}$ variable respectively. Again, the SUR estimates shown for Ireland and Luxembourg are from a 12 equation SURE estimated using fewer observations. Q(20) is the Ljung-Box Q test for serial dependence up to the 20^{th} order.*

Table 3.10

Correlation Matrix of Residuals from SURE with Euro dummy alone

This table presents the correlation matrix of the residuals from the 10 equation seemingly unrelated regression (SUR) reported in Table 3.8, panel B.

	GER	FRA	ITA	BEL	NET	SPA	POR	AUS	FIN	GRE
GER	1.0000	0.8474	0.5465	0.8150	0.8682	0.7106	0.7340	0.8024	0.5390	0.2530
FRA		1.0000	0.7990	0.5382	0.8874	0.8314	0.7227	0.8029	0.7905	0.4347
ITA			1.0000	0.1939	0.7014	0.7644	0.5466	0.6144	0.8095	0.5316
BEL				1.0000	0.6188	0.4135	0.6004	0.5866	0.1963	0.2490
NET					1.0000	0.7890	0.7060	0.7845	0.6739	0.3763
SPA						1.0000	0.6489	0.6983	0.7436	0.4403
POR							1.0000	0.6449	0.5649	0.3240
AUS								1.0000	0.5937	0.3207
FIN									1.0000	0.4895
GRE										1.0000

Table 3.11

Correlation Matrix of Residuals from SURE with other Currency Union variables

This table presents the correlation matrix of the residuals from the 12 equation seemingly unrelated regression (SUR) reported in Table 3.9, panel B.

	GER	FRA	ITA	BEL	NET	IRE	SPA	POR	AUS	FIN	LUX	GRE
GER	1.0000	0.9035	0.3450	0.9196	0.9332	0.8945	0.8381	0.8428	0.7794	0.7497	0.4929	0.1600
FRA		1.0000	0.6617	0.7943	0.9633	0.9365	0.9357	0.8088	0.8594	0.9140	0.4317	0.3456
ITA			1.0000	0.2387	0.5760	0.5862	0.6827	0.3952	0.5907	0.7694	0.1139	0.4705
BEL				1.0000	0.8600	0.8003	0.7469	0.8042	0.6566	0.6247	0.5039	-0.0065
NET					1.0000	0.9344	0.9121	0.8294	0.8314	0.8657	0.4616	0.3022
IRE						1.0000	0.9006	0.8164	0.8282	0.8690	0.4643	0.1469
SPA							1.0000	0.7963	0.8197	0.8896	0.4068	0.2098
POR								1.0000	0.7207	0.7097	0.4806	0.3836
AUS									1.0000	0.8184	0.4036	0.2215
FIN										1.0000	0.3605	0.2710
LUX											1.0000	0.4157
GRE												1.0000

Building on from the Granger causality tests (previously discussed in section 3.3.2), a multivariate analysis is initiated with the simple assumption that stock market integration has been solely driven by the formal introduction of the Euro (as proxied by the EMU dummy). As mentioned earlier (in section 3.3.1), to provide accurate estimates on the relative importance of the EMU in explaining comovement in stock markets with the EMU, stock market volume and financial development are controlled for in the regressions documented as are other confounding seasonal anomalies that might change stock market returns. Thus, day of the week effects and turn of the year effects are controlled for by introducing a Friday dummy and a January dummy respectively. Furthermore, the persistence in stock market integration levels are accommodated with lags of the dependent variable included. Specifically, the following model is estimated both individually for each country using OLS and together for all EMU members and then for Japan and the US together using SUR:

$$\hat{INT}_{i,t} = \alpha_{1i} + \alpha_{2i} FIN\_DEPTH_{i,t-1} + \alpha_{3i} Log(VOL)_{i,t-1} + \alpha_{4i} FRI\_DUM_{i,t}$$
$$+\alpha_{5i} JAN\_DUM_{i,t} + \alpha_{6i} EMU_{i,t} + \alpha_{7i} \hat{INT}_{i,t-1} + \alpha_{8i} \hat{INT}_{i,t-2} + u_{it} \quad (3.11)$$

where the dependent variable ($\hat{INT}_{it}$) is the estimated conditional correlation series for each country *i*[22], *FIN_DEPTH* = stock market capitalization divided by GDP, *LOG(VOL)*[23] = logarithm of the stock market's turnover by volume, *FRI_DUM* and *JAN_DUM* are the seasonal dummies, *EMU* is the Euro dummy[24] which takes a value

[22] If some variables in a regression are generated from prior estimations, there is a potential bias in the hypotheses testing associated with those generated variables – same in principle to the 'generated regressor' problem (as explained in Pagan (1984), McAleer and McKenzie (1991) and Oxley and McAleer (1993)). In addition, this two-step regression process implicitly assumes that the conditional correlations can be modelled with an independent error process, which is the basis for stochastic volatility modelling.

[23] As a robustness check, the volume variable was also detrended by first estimating the regression $VOL_{it} = \alpha_i + \beta_i t + \xi_{it}$ where t is a time trend and then using $\hat{\xi}_{it-1}$ in equations (3.11)-(3.12) in place of $LOG(VOL)_{i,t-1}$. The significance of the two stock market volume variables did not differ greatly.

[24] As a robustness check, an alternative EMU dummy used for Greece took a value of one for dates after 1 January, 2001 (Greece's formal entry into the EMU) but there were no qualitative differences.

of one from 1st January 1999 (zero otherwise) and $\hat{INT}_{i,t-1}$ and $\hat{INT}_{i,t-2}$ are the first and second lags of the dependent variable.[25]

It can be seen in panel A, Table 3.8, that the benchmark OLS estimates are not very informative but in panel B, the SUR estimate for the EMU dummy variable is significant for most of the EMU member states and also for Japan but not the US. As expected, the SUR coefficients had lower standard errors than their OLS counterparts in most cases. However, p-values have been shown to facilitate the interpretation of statistical significance. As expected, the regressions indicate that the introduction of the Euro has had a significantly positive effect on the integration of stock markets with the Euro zone. The stock market control variables are nearly all significant suggesting that existing levels of stock market development are important for the integration process. The Friday dummy is significant only for Greece and the January effect is significant in Portugal, Greece and to a lesser extent in Japan implying that integration is subject to seasonality issues in these countries. This is the first study to have analysed seasonality in European stock market integration and it is clearly present.

On the basis of these preliminary regression results, the Euro dummy is subsequently replaced with proxies for the three main channels through which the EMU has potentially affected stock market integration – namely, reduction in exchange rate risk, convergence in the real economy and also in monetary policies.[26] The variables used in each category are those that are commonly employed in the OCA literature and

[25] Two lags sufficiently eliminated most of the serial correlation for all countries in the estimations.

[26] Unlike Fratzscher (2002) who uses principal component analyses, individual proxies are used here to facilitate more meaningful interpretation of estimated coefficients.

have already been defined in Table 3.6. In this chapter, all individual members are thoroughly weighted to measure convergence in real and monetary terms with regional EMU levels. In the existing literature, convergence towards Germany has been commonly assessed as Germany is considered to be an anchor country to which other members in the union converge towards. However, given that economic performance between member states have been diverging in recent times, a weighted average of all members would be a better proxy for regional levels and provide a more accurate assessment of convergence due to the EMU. It is recognised that in this attempt to explicitly model the different facets of currency unification, a degree of joint endogeneity may be introduced in that these economic changes occurred simultaneously and coincided with the process of stock market integration in the transition period leading up to the EMU. Thus, a degree of multicollinearity may also be introduced which potentially invalidates the inference of the estimators. Given the evidence on unidirectional causality from the monetary union to stock market integration, the independent variables that are not dummy variables have been lagged by one day in the regressions to separate the different contemporaneous sources of integration and to minimize bias in the estimated coefficients. Preliminary correlation analyses conducted for each country also suggest that multicollinearity is not of major concern in these models.[27] Specifically, the model below is estimated individually for each country using OLS and together for all EMU members and then for Japan and the US using SUR:

$$\hat{INT}_{i,t} = \beta_{1i} + \beta_{2i}EX\_VOL_{i,t-1} + \beta_{3i}OUTPUT_{i,t-1} + \beta_{4i}IRATE_{i,t-1} + \beta_{5i}FIN\_DEPTH_{i,t-1} + \beta_{6i}Log(VOL)_{i,t-1}$$
$$+\beta_{7i}FRI\_DUM_{i,t} + \beta_{8i}JAN\_DUM_{i,t} + \beta_{9i}\hat{INT}_{i,t-1} + \beta_{10i}\hat{INT}_{i,t-2} + u_{it} \quad (3.12)$$

[27] Correlation matrices for all explanatory variables used in the regressions for each of the 12 countries have not been included due to space considerations.

where the dependent variable ($\hat{INT}_{it}$) is the estimated conditional correlation series for each country *i*, *EX_VOL* = conditional exchange rate volatility, *OUTPUT* = correlations in the growth of industrial production rates with Euro area weighted averages, *IRATE* = correlations in nominal short term (30 day) interest rates with Euro area weighted averages, *FIN_DEPTH* = stock market capitalization/GDP, *LOG(VOL)* = logarithm of the stock market's turnover by volume, FRI_DUM and JAN_DUM are the seasonal dummies previously introduced and $\hat{INT}_{i,t-1}$ and $\hat{INT}_{i,t-2}$ are the first and second lags of the dependent variable. It should be noted that conditional exchange rate volatilities from a univariate GARCH(1,1) process have been used to better capture the influence of past exchange rate variances.[28]

3.3.4 Regression results on Stock Market Integration

The OLS and SURE results from this final specification are shown in Table 3.9 and summarised in Table 3.12.[29] From a statistical perspective, the model is adequate in explaining the variations in the stock market integration series. While the adjusted R-squares are close to one in the presence of two auto-regressive terms used to eliminate serial correlation, they fall to around 0.3-0.4 in their absence. As the sum of the parameter estimates on the lagged dependent variables are also close to one, there is a

[28] The European Currency Unit (ECU) has been used prior to the Euro's launch and an implicit 1:1 exchange rate has been assumed between the ECU and its replacement, the Euro.

[29] Since estimated coefficients in the SURE were sufficiently different across the equations in the system, there was no economic justification for imposing equality constraints across the equations (ie. a pooled estimation). However, as a robustness check, such a restriction was imposed with no qualitative improvements in the results.

potential non-convergence problem and hence, inconsistency in these estimates. Furthermore, significance of the explanatory variables suggests that multicollinearity is not a problem in this model specification. From an economic perspective, most of the significant estimated coefficients have the expected signs. The intercept terms are significant and positive in most cases. Consistent with the initial specification, one of the two financial control variables (log of volume and financial depth) is positively significant for most countries in the EMU. This reinforces the hypothesis that stock market integration is largely dependent on the existing size and level of financial development and is consistent with findings in Bekaert and Harvey (1995), Ng (2000) and Carrieri et al. (2001) for the integration of emerging stock markets with world financial markets. The Friday dummy is insignificant for all countries whilst the January effect is significant for Japan and Ireland, Portugal, Austria, Luxembourg and Greece within the EMU (consistent with its presence in other studies of major stock markets – for instance see Gultekin and Gultekin, 1983). Contrary to Karolyi and Stulz (1996)'s study on stock market comovements between Japanese and US markets, this study finds little evidence of day of the week effects. These are indeed new findings for integration in European stock markets.

Contributions made by the three different mechanisms of the monetary unification process have varied for member states in the EMU and there are some differences in the results presented in this chapter with existing studies due to the innovative systems estimation approach employed. Reductions in conditional foreign exchange volatilities have only been important to stock market integration for the Netherlands and the two smaller countries, Luxembourg and Greece as indicated by the negative and significant coefficients. This result appears to be a compromise between the theoretical arguments made by Morana and Beltratti (2002) and Fratzscher (2002)'s and Baele (2004)'s empirical findings in that this study reveals exchange rate stability (conditioned on the past) has only been important for the integration of some stock markets and not all. These empirical results lend more support to the argument that changes in stock market comovements are not primarily due to changes in the currency risk premia, consistent with both De Santis et al. (2003)'s finding that the adoption of the Euro did not have a large impact on aggregate currency risk premia and Bodart and Reding (1999)'s finding that correlations in stock returns are not very sensitive to the exchange rate regime (using the experience of the European Monetary System (EMS)). This makes intuitive sense given that as part of the EMS, exchange rates have been required to fluctuate within narrow bands from a basket of European currencies (ECU) since 1979. This made the Euro a close substitute for the national currencies of most major EMU countries anyway. The results show that it is only in those smaller member states with fundamentally different economic structures, where the reduction in exchange rate risk has spurred integration in their stock markets. The results for the other two EMU variables are not directly comparable with Fratzscher (2002)'s findings as the principal component approach has not been used. Nevertheless, this chapter sheds light on the importance of the proxies used in the empirical model for explaining stock market integration. Real convergence via growth in industrial production appears to have provided impetus for the integration process in Italy, Portugal, Austria and to a lesser extent Japan. Finally, convergence towards a single interest rate has only been significant and beneficial for Italy. These results are consistent with the existing evidence that reductions in the volatility of macroeconomic fundamentals associated with the Euro's introduction have been the key reason behind calmer stock market volatility in Italy (Morana and Beltratti, 2002). Although these authors also reach similar conclusions for stock market volatility in Spain, and similarly, Kearney (1998) revealed the importance of exchange rate volatility for Irish stock market volatility under the EMS. The analyses in this chapter suggest the EMU stabilization process has not played a key role in its more recent path towards stock market integration.

An alternative specification estimated for Japan and the US is also shown in Table 3.9. Correlation in consumer price inflation is used to proxy monetary policy convergence instead of nominal short term interest rates. It is revealed that the commitment of monetary authorities to price stability has been an important factor behind higher levels of transatlantic comovement between the EMU and the US stock markets (consistent with their monetary policy commitments to low rates of inflation) whilst real convergence in industrial output growth has been more important for increasing ties between the EMU and Japan. This suggests that implementation of a single currency area has enhanced supranational economic policy coordination by the ECB and has contributed to the phenomenal integration of stock market across regions. Although not tabulated, correlations in inflation rates were found not to have significant explanatory power for EMU members in place of correlations in short term interest rates in equation (3.12). This is not surprising given that within a currency union, economies (particularly the smaller and less developed ones) tend to experience relatively higher levels of consumer price inflation due to increased competition, resulting in major price imbalances instead of stabilization (see Eichengreen and Ghironi, 2001).

All these results suggest that the increase in stock market integration has been a self-fuelling process driven by existing levels of stock market development in the economy. The EMU has played a significant role in stock market integration for those member states with fundamentally different macroeconomic structures or historically volatile stock markets and also on an inter-regional level through more coordinated policy stances.

Table 3.12

Significance of variables in explaining stock market integration

In this table, a summary of the significant variables for explaining each country's stock market integration with the EMU is presented. The estimated coefficients for EURO_DUM are shown in panel B of Table 3.8 and the other estimates are shown in panel B of Table 3.9.

	Economic Variables					Financial Variables		Seasonal Effects		Persistence	
	EURO_DUM	EX_VOL	OUTPUT	IRATE	INFLA	FIN_DEPTH	LOG(VOL)	FRI_DUM	JAN_DUM	$\hat{INT}_{t-1}$	$\hat{INT}_{t-2}$
Panel A:Euro zone:											
GER	X					X	X			X	
FRA	X					X				X	X
ITA	X		X	X			X			X	X
BEL	X					X				X	X
NET	X	X				X	X			X	X
IRE						X			X	X	X
SPA						X	X			X	X
POR	X		X				X		X	X	X
AUS	X		X			X			X	X	X
FIN						X	X			X	X
LUX		X							X	X	X
GRE		X				X	X		X	X	X
Panel B:Non-Euro zone:											
JAP	X		X				X		X	X	
US					X		X			X	

3.4 Conclusions

The aim of this chapter has been to investigate the dynamic nature and determinants of regional and global stock market integration. It has documented that both intra-regional and inter-regional stock market integration was highly volatile prior to the second half of the 1990s and it had increased rapidly in the two years leading up to the official launch of the Euro. Since 1999, the process has been much stronger and more stable than before and with the benefit of a longer post-Euro sample period, a regime shift has been unmasked for all EMU stock markets. As a result, intra-regional and inter-regional return and volatility spillovers have been heightened in the period characterized by the introduction of the Euro. This chapter has managed to shed new light on the gaps and disparities in the link between currency unions and stock market integration. In particular, it has established unidirectional causality from the political creation of the European currency union to the integration of stock markets within EMU member states and also the EMU's integration with Japan and the US. Moreover, the innovative two-step systems estimation approach used for the group of 12 EMU members reveals that increasing stock market return comovements can be explained with the macroeconomic convergence process associated with the introduction of the Euro and implementation of the EMU. However, financial market integration is largely a self-fuelling process dependent on the existing levels of financial sector development and is particularly strong during the month of January. In addition, the contribution of currency stability to stock market integration is found to be only significant for the smaller EMU members with historically different economic structures. As a result of the European Monetary System introduced in 1979, the Euro was already a very close substitute for most major European currencies. On a global level, the commitment to price stability has significantly strengthened stock market integration between the EMU and the US whilst convergence in industrial production has increased ties between the EMU and Japan. Although diversification benefits have reduced, the process of financial integration remains incomplete for the smaller and newer EU member states and alternative investment opportunities remain. Complete integration of Europe's stock markets will ultimately depend on many institutional, microstructural and cultural factors and the removal of other impediments will take some time.

Chapter 4[*]

Dynamic Bond Market Integration in an Enlarged European Union

[*] A shorter version of this chapter is forthcoming in a special issue on International Bond and Debt Market Integration in the *Journal of International Financial Markets, Institutions and Money*, 2005.

4.1 Introduction

The political, economic and monetary developments within the European Union (EU) have been major catalysts for regional financial market integration. As such, the recent EU enlargement will also have financial implications. Whilst there is substantial evidence of convergence in the present bond markets within the European Union (EU) (for example, see Santillan et al., 2000, and Galati and Tsatsaronis, 2003), less is known about the extent and dynamics of financial integration between the new and established members. The fledgling international finance literature on transition EU members has largely focused attention on their macroeconomic convergences with core European markets (for example, see Brada et al., 2005 and Orlowski, 2005). In this chapter, the focus is on the financial integration experience between government bond markets of three new EU countries (Poland, the Czech Republic and Hungary), as well as a subset of countries already belonging to the EU (Belgium, France, Ireland, Italy, Netherlands, UK and Germany). The choice of sample countries has been determined by data and economic considerations. In regards to data, the three new EU countries chosen represent those that have the longest available time-series data comparable to the established EU countries. In economic terms these countries represent the largest, most developed economies amongst the new and established member groups, with the largest and most liquid government debt markets.

The concept of financial market integration is integral to international finance and it is natural that financial market integration changes with economic conditions. The economic explanation that is generally accepted is that investors' risk aversion level varies over time, causing them to require varying compensation for accepting a risky payoff from financial assets. For this reason, recent studies have allowed financial integration to vary over time. For government bonds, Ilmanen (1995) provided one of the first assessments on time-varying expected returns using an asset pricing model. Extending from this, Barr and Priestley (2004) applied a similar framework to assess international bond market integration by investigating the extent to which bond returns are determined by world risk factors rather than by domestic risk factors. Moreover, both Clare and Lekkos (2000) and Cappiello et al. (2003) have found significant variations in international bond market return comovements. Like Cappiello et al. (2003), Christiansen (2003) has also found some changes in European bond markets since the introduction of the Euro. She provides empirical evidence that regional effects have become dominant over both own country and global effects in EMU bond markets with the introduction of the Euro but not in non-EMU countries where country effect remains strong. Given that Driessen, Melenberg and Nijman (2003) find factors relating to the term structure to explain most of the variations in international excess bond returns, it is conceivable that economic convergence required as part of EU membership has inevitably led to higher levels of bond market convergence. However, this remains to be determined for new EU members, as there is little academic evidence of the extent, still less the dynamics, of bond market integration in this new group.

The attention on comovements across government bond markets in the literature pales in comparison to that on stock markets. Smith (2002) is one of the few studies to have tested for cointegration (long-term relationship) in international government bond markets. They apply the Johansen (1988) and Johansen and Juselius (1990) techniques on monthly mixed maturity bond index returns and detect the existence of cointegrating vectors. However, the literature is scant on the time-varying nature of bond market integration in new EU members, despite the serious implications of this for policy making in an enlarged EU. This chapter attempts to address this void and provide empirical evidence on the dynamic nature of bond market integration amongst the established and new EU countries. This is accomplished by the investigation of the time-varying nature of bond market integration via three advanced econometric modelling methodologies. Given that yield differences between government bond issues in the European Monetary Union (EMU) are small (through monetary policy coordination), one expects EMU bond markets to be more closely integrated overall than with new incoming members, and the aim of this chapter is to investigate the extent to which these new EU government bond markets differ from the existing markets. This is vital for the success of the European Union's next phase of enlargement, which began in May 2004. Barr and Priestley (2004) believe the economic costs and benefits of international bond market integration are likely to be significant, ultimately leading to lower cost of fiscal funding for governments. This suggests that the benefits of financial integration are likely to outweigh the costs.

The Exchange Rate Mechanism, the various macroeconomic convergence policies as well as the EU structural and cohesion funding that facilitated EU accession, should help to drive real and nominal economic convergence between the new and existing members of the EU. This should also be logically reflected in their financial markets. This motivates an investigation into the extent of financial integration between the established and new EU government bond markets.

The major findings of this chapter are: i) Although there are strong linkages between established EU bond markets with that of Germany, the three new EU countries' linkages are weaker and show no evidence of growing integration with the EU core in the near term; ii) the UK bond market's linkage with Germany is relatively weaker than those in the Euro zone markets; iii) of the three new EU countries, the Czech Republic is the least integrated with the established EU bloc.

The remainder of this chapter is organized as follows: Section 4.2 discusses the bond market index data used in this chapter; Section 4.3 details the empirical methodologies employed; and the estimation results are discussed in section 4.4. Lastly, concluding comments are provided in section 4.5.

4.2 Data description

The data used in this chapter are all-maturity total returns[1] on MSCI (Morgan Stanley) Government Bond Indices for the Czech Republic, Hungary, Poland, Belgium, France, Ireland, Italy, Netherlands, the UK and Germany, sourced from Thompson Datastream International. These bond market indices have been chosen because they are from a reliable source and are available at a daily frequency for the longest time period for the three new EU countries: the Czech Republic, Hungary and Poland. Daily returns provide a more accurate assessment of integration dynamics than lower frequency returns. The bond indices are all denominated in US dollars, and the sample period is from 30 June 1998 to 31 December 2003 (yielding 1435 usable observations). Returns are calculated as first log differences so this analysis follows the existing literature in applying log-changes of total return government bond indices (see for example, Bodart

[1] Total return indices account for both price changes and dividends reinvested.

and Reding, 1999, Christiansen, 2003 and Driessen et al., 2003).[2] In this analysis, the German government bond index has been chosen as the proxy for the established EU bloc, because German bonds have benchmark status in the European financial markets. By using Germany as a proxy for the EU region, the analysis avoids spurious integration results as individual bond markets will not be a composite of the EU regional government bond index. The UK has been included in the analysis as the three new EU countries under investigation are not expected to adopt the Euro for a number of years. Thus, exclusion of the sterling debt market would be unwarranted.

Table 4.1 provides descriptive statistics on the bond returns. In general, bond returns are higher in the new EU countries compared to the existing EU member countries, and this corresponds to generally higher return variances in these countries due to perceived higher levels of credit, political and transfer risks. In addition, it is revealed in this table that the distributions of these bond market returns are statistically non-normal (significant levels of skewness and excess kurtosis), with the three new EU countries having larger (in magnitude) skewness than the rest. Interestingly, Hungary and Poland show significant negative skewness while all other countries show positive skewness. Also, the excess kurtosis of these two countries are considerably larger than the other countries. The bond index returns are not serially correlated in the first moment in all cases except Poland. However, significant correlation in the second moments is found in all three new EU countries and the UK. This is clear evidence of

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[2] As only European countries are included in the sample, data asynchronicity is not a huge problem with the daily frequency returns. The maximum time difference between Eastern and Western European countries is ±2 hours and government bond market trading hours in the sample countries deviate by a maximum of ±1hour.

time-varying volatility in these government bond markets. In addition, the significance of the bivariate i.i.d. (independent and identically distributed) tests for joint white noise in each government bond market return index and the German benchmark indicates that the first and second moments of all these return series move closely together and that the bivariate nature of these distributions needs to be accounted for in the modelling of these daily government bond market returns.[3]

Table 4.1 Descriptive Statistics on daily MSCI bond market index returns (per cent), 1/7/1998-31/12/2003

This table shows the summary statistics for the bond index returns of new EU members in Panel A and existing members in Panel B. Asymptotic p-values are shown in the brackets. *, **, *** denotes statistical significance at the 10, 5 and 1% level respectively. Test results for H_0:Skewness=0 and H_0:Excess kurtosis=0 are indicated. Q(40) is the Ljung-Box test statistic for serial correlation up to the 40th order in the return series (since $\sqrt{N} = 1435 \approx 40$); $Q^2(40)$ is the Ljung-Box test statistic for serial correlation up to the 40th order in the squared returns. $Q_b(40)$ and $Q^2_b(40)$ are the bivariate Ljung-Box tests for joint white noise in the linear and squared standardised returns up to the 40th order.

	Bond Index Return				Test of univariate i.i.d.		Test of bivariate i.i.d. (with German benchmark)	
	Mean	Variance	Skewness	Excess Kurtosis	Q(40): $\chi^2(40)$	$Q^2(40)$: $\chi^2(40)$	$Q_b(40)$: $\chi^2(160)$	$Q^2_b(40)$: $\chi^2(160)$
Panel A: New EU members:								
Czech	0.056	0.543	0.295***	1.033***	45.143	105.839***	140.968	225.174***
			{0.000}	{0.000}	{0.266}	{0.000}	{0.858}	{0.001}
Hungary	0.045	0.611	-0.586***	4.837***	45.432	257.530***	113.522	371.959***
			{0.000}	{0.000}	{0.256}	{0.000}	{0.998}	{0.000}
Poland	0.052	0.593	-0.377***	3.066***	72.257***	277.988***	127.583	371.230***
			{0.000}	{0.000}	{0.001}	{0.000}	{0.972}	{0.000}
Panel B: Existing EU members								
Belgium	0.032	0.528	0.161**	0.991***	30.211	50.912	298.226***	165.817
			{0.013}	{0.000}	{0.869}	{0.116}	{0.000}	{0.360}
France	0.031	0.528	0.173***	1.033***	29.819	48.447	198.438**	231.686***
			{0.007}	{0.000}	{0.880}	{0.169}	{0.021}	{0.000}
Ireland	0.033	0.557	0.118*	1.015***	31.682	47.539	254.932***	125.563
			{0.068}	{0.000}	{0.823}	{0.193}	{0.000}	{0.980}
Italy	0.031	0.513	0.137**	1.034***	30.473	50.863	338.878***	334.921***
			{0.034}	{0.000}	{0.862}	{0.117}	{0.000}	{0.000}
Netherlands	0.031	0.523	0.178***	1.018***	30.006	49.469	204.418***	249.609***
			{0.006}	{0.000}	{0.875}	{0.145}	{0.010}	{0.000}
UK	0.028	0.358	0.074	0.942***	42.183	70.223***	102.000	118.417
			{0.253}	{0.000}	{0.377}	{0.002}	{0.999}	{0.994}
Germany	0.030	0.521	0.173***	1.004***	29.832	50.429		
			{0.007}	{0.000}	{0.880}	{0.125}		

[3] A bivariate version of the Ljung-Box (portmanteau) Q test for serial correlation devised by Hosking (1980) has been used on linear and squared standardised market returns.

4.3 Dynamic Methodologies

It is vital to consider the time-varying nature of financial market integration as economic fundamentals and political climates are changing in European economies meaning some parts of the sample period may be more integrated than other parts. The methodologies used in this chapter expressly allow the analysis to capture this important element. In general, comovements between new EU government bond markets and the German benchmark are interpreted as a proxy measure for the extent of financial integration. A high degree of comovement with the German benchmark would provide indirect evidence that the new EU bond markets are pricing in common regional information in the same manner as the bond markets of existing EU countries, and are therefore relatively well integrated into the EU financial core.

4.3.1 Dynamic Cointegration

The essence of cointegration is that the time-series cannot diverge arbitrarily far from each other, implying that there exists a long-term relationship between these time-series and that they can be written in an Error Correction form. By definition, cointegrated markets thus 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 (see Darrat and Zhong, 2002, Masih and Masih, 2001 and Smith, 2002). The requirement for assets that are integrated to share common stochastic factors, is an alternative definition of cointegration, as pointed out in Chen and Knez (1995).

In the literature, two primary methods exist to examine the degree of cointegration among indices.[4] 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). This technique 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 Johansen-Juselius approach allows testing for the number as well as the existence of these common stochastic trends. In essence, the Johansen-Juselius approach involves determination of the rank of a matrix of cointegrating vectors.

To illustrate, for a given lag length of one and assuming no deterministic components[5], the Vector Auto-regressive (VAR) representation of the stock indices in levels can be written as equation (4.1):

$$\mathbf{E}_t = \mathbf{A}_1\mathbf{E}_{t-1} + \mathbf{A}_2\mathbf{E}_{t-2} + \ldots\ldots + \mathbf{A}_l\mathbf{E}_{t-l+} + \mu_t \qquad (4.1)$$

where $\mu_t \approx N(0,\sum)$ and E represents a *(nx1)* vector of stock equity indices, **A** is a *(nxn)* matrix of coefficients. This relationship can be represented more generally in a Vector Error Correction model (VECM) as

[4] See Enders (1995) for a detailed statistical description of these techniques.

[5] 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) become very complex.

$$\Delta \mathbf{E}_t = \prod \mathbf{E}_{t-1} + \Gamma_1 \Delta \mathbf{E}_{t-1} + \Gamma_2 \Delta \mathbf{E}_{t-2} + \ldots.. + \Gamma_{l-1} \Delta \mathbf{E}_{t-l+1} + \Gamma_l \Delta \mathbf{E}_{t-l} + \mu_t \quad (4.2)$$

Or

$$\prod \mathbf{E}_{t-1} = \Delta \mathbf{E}_{t-1} - \sum_{i=1}^{l} \Gamma_i \Delta \mathbf{E}_{t-i} - \mu_t \quad (4.3)$$

where the right hand side terms of Equation (4.3) are stationary, it follows that $\prod \mathbf{E}_{t-1}$ is also stationary. The Johansen-Juselius technique endeavours to ascertain the rank, 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 $\beta'\mathbf{E}_t$.[6]

The Johansen-Juselius 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 financial market integration is changing over time.[7] 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 has been used is twofold: first, the largest value of the λ_{trace} statistic which tests

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[6] 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.

[7] 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 Johansen-Juselius approach. Barari and Sengupta (2002) concentrate on the λ_{trace} statistic.

the general hypothesis of no cointegration versus cointegration, and second, the number of cointegrating vectors given by the λ_{max} statistic. A set of return time-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. Considering there are k vectors later on where $n<k<p$, then there are additional combinations that can be used in the representation of the p data. If there is a static number of cointegrating vectors then recursive estimation will simply lead to an upward trend in the λ_{trace} statistic. It should be noted that in general the λ_{trace} statistic is more powerful and to be preferred to the λ_{max} statistic in the dynamic cointegration approach.

4.3.2 Haldane and Hall Kalman Filter

There is a variety of feasible alternative approaches to the cointegration methodology. The Haldane and Hall (1991) Kalman filter based methodology is one that has been used in a number of settings.[8] The Haldane and Hall method estimates a simple equation of the following specification

$$\ln\left(\mathbf{E}_{jt} / \mathbf{E}_{Bt}\right) = \alpha + \beta_t \ln\left(\mathbf{E}_{jt} / \mathbf{E}_{Xt}\right) + \varepsilon_{jt} \qquad (4.4)$$

[8] Manning (2002) examines Asian stock market integration taking the Haldane and Hall (1991) approach of specifying time-varying coefficients via a Kalman filter.

via Kalman filter estimation. Here the market subscripted B is the pre-imposed internal base market and that subscripted X is the pre-imposed external market. Thus, for example, in testing for integration among South-East Asian markets, Manning (2002) imposes the US market as the external market (to which the South-East Asian markets are assumed to be converging) and Hong Kong as the dominant local market.

In this European analysis, the German bond market is set as the local base (B) and the UK as the external bond market (X) and the system is then estimated. These relationships are also inverted, as it is unclear as to which market, over the time period of this investigation, 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 chapter works in the following simplified manner. The given 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 β_t is set as the coefficient of interest at time t, then the transition equation is given by $\beta_t = \beta_{t-1} + v_t, \text{var}(v_t) = \text{M}_t$. 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 (4.5), (4.6) and (4.7).

$$S_t = \Sigma_{t-1} + M_t \quad (4.5)$$

$$\Sigma_t = S_t - S_t X_t'(X_t S_t X_t' + \eta_t)^{-1} X_t S_t \quad (4.6)$$

$$\beta_{t|t} = \beta_{t-1|t-1} + S_t X_t'(X_t S_t X_t' + \eta_t)^{-1}(Y_t - \alpha_{t-1} X_t \beta_{t-1|t-1}) \quad (4.7)$$

4.3.3 Dynamic Conditional Correlations

In addition, the recently developed Dynamic Conditional Correlation (DCC) model of Engle (2002)[9] has been used to model the volatility of bond market total returns in Germany and other EU members and to derive the time-variations in conditional correlations between them.[10] The Dynamic Conditional Correlation model is formulated as a generalisation of Bollerslev (1990)'s constant conditional correlation assumption. Hence, the residual vector r_t is specified as

$$r_t | I_{t-1} \sim N(0, H_t) \quad (4.8)$$

where $H_t = D_t R_t D_t$ and $D_t = diag(\sqrt{h_{1,t}}, \sqrt{h_{2,t}})$ is the diagonal matrix of conditional standard deviations, R_t is the time-varying conditional correlation matrix and I_{t-1} is the

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[9] An asymmetric multivariate DCC extension by Cappiello et al. (2003) has been used by Kearney and Poti (2004) to examine European equity market correlation dynamics.

[10] The bivariate EGARCH model (as used in Chapter 3 for stock markets) has also been estimated assuming both student-*t* and a normal distribution for the residuals with no qualitative differences. The results assuming a joint normal distribution are provided in Table A.2 in the Appendices to facilitate a comparison with the estimated DCC results. However, this model is not presented in this chapter given inconsistent findings in the literature regarding the presence of asymmetries in bond returns.

information set available at time *t-1*.[11] In short, the actual H matrix is generated in two steps involving a combination of separate univariate GARCH models for the variances of individual bond market returns and the time-varying conditional correlations produced by another GARCH parameterization for the unconditional covariance matrix.

The conditional variances for each individual bond market return process is modelled as a typical univariate GARCH(1,1)[12]

$$h_{i,t} = \omega_i + \alpha_i r_{i,t-1}^2 + \beta_i h_{i,t-1} \tag{4.9}$$

where α_i represents the ARCH effects (short-run persistence of shocks to bond market return *i*) and β_i represents the GARCH effects.

Following Engle (2002), the entire covariance matrix is also parameterized directly as a GARCH(1,1) model as shown in the matrix specification in equation (4.10)

$$Q_t = (1-\lambda_1-\lambda_2)Q + \lambda_1 \varepsilon_{t-1}\varepsilon_{t-1}' + \lambda_2 Q_{t-1} \tag{4.10}$$

where Q is the positive definite unconditional covariance matrix used solely to provide the correlation matrix. λ_1 and λ_2 are scalar parameters used to capture the effects of past standardised shocks ($\varepsilon_t = D_t^{-1} r_t$) and past dynamic conditional correlations on current

[11] Following the GARCH literature that uses daily returns, a constant and an error term in the conditional mean equation has been used, that is, $Y_t=\mu+r_t$.

[12] The bond market integration literature reports little evidence of asymmetry in volatility so this aspect has not been modelled in this chapter.

dynamic conditional correlations respectively. In matrix terms, the correlation estimator is derived from the covariance matrix using

$$R_t=\text{diag}[Q_t]^{-1/2}[Q_t]\ \text{diag}[Q_t]^{-1/2} \tag{4.11}$$

In theory, these parameters can be obtained by maximum likelihood estimation using a joint normal distribution assumption for the vector of residuals. Although the descriptive statistics in Table 4.1 suggest the residuals follow a non-normal distribution, the use of a normal distributional assumption can still be justified asymptotically by quasi-maximum likelihood theory. Under suitable regularity conditions for large samples, quasi-maximum likelihood estimators are consistent (but inefficient) and asymptotically normal (see Newey and McFadden, 1994). The log likelihood function can be written as

$$L(\theta,\phi)=\sum_{t=1}^{T}L_t(\theta,\phi) \tag{4.12}$$

where θ and Φ denote the parameters in D_t and R_t respectively. As shown in Engle (2002), this can be expressed as follows[13]

$$L(\theta,\phi)=-\frac{1}{2}\sum_{t=1}^{T}[n\log(2\pi)+2\log|D_t|+r_t'D_t^{-1}D_t^{-1}r_t-\varepsilon_t'\varepsilon_t+\log|R_t|+\varepsilon_t'R_t^{-1}\varepsilon_t] \tag{4.13}$$

[13]This expression is to facilitate a two-step maximization process using the volatility and correlation parts of the likelihood function decomposed in Engle (2002). This estimation has been performed in RATS v.6.0 using the Broyden, Fletcher, Goldfarb and Shanno (BFGS) convergence algorithm.

4.4 Empirical Results

In preliminary tests, all bond market index returns (in levels) were found to contain a unit root with zero drift. Thus, cointegration analysis is possible. It was found that on the whole, bond markets in the established EU members are already fully integrated, corroborating with European financial market studies such as Galati and Tsatsaronis (2003), Cappiello et al. (2003) and Baele et al. (2004). However, bond markets in the new EU countries are not as well integrated with the established EU bloc and this is a new result. Moreover, the UK bond market is not as well integrated with the rest of the EU, which perhaps is not surprising given that it is not a member of the EMU. The UK economy has also performed differently to the rest of the EU over the sample period, and it has a more flexible economy and lower government debt levels. This finding is consistent with the lower unconditional correlations found by Cappiello et al. (2003) between EMU and non-EMU bond markets on a regional level.

The results for the dynamic cointegration analyses are shown in Figures 4.1 and 4.2. Figure 4.1 shows the results for the global, recursive analysis. The models are initially estimated over the first five hundred observations, equating to approximately end of May 2000. Thereafter twenty observations, or four weeks of data, are added to successive iterations and the data is reanalysed. The trace statistics are normalized to the asymptotic 90 per cent critical values – thus a value greater than one implies cointegration and less than one, no cointegration. It is clear that over the time period in general there is consistent evidence of cointegration indicating that the EU bond markets are in a stable relationship: the bond markets of the accession countries and those of the existing countries form part of a system[14]. However, the number of cointegrating vectors from the λ_{max} statistic settles at between three and four, again indicating that the system is not integrating further. Recall that in a system of nine variables full integration would be achieved with between one and eight cointegrating vectors. The results of this analysis are perhaps a reflection of the near complete integration of the two sets of countries considered independently with a very weak linkage between the two sets of markets. The local plots are shown in Figure 4.2: the evidence is more favorable to the hypothesis of an integrated system, but again there is little evidence that the system of EU bond markets is increasing in convergence.

The Haldane and Hall convergence factors for the three accession countries with the UK and with Germany are shown in Figure 4.3. It is clear that the bond markets of the three new EU members are not in general close to convergence, with the surprising exception of Poland, which has converged to the UK. In so far as there is any evidence, it is that the markets are converging more to the UK than to Germany. This has obvious policy implications for effective ECB monetary policy transmission to new EU members. In general, this would appear to cast some doubt on the suitability of these new EU countries for moving towards EMU membership and full adoption of the Euro in the immediate term.

[14] The evidence from an analogous examination of the existing members is that they are multivariate cointegrated, as are generally, the three accession countries.

Figure 4.1 Global Trace and Vector

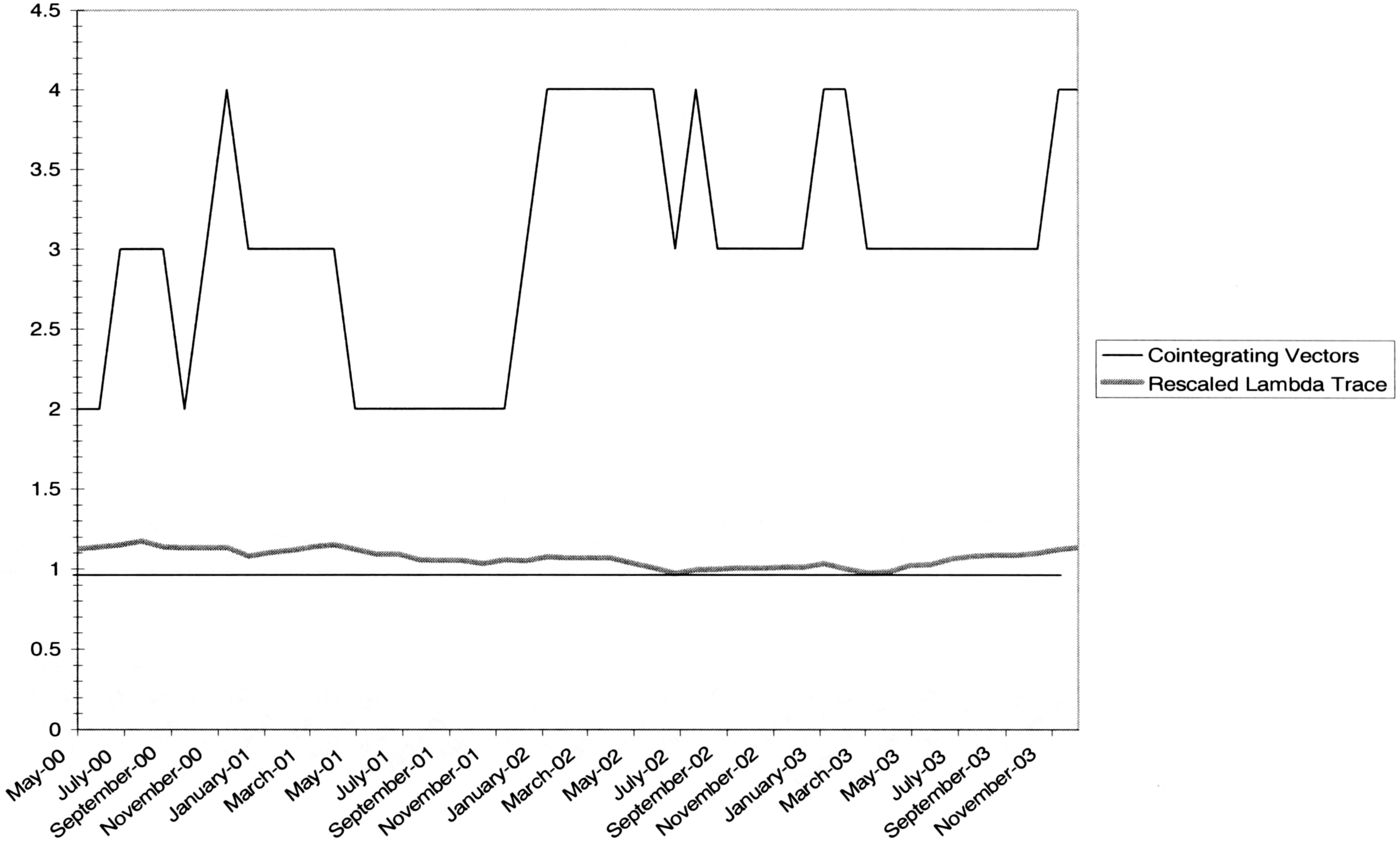


Figure 4.2 Local Trace and Vector

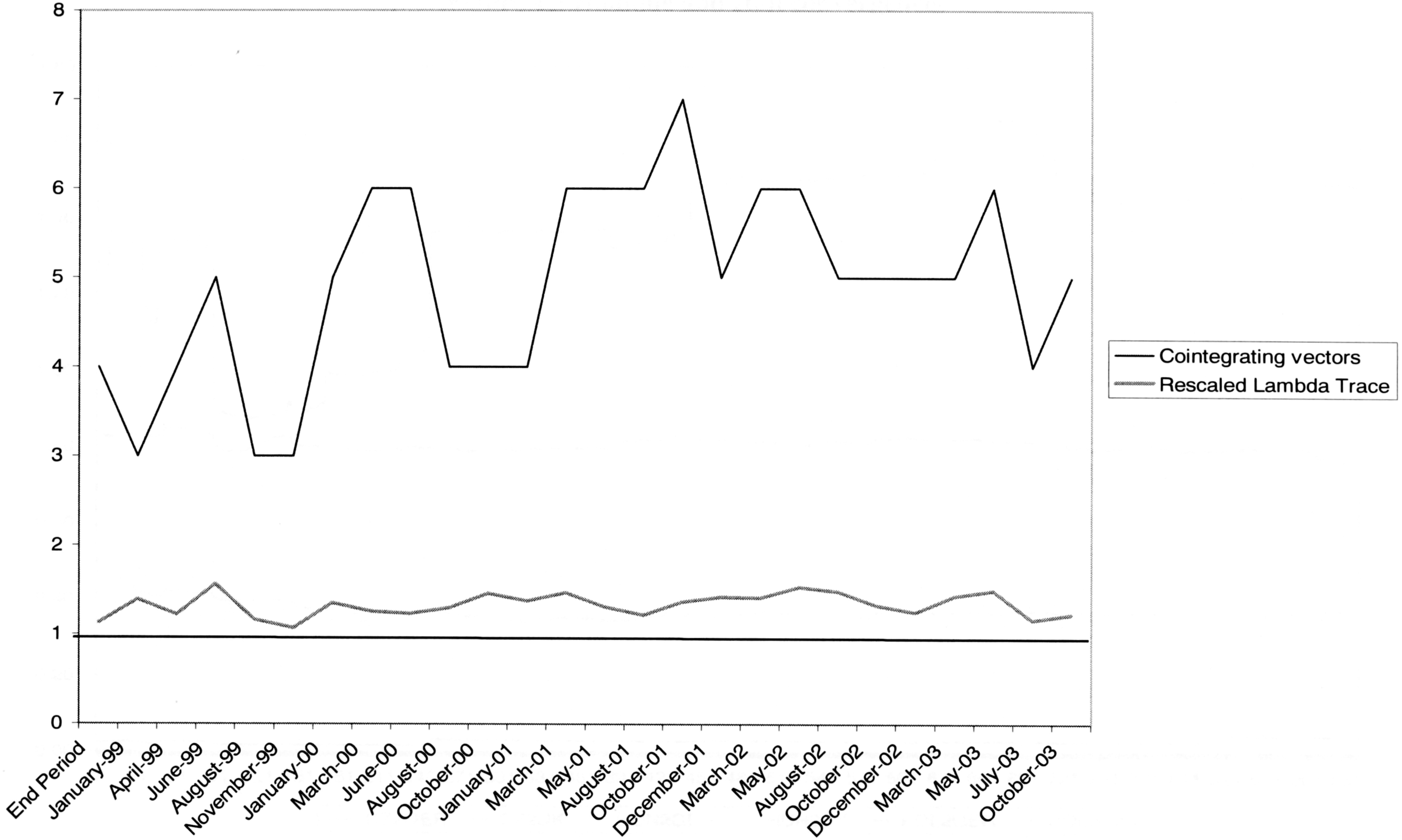
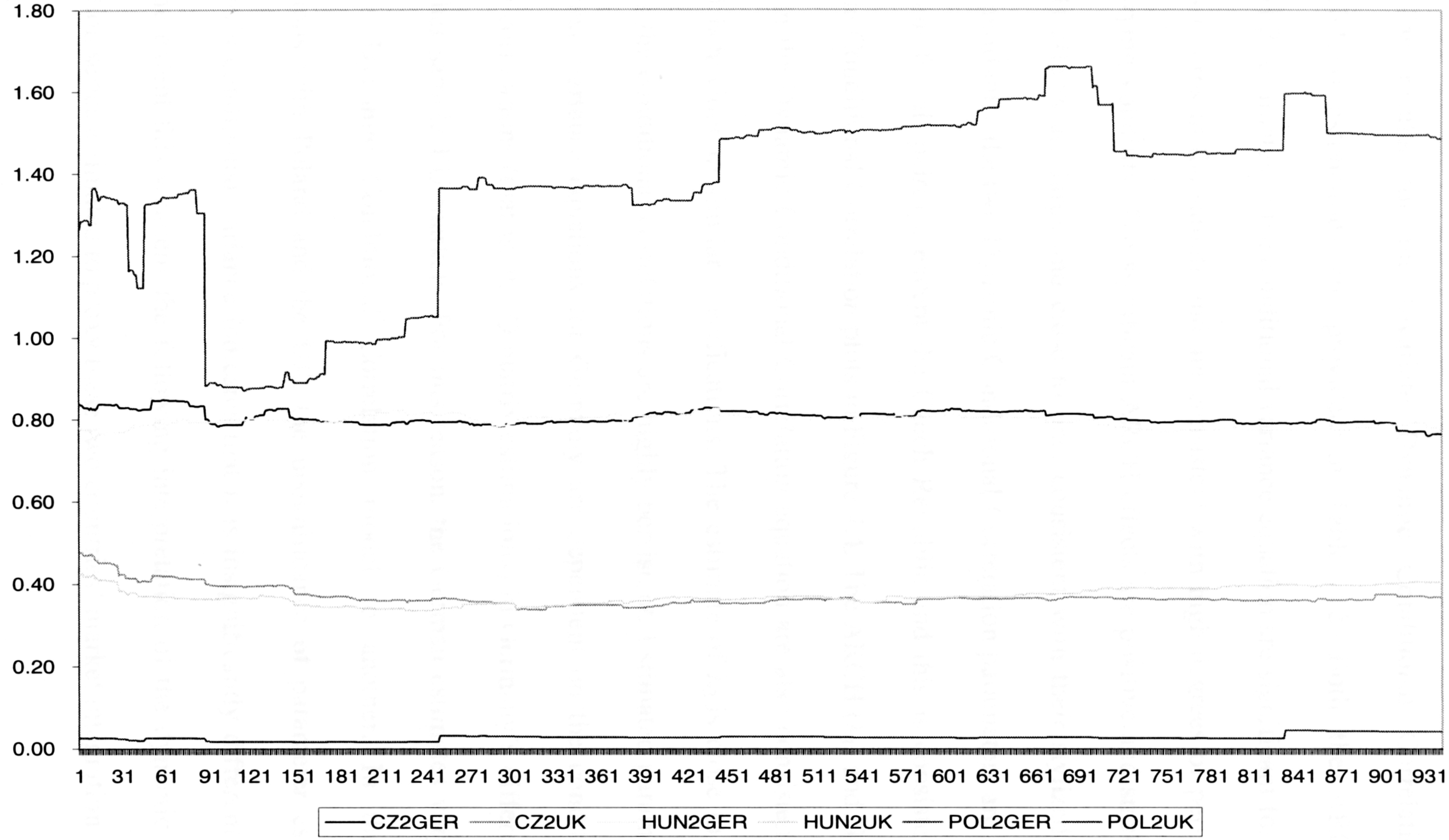


Figure 4.3 Haldane and Hall convergences



The results for the bivariate Dynamic Conditional Correlation (DCC-GARCH(1,1)) estimations are provided in Table 4.2. Both the ARCH(α) and GARCH(β) estimates in the conditional variance equation are significant for most bond markets returns in the sample and are consistent with high degrees of persistence and time-varying volatility. The significant ARCH effects are positive and small while the GARCH effects are large and close to one, consistent with their stylized behaviour. More importantly the two Dynamic Conditional Correlation parameters are statistically significant for all pairings except the Czech Republic and this is consistent with the Dynamic Conditional Correlation plots in Figure 4.4. The ARCH (λ_1) and GARCH (λ_2) effects in the Dynamic Conditional Correlation equation are also consistent with their stylized behaviour in similar specifications. The estimate of λ_2 is close to one which suggests the conditional correlations are highly persistent. Estimated parameters in the conditional variance equations for Germany are dependent on the conditional time-varying correlations (that is, the Q matrix estimations) in Germany's different pairings with other sample EU markets. For this reason, the German estimates vary from one bivariate Dynamic Conditional Correlation model to another. In the bivariate estimations with Poland and the UK, the insignificance of parameter estimates for Germany's conditional variance indicates that it is insignificantly different from zero. To some extent this weakens the following interpretation of the dynamic conditional correlation series estimated to proxy these two countries' market integration.

It is clear from Figure 4.4 that conditional correlations in EU bond markets are dynamic as there is considerable variation in the conditional correlations, providing empirical evidence that Engle (2002)'s Dynamic Conditional Correlation model has been appropriately used in this investigation. The historical Dynamic Conditional Correlation plots suggest that integration between established bond markets in the EU increased rapidly in the late 1990s leading up to the start of accession talks and the formal inauguration of the European Monetary Union (EMU) in 1999. However, bond market integration appears to be relatively low in the UK perhaps due to the British government's desire to stay out of the EMU and to maintain a monetary policy stance that was independent of the European Central Bank (ECB). Low integration in the UK government bond market was also found in Barr and Priestley (2004) and they provided low liquidity (from low levels of public debt in the UK) and an underdeveloped repo market as explanations. However, they overlooked the political concerns of the UK government to join the EMU.

Of the three new EU bond markets, the Czech Republic displays the least variation in interdependence with other bond markets in the EU whilst Hungary and Poland showed generally increasing trends as they progressed with formal EU accession. In both Hungary and Poland, the government bond markets became rapidly more interdependent with the established EU bloc from the late 1990s but a correction occurred for both markets during 2001 when the accession talks became more difficult and uncertain. Since then, the Polish bond market has again become rapidly interdependent with established bond markets in the core EU bloc but the Hungarian bond market has not. The strength of interdependence in the late 1990s appears to have been promoted by expectations on EU accession and the EU's Structural Funds initiative. In particular, the Poland-Hungary Aid for Economic Restructuring (PHARE) program was specifically designed to help the two young democracies to rebuild their economies and to encourage political reform subsequent to the fall of the Berlin wall and the Iron Curtain, previously separating socialist and non-socialist governments in Europe. It was only later re-orientated towards pre-accession priorities and funded other CEECs like the Czech Republic. This means that Poland and Hungary have benefited for the longest time from this EU aid program and it is reasonable that they would be more integrated with the EU as a consequence of more structural economic reforms.

In the beginning of the sample period there is a common downward spike in all conditional correlations series between the German government bond market and other sample EU markets (except the UK and Czech Republic) - coinciding with the Russian Crisis of 1998. The magnitude of the percentage decreases in these conditional correlations was much higher for the Hungarian and Polish bond markets (130 per cent and 75 per cent respectively) compared with the more established EU bond markets (11 per cent for Italy, 5 per cent for Ireland, 2 per cent for Belgium and 0.4 per cent for France and the Netherlands). These corrections are in line with the perceived level of default risk associated with these national bond markets and Kaminsky and Schmukler (2002)'s finding of stronger outlook changes on bonds during financial crises. German Bundesbank bonds are traditionally deemed to be the benchmark bonds in the EU and so the government bond market is viewed as the least risky. During the Russian Crisis it is likely that greater risk premia were priced into the other EU government bond markets as investors became more risk averse (also less confident) resulting in the sudden divergence in bond returns with Germany. Naturally, this divergence was more extreme in the more illiquid emerging debt markets in Hungary and Poland. This was repeated to a greater extent for Poland than Hungary between 2000 and 2001 in the aftermath of the technology boom.

Of the established EU government bond markets, Ireland and the UK had different convergence experiences compared with the core Euro zone markets (Belgium, France, the Netherlands and Italy), reflecting their structural economic differences with Germany. The EMU markets had all rapidly integrated with Germany, with the inception of the EMU in 1999.

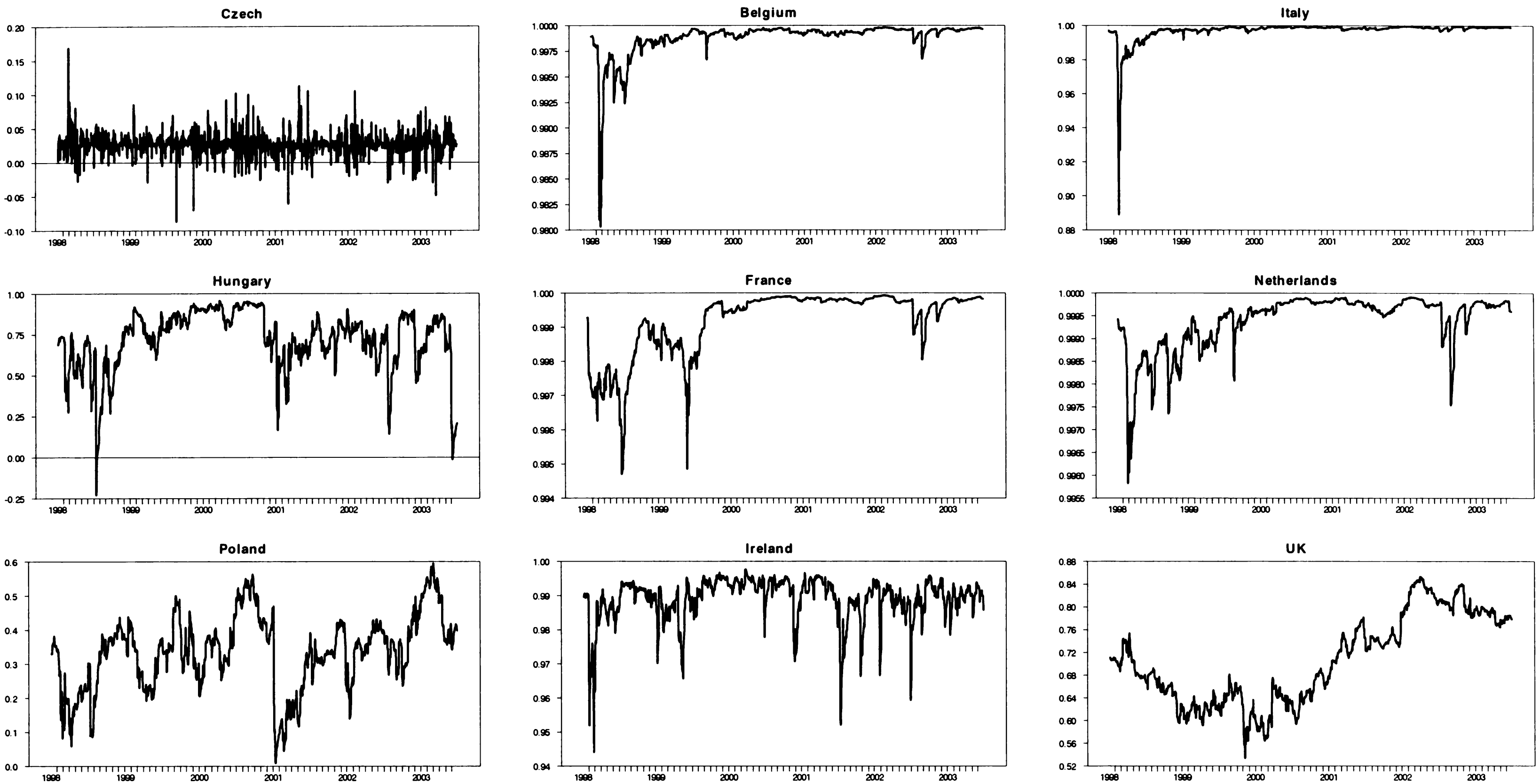
Table 4.2 Parameter Estimates and Diagnostic Tests for the DCC-GARCH(1,1) Models: 8/7/1998 to 31/12/2003.

The conditional variances are modelled as shown in equation (4.9) and the DCC structure is modelled in equation (4.10).

	Conditional Variance			DCC			Univariate	Bivariate
	ω	α	β	λ_1	λ_2	LogL	Q(40): $\chi^2(40)$	$Q_b(40)$: $\chi^2(160)$
Germany	0.505***	-0.006	0.040	0.018	0.000	-3143.226	49.513	132.910
	{0.000}	{0.745}	{0.175}	{0.454}	{1.000}		{0.144}	{0.942}
Czech	0.025***	0.041***	0.911***				30.943	
	{0.000}	{0.000}	{0.000}				{0.847}	
Germany	0.024***	0.062***	0.898***	0.079***	0.909***	-2508.127	38.297	113.819
	{0.008}	{0.000}	{0.000}	{0.000}	{0.000}		{0.547}	{0.998}
Hungary	0.020***	0.106***	0.870***				25.350	
	{0.001}	{0.000}	{0.000}				{0.966}	
Germany	0.582	0.011	-0.133	0.023***	0.955***	-3020.938	49.834	125.810
	{0.226}	{0.566}	{0.886}	{0.000}	{0.000}		{0.137}	{0.979}
Poland	0.061***	0.165***	0.732***				41.252	
	{0.000}	{0.000}	{0.000}				{0.416}	
Germany	0.019***	0.041***	0.922***	0.056***	0.937***	1566.747	34.562	194.132**
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}		{0.713 }	{0.034}
Belgium	0.019***	0.041***	0.923***				35.117	
	{0.000}	{0.000}	{0.000}				{0.690}	
Germany	0.442***	0.003	0.133***	0.036***	0.962***	1967.037	49.585	147.141
	{0.000}	{0.228}	{0.000}	{0.000}	{0.000}		{0.142}	{0.759}
France	0.573***	0.004	-0.117***				48.054	
	{0.000}	{0.170}	{0.000}				{0.179}	
Germany	0.023	0.035***	0.921***	0.076***	0.869***	-324.042	33.864	115.062
	{0.024}	{0.000}	{0.000}	{0.000}	{0.000}		{0.742}	{0.997}
Ireland	0.025**	0.035***	0.921***				36.709	
	{0.023}	{0.000}	{0.000}				{0.619}	
Germany	0.023***	0.051***	0.901***	0.073***	0.915***	1145.669	36.857	336.615***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}		{0.613}	{0.000}
Italy	0.023***	0.053***	0.898***				41.335	
	{0.000}	{0.000}	{0.000}				{0.412}	
Germany	0.486***	0.028**	0.019	0.040***	0.954***	2013.189	50.496	167.194
	{0.000}	{0.034}	{0.487}	{0.000}	{0.000}		{0.124}	{0.332}
Netherlands	0.491***	0.031**	0.005				50.499	
	{0.000}	{0.021}	{0.836}				{0.124}	
Germany	0.381	0.001	0.259	0.011***	0.987***	-2318.232	49.496	97.017
	{0.157}	{0.865}	{0.608}	{0.000}	{0.000}		{0.144}	{0.999}
UK	0.008***	0.020***	0.958***				42.600	
	{0.000}	{0.000}	{0.000}				{0.360}	

*Notes: P values are shown inside the brackets. *, ** and *** denote significance at the 10, 5 and 1% respectively. Q(40) denotes the test for the null hypothesis of no serial correlation up to 40 lags. The statistic is reported for individual squared standardised residuals (ε_t^2's) and the bivariate test on both standardised residuals to test for the adequacy of the Dynamic Conditional Correlation model for variance and correlations. The statistic is asymptotically distributed as $\chi^2(40)$ in the univariate test and $\chi^2(160)$ in the bivariate case.*

Figure 4.4 Time-variations in European bond market integration from DCC-GARCH(1,1) model: 1/7/1998-31/12/2003



The descriptive statistics for the dynamic conditional correlations are shown in Table 4.3. The skewness and excess kurtosis of the dynamic conditional correlations indicate a negatively skewed and fat-tailed distribution. The means for established EU bond markets are almost one signifying extreme interdependence whilst those for Hungary (0.721) and Poland (0.336) indicate medium interdependence and there is higher volatility relative to the established EU bond markets. The Czech Republic appears to be independent of the established EU markets (correlation mean is 0.027) and there is no sign of any changes as it appears to be a very stable process. On the basis of the Ljung-Box Q test statistics up to 40 lags[15], it is clear that serial correlations in the conditional variances and correlations of the standardised residuals have been successfully eliminated in all bivariate estimations except with Belgium and Italy. This suggests that the bivariate dynamic conditional correlation estimations are robust and adequate.

Table 4.3 Descriptive Statistics on DCCs: 8/7/1998 to 31/12/2003.

This table summarizes the descriptive statistics on the dynamic conditional correlation time-series estimated for each sample country from a bivariate version of Engle (2002)'s model.

Country	Mean	Std Error	Skewness	Excess Kurtosis
Czech	0.027	0.017	0.194	9.371
Hungary	0.721	0.184	-1.424	2.601
Poland	0.336	0.110	-0.319	-0.062
Belgium	0.999	0.002	-5.461	39.187
France	0.999	0.001	-1.726	2.652
Ireland	0.989	0.007	-2.249	7.231
Italy	0.997	0.006	-8.565	99.006
Netherlands	0.999	0.001	-2.093	5.117
UK	0.706	0.077	0.151	-1.181

[15] As $\sqrt{N} = \sqrt{1430} \approx 38$, the data has been tested for serial correlation up to 40 lags although this is by no means a definitive rule on lag selection.

4.5 Conclusions

Previous research on European bond market integration has predominantly focused on established EU markets. This chapter has added to the existing body of academic knowledge by examining the evolving nature of the relationship between the MSCI government bond market indices of selected new EU and established EU countries, using a variety of complementary dynamic perspectives. The dynamic nature of the linkages has been comprehensively examined using dynamic cointegration, Haldane and Hall's Kalman filtering method and a bivariate version of Engle (2002)'s Dynamic Conditional Correlation model. As to be expected, they provide a complete picture of government bond market integration in an enlarged EU. This chapter provides robust empirical evidence for strong contemporaneous and dynamic linkages between the existing EU member country government bond markets with that of Germany. For the UK and the three new EU countries of the Czech Republic, Poland and Hungary, however, the linkages proved to be weak and relatively stable over the sample period with the established EU core markets. Of the three new EU government bond markets, the Polish and Hungarian markets are more integrated with the EU core in line with the development of the EU PHARE program initiative which funded these two CEE economies for more structural reforms towards qualifying for EU membership. Overall convergence towards the EMU, so far as it exists, appears to be slow. It appears that the pre-accession measures to achieve economic convergence were insufficient to generate rapid and sustainable integration in government bond markets. Thus, these results suggest that bond market participants believe that the new EU countries are not yet ready to adopt the Euro. In fact, the strength of the new EU markets' financial convergence towards the UK government bond market (revealed by

Kalman filtering results) suggest that changes in EMU monetary policy would not immediately impact on bond yields in the new EU markets, therefore making monetary policy transmission less effective across an enlarged EU. This clearly poses unique challenges for policy makers.

Chapter 5[*]

International Stock and Bond Market Integration and the EMU

[*] A shorter version of this chapter is forthcoming in the *Journal of Banking and Finance*.

5.1 Introduction

The concept of financial market integration is central to the international finance literature and the benefits of economic growth via risk sharing, improvements in allocational efficiency and reductions in macroeconomic volatility and transaction costs are all well accepted (see Pagano, 1993, Obstfeld, 1994, Prasad et al., 2003 and Baele et al., 2004). The topic of financial integration encompasses many different aspects of the complex interrelationships across various financial markets but this chapter focuses on one important aspect on which there is a large empirical literature – the nature and extent of financial interdependence (comovements) across daily asset returns.[1] Whilst international integration within specific financial asset markets has received much attention, the subject of integration *across* different financial asset markets has not, despite its importance for investors' asset allocation and portfolio risk management decisions. This chapter investigates stock and bond market integration over time within a common market jurisdiction as it is motivated by: recent developments on stock-bond return comovements in financial economics; and the historical European Economic and Monetary union (EMU) experience. Comovements in asset market returns provide indirect evidence on financial markets' expectations and their reaction to common information that are priced into different asset types. To one's best knowledge, comovements in stock and bond returns have not been previously interpreted in an inter-financial market integration context and to this end, the main contribution of this chapter is in merging these two separate strands of literature to advance knowledge in

[1] More recent studies include Bekaert and Harvey (1995, 1997), Bracker et al. (1999), Karolyi and Stulz (1996) and Longin and Solnik (1995).

both. Moreover, with the implementation of a currency union and associated stabilization of macroeconomic fundamentals in Europe, this chapter also examines whether there have been any changes in the integration process between stock and bond markets as this has not been addressed in the existing financial market integration literature. By addressing this gap, a better understanding on both the progression of international financial market integration and stock-bond return comovements is achieved.

The nature of stock-bond market comovements has perplexed researchers in financial economics for many years and there have been many attempts to understand their fundamental relationship. Existing stock-bond pricing studies are generally in agreement on *how* stock and bond returns comove over time but not *why* they comove. Early studies to address the latter can be represented by Campbell and Ammer (1993) as they implicitly assume time-invariance in the stock-bond relation, and conclude that observed covariance levels can not be justified by economic fundamentals.[2] Most recently, researchers have recognised and incorporated an element of time-varying risk premia in their investigation. They have established that stock and government bond returns exhibit a modest positive correlation over a long horizon but the relationship is a dynamic one, meaning that the amount of portfolio diversification with a given asset allocation is constantly changing (see for example, Cappiello et al. 2003, Connolly et al.

[2] These works involved variance/covariance decompositions of stock and bond returns into changes in expectations of future stock dividends, inflation, short-term real interest rates and excess stock and bond returns. Within Europe, Engsted and Tanggaard (2001) applied a slightly modified version on Danish stock and bond markets.

2004, Fleming et al., 1998, Li, 2002 and Scruggs and Glabadanidis, 2003). In particular, Cappiello et al. (2003) and Scruggs and Glabadanidis (2003) investigate the asymmetric nature of stock and bond market conditional variances and their comovements. Moreover, the importance of the contemporaneous and lead-lag relations between stock and bond returns for asset pricing purposes are highlighted in Bekaert and Grenadier (2001), Li (2002), Mamaysky (2002) and Scruggs and Glabadanidis (2003). Also in the asset pricing literature, Ilmanen (1995) and Barr and Priestley (2004) find that world stock and bond markets are largely segmented and that further understanding of their joint behaviour is needed.

Informational linkages have formed the basis of most recent theoretical models on time-varying stock-bond return comovements. There are two main channels through which information drives that relationship: 1) Common sources of information influencing expectations in both stock and bond markets at the same time and 2) Sources of information that only alter expectations in one market but spill over into the other market. Informational spillovers between the two markets are the crux of dynamic cross-market hedging studies (see Fleming et al., 1998 and Kodres and Pritsker, 2002) and also the motivation behind analysing comovements in stock and bond market liquidities and the interaction with returns, volatility and order flow in Chordia et al. (2004). It is argued that a shock in one asset market may generate cross-market asset rebalancing and affect the other thereby generating volatility linkages. Generally, government bonds are deemed to be a safe haven for investors engaging in a "flight to quality" in times of financial turmoil. As investors substitute safe assets for their risky ones, bond and stock market returns become negatively correlated (see for example, Chordia et al., 2004, Connolly et al., 2004 and Hartmann et al., 2004). Macroeconomic news announcements have been traditionally viewed as key sources of new information and their impacts on high frequency stock and bond price changes have been assessed considerably (for example, Fair, 2003). Closely related is Ogden (2003)'s investigation into whether seasonalities in macroeconomic activity induce corresponding seasonal patterns in expected stock and bond returns in the US. Most recently, stock market uncertainty has been provided by Connolly et al. (2004) as a key explanation for the stock-bond return relation. They use implied volatilities from equity index options to proxy stock market uncertainty, emphasizing that this should be positively related to economic-state uncertainty in the sense of Veronesi (1999). In his seminal paper, Veronesi suggests that in the state of higher economic uncertainty (as opposed to a state of lower economic uncertainty), new information may receive higher weighting in the stock price formation process, leading to time-variations in stock market volatility. In spite of existing work, the explanation for long-term comovements in stock and bond returns remains conjectural.

This chapter aims to contribute to the plethora of mixed empirical evidence by interpreting stock-bond return comovements in a new light. Stock-bond comovements have traditionally been modelled as statistical contemporaneous correlations or covariances but have not been viewed as an integral aspect of inter-stock-bond market integration. Hence, this chapter extends the empirical framework presented in Chapter 3 to analyse the extent to which international stock-bond market integration has been influenced by the gradual formation of the EMU. It does so by documenting and determining the conditional correlation dynamics between daily stock and bond returns in a bivariate EGARCH model from 2/3/1994 to 19/9/2003 and then utilising these estimated time-series in second-pass regressions. The central hypothesis in this chapter is that the economic policies directed at achieving convergence in exchange rates, monetary stance and the real economy (three channels which have characterised the degree of economic integration across countries *with* the EMU) have been relevant and critical common influences on the extent of systemic stock and bond market integration in Europe and the rest of the world. Furthermore, the investigation in this chapter utilises additional information captured in a seemingly unrelated regression (SUR) to evaluate the significance of these economic channels, amongst seasonal effects.

The new findings presented in this chapter are, as follows. First, as intra-stock and intra-bond market integration with the EMU has strengthened over the sample period, inter-stock-bond market integration has trended downwards to zero and even negative mean levels in most European countries, Japan and the US, consistent with a flight to quality phenomena in international financial markets. Second, cross-market volatilities have overall stabilizing effects but bond market return shocks have more influence. Third, the EMU has *caused* the inter-stock-bond market segmentation dynamics (in a Granger sense) only in European countries. Fourth, real economic integration with the EMU and reduction in currency risk with the introduction of the Euro have generally stimulated inter-financial market integration but increasing monetary policy convergence with the EMU may have created uncertain investor sentiments in the international financial system. Finally, there are no signs of calendar effects in international inter-stock-bond market integration, particularly the January and day of the week effect.[3]

The remainder of this chapter is organized as follows. Section 5.2 introduces the data used for documenting and explaining the dynamics of stock-bond market integration. Section 5.3 focuses discussion on model selection, whilst Section 5.4 considers the progress of financial integration between stock and government bond markets over time. Section 5.5 investigates the causality and determinants of time-varying integration across stock and bond markets. Finally, concluding remarks are made in Section 5.6.

5.2 Data description and statistics

The data used in this chapter consists of daily government bond and stock market index returns and subsequently, various macroeconomic time-series for the purpose of explaining inter-bond-stock market integration dynamics.

5.2.1 Daily Bond and Stock market returns

The introduction of a monetary union in parts of continental Europe has radically changed the global financial architecture, providing a natural experiment on

[3] The January effect, first identified by Rozeff and Kinney (1976) is well documented for major equity markets (Gultekin and Gultekin, 1983) but its presence in other markets is mixed (for example, see Smith, 2002 and Chordia et al., 2004).

international financial market integration. For comparative purposes, the empirical analysis is conducted for a sample set of countries that fall into two distinct groups: 1) Euro zone members that have adopted the Euro as a common currency - France, Germany, Italy, and Spain having the largest and most developed financial markets in the EMU (and hence, comparable stock and government bond markets) and 2) The non-Euro zone countries which include the UK as it has opted to stay out of the EMU and Japan and the US being the other two major financial markets in the world, enabling inferences to be made on the EMU's global impacts.

Employed in this chapter are national total market return share indices from Datastream International and total return government bond indices for maturities greater than 10 years obtained from Bloomberg for the two groups of sample countries.[4] These market indexes have already been utilised in Chapters 3 and 4, respectively. Government bonds with more than 10 years to maturity are used in this chapter to effectively match their duration with stocks, which are generally viewed as relatively long-term investments. The indices are all in local currency units with daily frequency from 2 March 1994 to 19 September 2003 (amounting to 2493 usable observations). The sample period has been determined by the availability of daily bond market indices for all countries in the sample. The continuously compounded market returns examined in this chapter are measured as the natural logarithms of the ratios of successive closing index levels from one trading day to the next such that, $R_{it} = \ln\left(P_t / P_{t-1}\right) \times 100$ for market i on day t.[5] As in Chapter 3, local (unhedged) currency returns are needed to explicitly investigate the impact of changes in exchange rate risk induced by the introduction of the Euro for domestic investors. Also, daily frequency is important given that comovements in the stock and bond returns may often change on a rapid basis as investors shift their asset allocation. Weekly stock and bond return data have been previously used by Cappiello et al. (2003) to model stock-bond return correlations for a sample of European and Australasian countries and the US.

The stock and bond market returns for the entire Euro zone is calculated as the value-weighted average return of those sample EMU markets that have already adopted the Euro. Note that four artificial regional indices are created for the Euro zone by excluding each sample EMU country to avoid spurious intra-regional integration results. The Euro zone return index $R_{E,t}$ excluding each individual stock or bond market i is calculated as shown in equation (5.1):

$$R_{E,t} = \sum_{k \neq i} w_{k,t} R_{k,t} \qquad (5.1)$$

where the weight for stock market returns are the stock market capitalization values and the weight for government bond market returns are the values of annual gross

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[4] Total return on bonds capture the coupon payments that are reinvested back into the bonds forming the index as well as bond price changes and similarly, total return indices on shares account for price changes and dividend reinvestments.

[5] Log changes of total return government bond indices are commonly employed in the literature, see for example, Bodart and Reding (1999) and Driessen et al. (2003).

government liabilities – both in Euro terms. General government gross liabilities were sourced from the OECD whilst stock market capitalization values were extracted from Datastream International (as in Chapter 3). The annual government debt weights applied to the EMU bond market returns are shown in Table 5.1. In relative terms, it appears that the Italian and German governments have been the biggest borrowers in the EMU over the past decade or so.

Table 5.1 Annual Government Debt weights for the EMU, 1992-2003

	FRA	GER	ITA	SPA	Total
1992	0.1991	0.2831	0.4325	0.0852	1.000
1993	0.2104	0.2929	0.4021	0.0945	1.000
1994	0.2148	0.2837	0.4043	0.0972	1.000
1995	0.2233	0.3089	0.3709	0.0970	1.000
1996	0.2257	0.3105	0.3602	0.1037	1.000
1997	0.2296	0.3149	0.3512	0.1043	1.000
1998	0.2357	0.3152	0.3438	0.1053	1.000
1999	0.2344	0.3186	0.3428	0.1043	1.000
2000	0.2382	0.3204	0.3386	0.1028	1.000
2001	0.2412	0.3211	0.3377	0.0999	1.000
2002	0.2466	0.3265	0.3309	0.0960	1.000
2003	0.2517	0.3333	0.3225	0.0926	1.000
Mean	*0.2292*	*0.3108*	*0.3614*	*0.0986*	*1.000*

To provide some perspective before proceeding to the econometric modelling, Table 5.2 reports the statistical properties of the daily bond and stock market returns for each sample country and the (market capitalization) value-weighted average for the Euro zone in each asset market. The full sample statistics are shown in panel A and the pre- and post-Euro sub-sample periods are shown in panels B and C respectively. For the full sample period, bond returns are marginally higher than those for stocks (5 out of 8 cases) but bond returns show significantly lower volatility, consistent with the perceived safe haven status of government bonds. In the sub-sample split, it can be seen that bonds only outperformed stocks in the post-Euro period. This is also consistent with major declines in world equity prices since the collapse of the technology boom in 2001. In the pre-Euro sub-sample period, stock returns exceeded average bond returns for all countries except Italy and Japan. These observations are all consistent with well-documented stylized facts on stock and bond returns (for example, see Connolly et al., 2004, Li, 2002 and Scruggs and Glabadanidis, 2003). It is also revealed in this table that the distributions of these stock and bond market returns are statistically non-normal (indicated by skewness and excess kurtosis statistics that are significantly different from comparable normal distributions) and the standardised return series are highly persistent and conditionally heteroskedastic on the basis of univariate i.i.d. (independent and identically distributed) tests (see Bollerslev et al., 1992). The significance of the joint (bivariate) i.i.d. test statistics for each pair of stock and bond index returns indicates that the first and second moments of these time-series move closely together.[6] Henceforth, modelling of these return series must address the bivariate and fat-tailed nature of these distributions in addition to the high degree of univariate and bivariate serial correlations. The use of a bivariate GARCH model variant will be able to take this into account.

[6] As in Chapters 3 and 4, a bivariate version of the Ljung-Box (portmanteau) Q test for serial correlation devised by Hosking (1980) has been used.

Table 5.2

Statistical properties of daily bond and equity returns (per cent), 2/3/1994-19/9/2003

This table presents in panel A, the summary statistics on daily continuously compounded government bond and stock market index returns for the countries in the sample over the entire sample period. In panels B and C the summary statistics for the pre- and post-Euro sub-sample periods are shown respectively. Asymptotic p-values are shown in the brackets. *, **, *** denote statistical significance at the 10, 5 and 1% level respectively. Test results for H_0:Skewness=0 and H_0:Excess kurtosis=0 are indicated. Q(20) is the Ljung-Box test statistic for serial correlation up to the 20th order in the return series; $Q^2(20)$ is the Ljung-Box Q test statistic for serial correlation up to the 20th order in the squared returns. $Q_b(20)$ and $Q^2_b(20)$ are the bivariate Ljung-Box Q tests for joint white noise in the linear and squared bond and stock returns up to the 20th order. These are asymptotically χ^2 distributed.

	Bond Index Return				Test of univariate iid		Stock Index Return				Test of univariate iid		Test of bivariate iid	
	Mean return	Variance	Skewness	Excess Kurtosis	Q(20): $\chi^2(20)$	$Q^2(20)$: $\chi^2(20)$	Mean return	Variance	Skewness	Excess Kurtosis	Q(20): $\chi^2(20)$	$Q^2(20)$: $\chi^2(20)$	$Q_b(20)$: $\chi^2(80)$	$Q^2_b(20)$: $\chi^2(80)$
Panel A: Total sample period 2/3/1994 - 19/9/03														
FRA	0.032	0.237	-0.284***	2.558***	39.672***	658.256***	0.033	1.672	-0.126**	2.462***	46.873***	1691.335***	99.827*	2477.279***
					{0.005}	{0.000}					{0.001}	{0.000}	{0.066}	{0.000}
GER	0.032	0.276	0.479***	2.316***	27.708	318.654***	0.022	1.588	-0.340***	2.594***	51.849***	1451.574***	102.390**	1782.696***
					{0.117}	{0.000}					{0.000}	{0.000}	{0.047}	{0.000}
ITA	0.050	0.343	-0.642***	4.354***	48.740***	315.785***	0.031	1.915	-0.127 ***	2.247***	50.394***	1038.068***	107.345**	1448.621***
					{0.000}	{0.000}					{0.000}	{0.000}	{0.022}	{0.000}
SPA	0.041	0.228	-0.413***	2.981***	53.986***	530.419***	0.041	1.609	-0.234***	2.361***	44.778***	1281.858***	115.349***	1994.350***
					{0.000}	{0.000}					{0.001}	{0.000}	{0.006}	{0.000}
EMU*	0.039	0.231	-0.497***	1.975***	44.961***	252.617***	0.032	1.378	-0.288***	2.856***	59.729***	1694.770***	130.009***	2000.559***
					{0.001}	{0.000}					{0.000}	{0.000}	{0.000}	{0.000}
UK	0.032	0.253	-0.240***	2.421***	43.472***	216.616***	0.024	1.062	-0.235***	2.703***	70.392***	2417.721***	135.386***	2675.124***
					{0.002}	{0.000}					{0.000}	{0.000}	{0.000}	{0.000}
US	0.032	0.318	-0.389***	1.116***	23.099	123.414***	0.040	1.308	-0.122**	3.408***	32.301**	771.986***	84.864	922.435***
					{0.284}	{0.000}					{0.040}	{0.000}	{0.333}	{0.000}
JAP	0.027	0.178	-0.791***	6.941***	66.629***	1063.162***	-0.011	1.422	-0.007	2.430***	44.122***	339.270***	126.498***	1424.399***
					{0.000}	{0.000}					{0.001}	{0.000}	{0.001}	{0.000}
Panel B: Sub-sample period 1: 2/3/94-31/12/98														
FRA	0.046	0.249	-0.256***	3.493***	67.812***	524.188***	0.060	1.095	-0.226***	3.137***	47.225***	644.323***	110.797**	1261.283***
					{0.000}	{0.000}					{0.001}	{0.000}	{0.013}	{0.000}
GER	0.044	0.264	-0.703***	3.760***	54.657***	251.885***	0.062	1.077	-0.867***	5.381***	81.866***	845.385***	142.528***	1095.219***
					{0.000}	{0.000}					{0.000}	{0.000}	{0.000}	{0.000}
ITA	0.078	0.430	-0.820***	4.877***	52.439***	138.287***	0.070	1.976	-0.094	2.157***	50.538***	655.480***	93.504	900.643***
					{0.000}	{0.000}					{0.000}	{0.000}	{0.143}	{0.000}
SPA	0.061	0.261	-0.482***	3.733***	79.233***	325.431***	0.090	1.369	-0.561***	4.205***	84.546***	936.326***	168.617***	1397.832***
					{0.000}	{0.000}					{0.000}	{0.000}	{0.000}	{0.000}

EMU*	0.058	0.220	-0.694***	3.025***	84.056*** {0.000}	166.973*** {0.000}	0.068	0.922	-0.637***	5.097***	95.543*** {0.000}	1124.467*** {0.000}	187.665*** {0.000}	1336.299*** {0.000}
UK	0.050	0.267	-0.355***	3.959***	38.916*** {0.007}	143.838*** {0.000}	0.056	0.629	-0.227***	2.500***	52.017*** {0.000}	1208.309*** {0.000}	112.953*** {0.009}	1355.691*** {0.000}
US	0.039	0.288	-0.291***	1.534***	35.606** {0.017}	60.104*** {0.000}	0.088	0.769	-0.759***	8.737***	31.309* {0.051}	302.357*** {0.000}	75.673 {0.616}	385.556*** {0.000}
JAP	0.034	0.132	-0.825***	7.256***	61.743*** {0.000}	261.910*** {0.000}	-0.025	1.133	0.251***	3.810***	41.131*** {0.004}	361.192*** {0.000}	119.711*** {0.003}	629.910*** {0.000}
Panel C: Sub-sample period 2: 1/1/99-19/9/03														
FRA	0.019	0.225	-0.327***	1.374***	26.600 {0.147}	97.131*** {0.000}	0.006	2.262	-0.056	1.575***	36.789** {0.012}	689.908*** {0.000}	245.951*** {0.000}	1663.977*** {0.000}
GER	0.019	0.288	-0.273***	1.109***	31.182* {0.053}	96.063*** {0.000}	-0.018	2.109	-0.084	1.211***	36.631** {0.013}	528.853*** {0.000}	164.583*** {0.000}	1308.812*** {0.000}
ITA	0.020	0.251	-0.315***	1.371***	31.628** {0.047}	147.812*** {0.000}	-0.009	1.850	-0.170**	2.355***	30.726* {0.059}	515.490*** {0.000}	155.836*** {0.000}	1378.411*** {0.000}
SPA	0.020	0.194	-0.347***	1.342***	29.678* {0.075}	110.416*** {0.000}	-0.009	1.852	0.010	1.220***	24.010 {0.242}	547.439*** {0.000}	128.812*** {0.000}	1428.634*** {0.000}
EMU*	0.019	0.243	-0.315***	1.142***	31.441** {0.050}	116.862*** {0.000}	-0.005	1.844	-0.106	1.568***	35.882** {0.016}	610.903*** {0.000}	149.452*** {0.000}	1524.872*** {0.000}
UK	0.014	0.238	-0.115	0.480***	32.796** {0.036}	37.010** {0.012}	-0.008	1.505	-0.174**	1.761***	56.114*** {0.000}	904.504*** {0.000}	190.468*** {0.000}	1959.335*** {0.000}
US	0.024	0.349	-0.455***	0.756***	17.218 {0.639}	80.426*** {0.000}	-0.009	1.856	0.125*	1.425***	26.950 {0.137}	232.404*** {0.000}	123.713*** {0.001}	698.711*** {0.000}
JAP	0.019	0.225	-0.729***	5.982***	48.229*** {0.000}	501.105*** {0.000}	0.004	1.720	-0.159**	1.519***	26.980 {0.136}	66.161*** {0.000}	170.321*** {0.000}	1204.029*** {0.000}

Stock and bond market returns for the entire EMU are calculated as the value-weighted average return of the 4 sample Euro zone markets. The weights used for stock and bond returns are stock market capitalization values from Datastream International and annual government gross liabilities sourced from the OECD respectively.

5.2.2 Explanatory Variables

The list of variable definitions and data sources used in this chapter for the real and monetary convergence and exchange rate stability criteria is shown in Table 5.3. First, correlations in nominal short term interest rates, inflation and real short term interest rates are used to proxy convergence in monetary policy, and secondly, the size of the trade sector, intra-regional trade integration and correlations in output and term structure and dividend yield changes proxy the degree of real economic integration. Extending the earlier probe into the link between stock market and economic integration in Chapter 3 provides new insights into the potential determinants of stock and bond return comovements. Lastly, conditional exchange rate volatilities are generated using univariate GARCH(1,1) estimations for the change in local currency : Euro exchange rates to capture past information in exchange rates and associated regimes.[7]

Furthermore, this chapter builds on Connolly et al. (2004)'s US-focused study and uses implied volatilities from equity index options as an additional explanatory variable for economic uncertainty in the European and international financial system. On a geographical basis, the Chicago Board of Options Exchange (CBOE)'s volatility index (VIX) is utilised for explaining inter-stock-bond market integration in the US and Japan and the implied volatilities derived from options on the German DAX equity index (VDAX) for all European countries in the sample.[8]

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[7] The European Currency Unit (ECU) was used prior to the Euro's launch and an implicit 1:1 exchange rate is assumed between the ECU and its replacement, the Euro. As a robustness check, rolling standard deviations over 3 month time windows were also used to proxy exchange rate volatility and there was no qualitative improvement in the regression results.

[8] See Connolly et al. (2004) for details on how these implied volatility indices are constructed.

Table 5.3
Explanatory Variable Definitions and Data Sources

Category	Variable	Frequency	Source	Definition
Exchange Rate risk	EX_VOL	Daily	Datastream	Conditional variance from a GARCH(1,1) model for daily local currency to Euro exchange returns.
	EX_SD*	Daily	Datastream	Rolling standard deviations of daily changes in the foreign exchange rate over the past 3 months (quarter).
Real Convergence (REAL_INT)	OUTPUT	Monthly	IMF/Eurostat	Rolling correlations in annual growth rates of seasonally adjusted industrial production (IP) with the Euroarea equivalent (weighted by annual GDP share prior to Jan. 1999) over the past 3 months (quarter).
	TERM_STRUC	Daily	Datastream	Rolling correlations in the term structure changes (long-term benchmark rates - 1 month LIBOR rates) with Euro area equivalent (weighted by annual GDP share prior to Jan. 1999) over the past 3 months (quarter).
	DIV_YIELD	Daily	Datastream	Rolling correlations for changes in dividend yields with the Euro area equivalent (weighted by stock market capitalization) over the past 3 months (quarter).
	TRADE_OPEN	Monthly	Datastream/IMF	Ratio of total exports plus imports to annual GDP
	TRADE_INT	Monthly	Datastream	Ratio of exports plus imports to/from EMU/EU to total trade
Monetary Policy Convergence (MON_INT)	NOM_SRATE	Daily	Datastream and IMF	Rolling correlations in nominal short-term interest rates (1 month LIBOR rates) with the Euro area equivalent (weighted by annual GDP share prior toJan.1998) over the past 3 months.
	INFLA	Monthly	Datastream and IMF	Rolling correlations in seasonally-adjusted consumer price inflation with the Euro-area equivalent (weighted by annual GDP prior to Jan.1998) over the past 3months.
	REAL_SRATE	Monthly	Datastream and IMF	Rolling correlations in real short-term interest rates (1 month LIBOR rates - inflation) with the Euro area equivalent (weighted by annual GDP share prior to Jan. 1998).
Control	FRI_DUM*	Daily		Indicator is equal to one if that trading day was a Friday, zero otherwise.
	MON_DUM*	Daily		Indicator is equal to one if that trading day was a Monday, zero otherwise.
	JAN_DUM	Daily		Indicator is equal to one if that trading day was in January, zero otherwise.
	EURO_DUM*,**	Daily		Indicator takes a value of one if the Euro has already been introduced on the date ie. from 1st January 1999 onwards, zero otherwise.
	DIV*	Daily	Datastream	Dividend yield levels used to construct DIV_YIELD.
	ST_IRATE*	Daily	Datastream	Nominal short-term interest rates used to construct NOM_SRATE.
	TERM*	Daily	Datastream	Term spreads used to construct TERM_STRUC.
Economic Uncertainty***	UNCERT	Daily	Datastream	Natural logarithm of implied volatilities from equity options index from the Chicago Board of Options Exchange and the German DAX.

5.3 Econometric Model

The aim of this chapter is to examine whether the establishment of the EMU has induced a dynamic change in inter-stock-bond market integration by making inferences from the behaviour of their daily conditional volatility interdependencies and time-varying conditional correlations. Fundamentally, it extends the two-step regression methodology introduced in Chapter 3 to include principal components and is applied to examine financial market integration across asset markets.

Whilst the use of conditional econometric models capable of capturing asymmetric volatility has proliferated in stock market studies, government bond markets have not been dealt with in the same way.[9] As Scruggs and Glabadanidis (2003) strongly rejected symmetric models of conditional second moments for stock and bond returns, the joint return generating process of stock and bond markets are modelled in this chapter with a bivariate exponential generalised auto-regressive conditional heteroskedasticity (EGARCH) model. However, instead of the customary assumption of a bivariate normal density function for the residuals, which is generally inadequate for modelling financial time-series that are leptokurtotic, a bivariate student's *t* conditional density function for the residuals is applied, to explicitly account for positive and negative innovations and fat tails in returns. As mentioned in Chapter 2, previous studies like Bollerslev (1987) have found that the logarithmic specification in Nelson (1991)'s EGARCH model with a suitable distributional assumption fits financial

[9] See Bekaert and Wu (2000) and Wu (2001) for a survey of asymmetric volatilities in stock market studies and an exposition of the leverage and volatility feedback effects.

data well.[10] The implementation of this with the estimated variance-covariance matrix H_t and D degrees of freedom assumed for the joint distribution of the innovation vector is as discussed in section 3.2.2. The advantage of employing this bivariate student's *t*-conditional density for the residuals is that the unconditional leptokurtosis observed in most high-frequency asset price data sets can appear as conditional leptokurtosis and still converge asymptotically to the Normal distribution as D (the degrees of freedom) approaches infinity or 1/D to zero (usually in lower-frequency data). This provides added flexibility to the methodology employed in this chapter to jointly model stock and bond returns.

A bivariate EGARCH-*t* model with time-varying conditional correlations is certainly a worthwhile methodological contribution to the existing stock-bond comovement literature. The employment of regime switching models by Connolly et al. (2004) and Gulko (2002) requires volatility states to be probabilistically set and estimation results from asymmetric dynamic conditional correlation models in Cappiello et al. (2003) and Scruggs and Glabadanidis (2003) are not so easy to interpret. Moreover, the EGARCH process is supported by the theoretical underpinnings of Fleming et al. (1998)'s trading model of informational linkages between stock and bond markets. Furthermore, cross-market volatility interdependencies within individual countries have never been extensively investigated but in a bivariate EGARCH model for stock and bond market returns, the volatility spillover effects can be quantified to fill this gap in the literature. Existing studies have generally assessed volatility linkages and correlation dynamics in stock and bond markets outside of the US separately, to infer

[10] Formulation of logarithmic conditional variances also overcomes the need for non-negativity constraints to ensure positive definite covariance matrices.

interdependence from the timing of changes in both markets (see for example, Bodart and Reding, 1999 and Capiello et al., 2003).

In this chapter, the conditional first moments (means) of the stock and bond market index returns are estimated as a parsimonious restricted bivariate Auto-Regressive Moving Average - ARMA(p,q) process as shown in equations (5.2) to capture the dynamics between mean bond and stock market returns for each individual country and for completeness, the Euro zone (weighted average of the four EMU members).

$$\begin{aligned} R_{B,t} &= \alpha_B + \sum_{i=1}^{p_S} \alpha_{rS,i} R_{S,t-i} + \sum_{j=1}^{q_B} m_{B,j}\varepsilon_{B,t-j} + \varepsilon_{B,t} \\ R_{S,t} &= \alpha_S + \sum_{i^*=1}^{p_B} \alpha_{rB,i^*} R_{B,t-i^*} + \sum_{j^*=1}^{q_S} m_{S,j^*}\varepsilon_{S,t-j^*} + \varepsilon_{S,t} \end{aligned} \tag{5.2}$$

with

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{B,t} \\ \varepsilon_{S,t} \end{bmatrix} = \varepsilon_t \left| I_{t-1} \sim t(0, H_t, D) \right.,$$

$$H_t = \begin{bmatrix} h_{B,t} & h_{BS,t} \\ h_{SB,t} & h_{S,t} \end{bmatrix}$$

I_{t-1} = Information set available at $t-1$

where, $R_{B,t}$ is the bond market conditional mean return and is a function of past returns in the stock market and its own past idiosyncratic shocks, $\varepsilon_{B,t}$; and $R_{S,t}$ is the stock market conditional mean return that is a function of past returns in the bond market and its own past shocks, $\varepsilon_{S,t}$. To prevent over-parameterization in the conditional mean equations, the bivariate ARMA has been restricted such that past cross-market performance and past own market performance is captured by auto-regressive (AR) and moving average (MA) terms respectively. Note that p_B and p_S are the number of AR terms and q_B and q_S are the number of MA terms needed to eliminate univariate and bivariate serial correlations in the standardised residuals, $\frac{\varepsilon_{B,t}}{\sqrt{h_{B,t}}}$ and $\frac{\varepsilon_{S,t}}{\sqrt{h_{S,t}}}$, which are jointly t distributed.

The conditional second moments (variances) of the estimated model are estimated as equations (5.3)

$$\ln h_{B,t} = \beta_{cB} + \beta_{hB} \ln h_{B,t-1} + \left[\beta\varepsilon_{B1} \frac{\varepsilon_{B,t-1}}{\sqrt{h_{B,t-1}}} + \beta\varepsilon_{B2} \left(\frac{|\varepsilon_{B,t-1}|}{\sqrt{h_{B,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{S1} \frac{\varepsilon_{S,t-1}}{\sqrt{h_{S,t-1}}} + \beta_{S2} \left(\frac{|\varepsilon_{S,t-1}|}{\sqrt{h_{S,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right]$$

$$\ln h_{S,t} = \beta_{cS} + \beta_{hS} \ln h_{S,t-1} + \left[\beta\varepsilon_{S1} \frac{\varepsilon_{S,t-1}}{\sqrt{h_{S,t-1}}} + \beta\varepsilon_{S2} \left(\frac{|\varepsilon_{S,t-1}|}{\sqrt{h_{S,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] + \left[\beta_{B1} \frac{\varepsilon_{B,t-1}}{\sqrt{h_{B,t-1}}} + \beta_{B2} \left(\frac{|\varepsilon_{B,t-1}|}{\sqrt{h_{B,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right]$$

(5.3)

which permits the conditional variance of each asset market to be determined by its own past variance and its own negative and positive past unanticipated return shocks (coefficients on these terms indicate the asymmetric ($\beta\varepsilon_{B1}$, $\beta\varepsilon_{S1}$) and volume ($\beta\varepsilon_{B2}$, $\beta\varepsilon_{S2}$) effects respectively[11]) as well as those return shocks from the other asset market (similarly, β_{S1} and β_{B1} indicate the cross-market asymmetric effects whilst β_{S2} and β_{B2} indicate the cross-market volume effects). Volatility spillover effects in the conditional variances are explicitly modelled in this joint stock and bond market model as their cross-market volatility interdependencies have not been previously investigated using

[11] A negative (positive) sign for the asymmetric effect implies higher (lower) conditional variance in response to an unanticipated fall in the underlying asset market return in the previous time period. A positive (negative) volume effect suggests an increase (fall) in the conditional variance in response to an unanticipated change of either sign in the underlying return in the previous period – larger the shock, higher the conditional variance.

estimated parameter values.[12] This is a clear advantage of using the bivariate EGARCH model in this chapter. Importantly, the conditional covariance between bond and stock market returns are allowed to vary across time to capture the time-varying nature of the inter-market financial integration process. This is not only theoretically justified by the dynamic nature of financial market integration but it also builds on Scruggs and Glabadanidis' (2003) rejection of a constant correlation restriction on the covariance matrix between US stock and bond returns. The conditional covariance equation used is shown below: [13]

$$h_{BS,t} = \delta_0 + \delta_1\sqrt{h_{B,t}.h_{S,t}} + \delta_2 h_{BS,t-1} \tag{5.4}$$

where the dynamics have been modelled based on the cross-product of standard errors of the stock and bond market returns and past conditional covariance. Hence, by definition the time-varying conditional correlations can be computed as the time-variations in standardised covariance as shown in equation (5.5). This time-series can be used to indicate the level of comovement between stock and bond market returns. Moreover, this contemporaneous conditional correlation time-series can be interpreted to provide an historical time path for the integration process between stock and bond

[12] In the literature, Kroner and Ng's (1998) multivariate generalisations of Engle and Ng's (1993) news impact curves have been commonly utilised to investigate this.

[13] Various alternative specifications for the covariance structure, have been estimated in addition to the current form to ensure that the results obtained are robust to different functional forms for the conditional covariance parameterization. In general, alternative specifications made no qualitative differences to the time-varying conditional correlations from the bivariate EGARCH-t model.

markets due to the pricing of common information that is indirectly reflected in this measure at any point in time.[14]

$$\rho_{BS,t} = \frac{h_{BS,t}}{\sqrt{h_{B,t}.h_{S,t}}} \tag{5.5}$$

The next section will show that this econometric model is well suited to the joint modelling of bond and stock returns and offers deeper insights into the dynamics of international inter-stock-bond market integration.

5.4 International Stock-Bond market integration: Country level evidence

This section will show the extent to which international stock and bond markets have been integrated both inside and outside of the EMU over the sample period. Whilst stock and bond return comovements have been assessed by Scruggs and Glabadanidis (2003) using US data; and regional and cross-country stock-bond return correlations have been analysed by Cappiello et al. (2003) using the EMU, Australasia and the US, to one's best knowledge there has not been an international study on stock-bond-market comovements at the country level. Thus, the evolution of integration in each sample country is first assessed using graphs of the estimated conditional correlations from the bivariate EGARCH model. The section then proceeds to analyse the volatility linkages estimated between sample stock and bond markets using estimated parameters from the EGARCH model. This is a new approach to better understanding the nature of cross-market volatilities.

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[14] Whilst it is recognised that interdependence in asset returns is not a definitive condition for financial market integration, in an empirical context this is a good proxy as it does not involve joint tests of any

5.4.1 Inter-market time-varying Conditional Correlations

Figure 5.1 contains graphs of the estimated dynamic inter-stock-bond conditional correlations for each of the sample Euro zone countries (on the left-hand column) and the weighted average of these Euro zone countries and also for non-Euro zone countries (on the right-hand column).[15] There appears to be significant variations in the conditional correlations of stock and bond returns over the sample period.

The most striking conclusion from these pictures is that since the mid 1990s integration has been falling between these two major financial segments in Europe and in the rest of the world to zero mean levels (consistent with the behaviour of Cappiello et al., 2003's regional level stock-bond correlations over the same time period), with the exception in Italy where comovements between the two financial markets have been strengthening since 2000 and also Japan where the series has gyrated around a low negative correlation level (around -0.2) over the sample period. This is new country-level evidence on European cross-market integration as Cappiello et al. (2003) previously assessed *cross-country* inter-stock-bond correlations between Germany, France, Italy and the UK and found strong increases between all EMU countries around 1999 when the Euro was introduced. This sustained period of inter-stock-bond market segmentation cannot be attributed to the demise of the tech bubble in the late 1990s as it

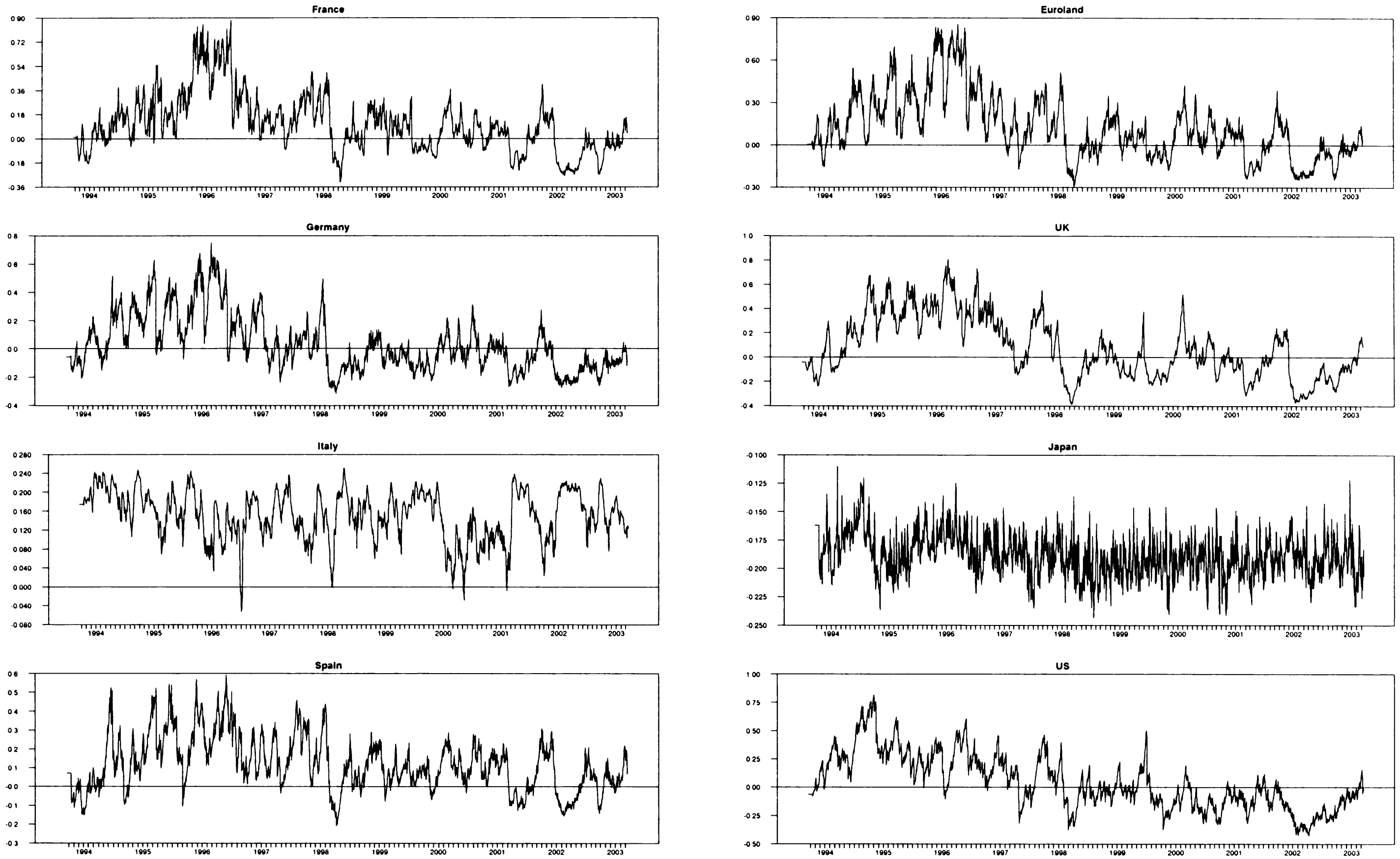
asset pricing model and market integration.

[15] A caveat of this analysis is the implicit assumption of same risk levels associated with investing in stocks and government bonds. Hence, the EGARCH model has also been estimated with excess stock returns (risk premia) to adjust for risk and the results are qualitatively similar for most countries except the US (see Figure A.2 in the Appendices).

began earlier on in the decade. The introduction of the Euro amongst EMU members may have had different demand effects on stocks and bonds. However, asset market segmentation can perhaps be explained in the context of a flight to quality hypothesis in the existing literature: investors' uncertainty in the future of the EMU and the macroeconomic fundamentals under the new exchange rate regime has resulted in investors flocking to the government bond markets (perceived safe havens) as evidenced by the declining correlations in bond and stock returns. This is certainly plausible given the poor economic performance of the larger member countries since the EMU's inception. However, for the historically volatile Italian financial markets, the monetary union has instead been perceived by investors in the post-Euro time period to reduce macroeconomic uncertainty and has thus increased comovements between stock and bond returns. This is supported by Morana and Beltratti (2002)'s finding that Italy's stock market volatility has dampened with the introduction of the Euro. These two explanations are also consistent with the fundamental approach represented by Campbell and Ammer (1993) in which a differential response to inflation expectations in the pricing of these two securities may induce low correlations as inflation is generally viewed as bad news for bonds and ambiguous news for stocks. Furthermore, consistent with the stylized fact of negative stock and bond return correlations in times of financial turmoil (for example, see Chordia et al., 2004 and Hartmann et al., 2004) it is not surprising that Japan exhibits a stable negative correlation level over the sample period given its enduring financial problems over the sample period since the start of the 1990s. Finally, using unconditional stock-bond return correlations over 22 trading day periods, Connolly et al. (2004) showed that negative correlations were more likely when stock market uncertainty (that is, economic uncertainty) was high. This also lends support for this explanation.

Figure 5.1 Time-varying integration between Bond and Stock returns: 2/3/1994 -19/9/2003

This figure shows the estimated inter-stock-bond conditional correlations from the bivariate EGARCH-*t* model. They indicate the evolution of inter-market integration between stock and government bond markets over time for each sample Euro zone country (LHS) and the weighted average of these for Euroland and also for non-Euro zone countries (RHS).



5.4.2 Intra-market time-varying Conditional Correlations with the EMU

Probing further into the EMU's influence on the observed segmentation trend in international stock-bond markets, Figure 5.2 provides some evidence on how the two individual financial segments have been integrating with the EMU region (that is, intra-market financial integration, as documented in Chapters 3 and 4). A similar bivariate EGARCH-*t* model with time-varying conditional correlations is estimated using national and value-weighted Euro zone asset returns (as in Chapters 3 and 4) instead of same country bond and stock returns.[16] Hence, in Figure 5.2 the historical path of conditional correlations between bond market returns are shown on the left hand side column (to proxy intra-bond market integration with the EMU) and those for stock market returns are depicted on the right hand side column (to proxy intra-stock market integration with the EMU).[17]

As Connolly et al. (2004) explained, Forbes and Rigobon (2002)'s critique on heteroskedastic bias of underlying volatilities can not be responsible for extended periods of negative correlation observed between stock and bond returns, when the two are normally positively correlated. To some extent, this is also supported by the second facet of the time-varying integration investigation in that it is not apparent that the downward stock-bond correlation trends have resulted from diverging integration trends in either of the two underlying financial segments.

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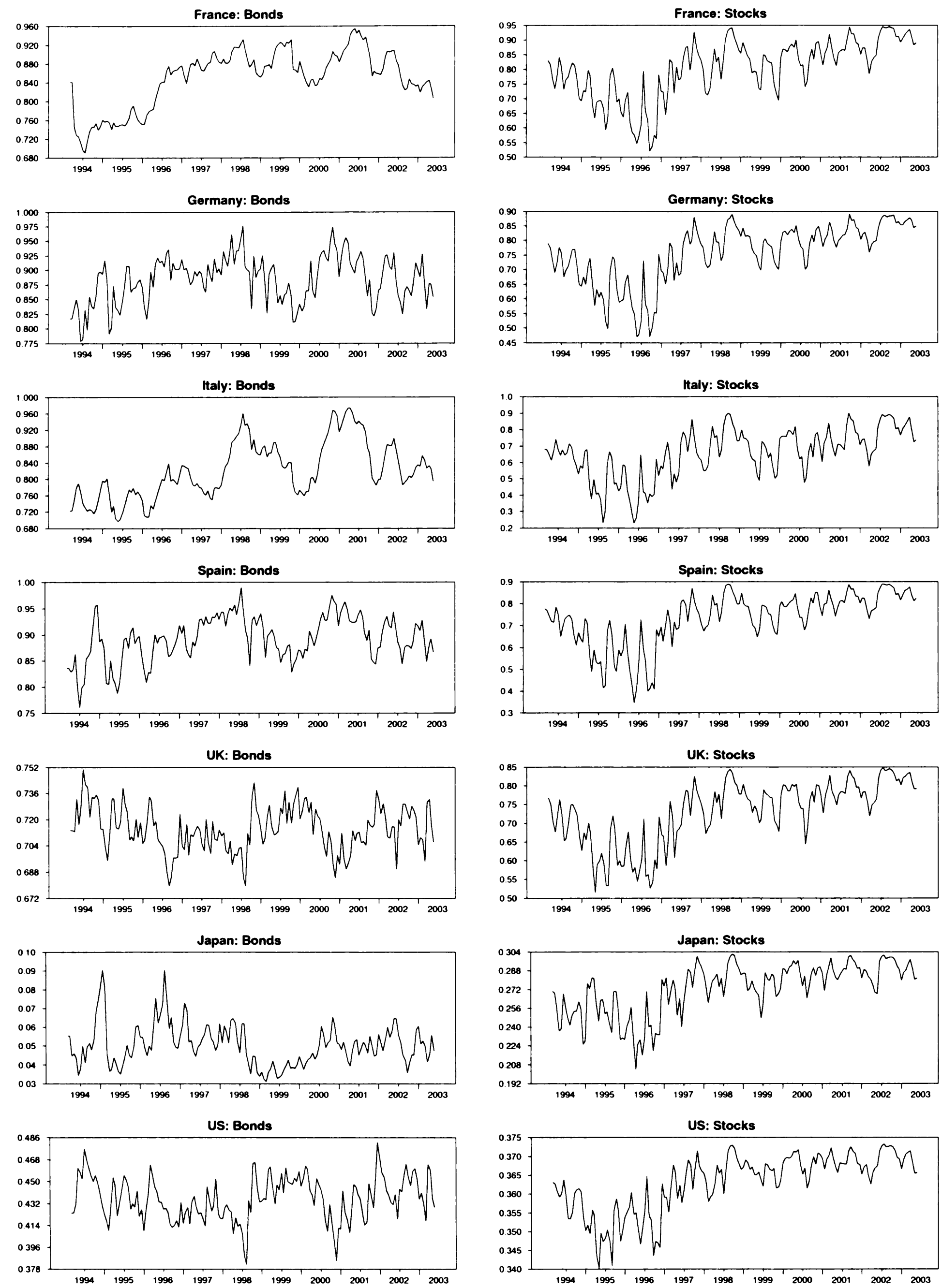
[16] To avoid spurious integration results from the bivariate EGARCH estimations, EMU regional indices are generated separately for stock and bond markets to exclude individual sample EMU countries in the weighted average calculation.

[17] The underlying estimation results for intra-market integration with the EMU are not reported as they are not the key focus of this chapter (unlike Chapters 3 and 4).

Figure 5.2 Time varying integration with the EMU in Government Bond (LHS) and Stock (RHS) markets: 2/3/1994 -19/9/2003

This figure illustrates the evolution of intra-market integration with the Euro region for national government bond markets (LHS) and stock markets (RHS) using estimated conditional correlations.



In Figure 5.2, it is clear that international stock markets had rapidly integrated with EMU stock markets in the two to three years leading up to the formal introduction of the Euro, corroborating with the finding in Chapter 3 on stock market integration and also increases in Cappiello et al. (2003)'s average contemporaneous correlation calculations for stock markets. However, compared to the series of intra-stock market conditional correlation charts, those for intra-bond markets are relatively heterogeneous but consistent with the findings on established EU government bond markets in Chapter 4. By construction, the four Euro zone bond markets are highly correlated with the Euro zone regional bond index return as evidenced by the extremely high conditional correlation levels (ranging from 0.65 to almost 1.0). However, the synchronization of monetary policy necessary for the effective introduction of the single currency has no doubt also contributed to this. Not surprisingly, outside of the Euro zone the United Kingdom's government bond market is the most correlated with the core Euro zone market index (correlations range 0.68 - 0.75), followed by the United States (0.38 - 0.48) and then Japan (0.03 – 0.09). There has generally been an upward trend in intra-bond market integration with the core Euro zone in part of the sample period for all sample countries. For the four EMU countries, bond markets had become integrated even earlier than the stock markets but they appear to have plateaued from mid 1998. This is consistent with existing European financial market studies that generally find the single currency and monetary policy had influenced government bond markets in the EMU even before the Euro was officially launched in 1999 (for example, see Galati and Tsatsaronis, 2003). Outside of the EMU, the UK, the US and Japanese bond markets have been slower to integrate with the EMU but a slight upward trend in the integration of international bond markets has emerged as the introduction of the fixed exchange rate regime (EMU) became imminent. This is also supported by increases in Cappiello et al. (2003)'s average correlation calculations for bond markets. While international stock and bond markets have become more intricately linked with the Euro zone markets, this international financial development has segmented stock and bond markets at the country level. This suggests that macroeconomic developments associated with the EMU should explain inter-stock-bond market integration dynamics.

5.4.3 Estimated Volatility Linkages

The bivariate estimation results for the EGARCH-*t* model with volatility spillovers are shown in Table 5.4. The coefficients for the lagged conditional variance terms (β_{hB} and β_{hS}) are very close to one for all pairs of bond and stock index returns indicating a high level of persistence in shocks to the conditional volatility (but the conditional variances are not integrated) and hence, the appropriateness of a GARCH framework.[18] The diagnostics for the maximum likelihood estimations are provided at the bottom of Table 5.4. The joint conditional *t* density function assumed for the stock and bond market innovations converged asymptotically to the Normal distribution as D (D being degrees of freedom) was very large and significant in all cases.[19] The Ljung-Box Q statistics show that both univariate and bivariate serial correlation have been successfully removed for all countries. This eliminates potential biases in the estimates presented. Furthermore, the high level of significance for terms in the covariance equations (also shown in Table 5.4) strengthens one's confidence in the validity of the conditional correlation time-series illustrated in Figure 5.1.

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[18] As a robustness check, this model was also estimated with the conditional variance included in the mean equations (EGARCH-M) but these terms were found to be insignificant for most markets.

Table 5.4

Bivariate-ARMA-EGARCH-t Model Estimations for bond and stock returns with conditional volatility spillovers

In this table, the results of the bivariate EGARCH estimations are reported. The bivariate EGARCH model for each country, as defined from equations (5.2) to (5.4):

$$R_{B,t} = \alpha_B + \sum_{i=1}^{p_S} \alpha_{rS,i} R_{S,t-i} + \sum_{j=1}^{q_B} m_{B,j}\varepsilon_{B,t-j} + \varepsilon_{B,t};\; R_{S,t} = \alpha_S + \sum_{i^*=1}^{p_B} \alpha_{rB,i^*} R_{B,t-i^*} + \sum_{j^*=1}^{q_S} m_{S,j^*}\varepsilon_{S,t-j^*} + \varepsilon_{S,t}$$

$$\ln h_{B,t} = \beta_{cB} + \beta_{hB}\ln h_{B,t-1} + \left[\beta\varepsilon_{B1}\frac{\varepsilon_{B,t-1}}{\sqrt{h_{B,t-1}}} + \beta\varepsilon_{B2}\left(\frac{|\varepsilon_{B,t-1}|}{\sqrt{h_{B,t-1}}} - \sqrt{\frac{2}{\pi}}\right)\right] + \left[\beta_{S1}\frac{\varepsilon_{S,t-1}}{\sqrt{h_{S,t-1}}} + \beta_{S2}\left(\frac{|\varepsilon_{S,t-1}|}{\sqrt{h_{S,t-1}}} - \sqrt{\frac{2}{\pi}}\right)\right],$$

$$\ln h_{S,t} = \beta_{cS} + \beta_{hS}\ln h_{S,t-1} + \left[\beta\varepsilon_{S1}\frac{\varepsilon_{S,t-1}}{\sqrt{h_{S,t-1}}} + \beta\varepsilon_{S2}\left(\frac{|\varepsilon_{S,t-1}|}{\sqrt{h_{S,t-1}}} - \sqrt{\frac{2}{\pi}}\right)\right] + \left[\beta_{B1}\frac{\varepsilon_{B,t-1}}{\sqrt{h_{B,t-1}}} + \beta_{B2}\left(\frac{|\varepsilon_{B,t-1}|}{\sqrt{h_{B,t-1}}} - \sqrt{\frac{2}{\pi}}\right)\right]$$

$$h_{BS,t} = \delta_0 + \delta_1\sqrt{h_{B,t}.h_{S,t}} + \delta_2 h_{BS,t-1}$$

D is the degrees of freedom in a student t distribution for the two joint error processes. -Ln L is the negative estimated value of log-likelihood. P-Values are shown in the brackets.*, **, *** denote significance at the 10%, 5% and 1% level respectively. $Q_b(10)$ and $Q^2_b(10)$ are the bivariate Ljung-Box Q tests for joint white noise in the linear and squared standardised residuals up to the 10^{th} order.

[19] A normal log density function was also assumed but there was little difference in the estimates due to the joint student *t* log density's ability to accommodate normal distributions.

Table 5.4 continued

	Eurozone					Non-Eurozone		
	FRA	GER	ITA	SPA	EMU	UK	JAP	US
Mean: R_B								
α_B	0.041***	0.044***	0.052***	0.051***	0.047***	0.040***	0.038**	0.040***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.011}	{0.000}
α_{rS}	0.008	0.013**	0.034***	-0.141	0.020***	-0.003	0.002	0.023**
	{0.174}	{0.015}	{0.001}	{0.196}	{0.003}	{0.728}	{0.669}	{0.035}
P_S	4	1	1	1	4	1	1	1
Q_B	5	1	1	1	1	1	1	1
Vol.: R_B								
β_{cB}	-0.084	-0.041**	-0.015	-0.057**	-0.076***	-0.057***	-0.070***	-0.012
	{0.101}	{0.014}	{0.415}	{0.024}	{0.003}	{0.000}	{0.000}	{0.254}
β_{hB}	0.943***	0.967***	0.980***	0.963***	0.950***	0.958***	0.963***	0.988***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
$\beta_{\varepsilon B1}$	-0.006	0.010	-0.003	-0.005	0.001	0.015	-0.008	0.026**
	{0.686}	{0.493}	{0.884}	{0.672}	{0.962}	{0.183}	{0.458}	{0.026}
$\beta_{\varepsilon B2}$	0.097**	0.121***	0.138***	0.127***	0.116***	0.101***	0.226***	0.062***
	{0.042}	{0.000}	{0.002}	{0.008}	{0.000}	{0.000}	{0.000}	{0.000}
B_{S1}	0.017	-0.014	-0.017	-0.008	0.002	-0.002	0.060***	0.032**
	{0.305}	{0.335}	{0.476}	{0.634}	{0.849}	{0.897}	{0.000}	{0.014}
B_{S2}	-0.008	0.002	0.045	-0.034*	-0.023	-0.063***	-0.002	-0.015
	{0.710}	{0.942}	{0.210}	{0.057}	{0.157}	{0.003}	{0.914}	{0.354}
Mean: R_S								
α_S	0.044**	0.021*	0.029	0.048**	0.020**	0.027**	-0.032	0.043***
	{0.034}	{0.082}	{0.343}	{0.014}	{0.042}	{0.030}	{0.144}	{0.000}
α_{rB}	-0.010	0.179***	0.029	0.189	0.042*	0.025	-0.053	0.066***
	{0.634}	{0.000}	{0.280}	{0.152}	{0.078}	{0.198}	{0.248}	{0.003}
P_B	4	1	1	1	2	1	1	1
Q_S	0	1	1	1	1	1	1	1
Vol.: R_S								
β_{cS}	0.001	0.005***	0.022***	0.001	0.001	-0.002*	0.010**	-0.001
	{0. 229}	{0.000}	{0.000}	{0.199}	{0.123}	{0.070}	{0.042}	{0.573}
β_{hS}	0.989***	0.981***	0.962**	0.993***	0.990***	0.994***	0.982***	0.992***
	{0.000}	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
$\beta_{\varepsilon S1}$	-0.037***	-0.072***	-0.050***	-0.025***	-0.044***	-0.066***	-0.057**	-0.074
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.155}
$\beta_{\varepsilon S2}$	0.089***	0.169***	0.204***	0.065***	0.121***	0.076***	0.113***	0.062***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
B_{B1}	-0.009**	0.004	0.006	0.022***	0.019***	0.027***	0.005	0.019**
	{0.045}	{0.669}	{0.608}	{0.000}	{0.000}	{0.000}	{0.719}	{0.011}
B_{B2}	-0.079***	-0.012	-0.014	-0.053***	-0.056***	-0.032***	0.035**	-0.062***
	{0.000}	{0.512}	{0.598}	{0.000}	{0.000}	{0.000}	{0.019}	{0.000}
Covariance								
δ_0	0.031***	0.084***	-0.061	0.171***	0.207***	0.374***	0.005	0.599***
	{0.000}	{0.000}	{0.282}	{0.000}	{0.000}	{0.000}	{0.716}	{0.000}
δ_1	-0.054***	-0.161***	0.258***	0.473**	0.393***	-0.832***	-0.158***	-1.070*
	{0.000}	{0.000}	{0.000}	{0.038}	{0.000}	{0.001}	{0.000}	{0.072}
δ_2	0.952***	0.595***	0.004	0.401***	0.333***	-0.248***	0.256	-0.143
	{0.000}	{0.000}	{0.981}	{0.000}	{0.000}	{0.000}	{0.108}	{0.355}
Diagnostics								
D	2321.467***	2029.673***	176.446***	357.304***	3403.337***	8724.01***	41.910***	5443.852***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.005}	{0.000}	{0.000}
-Ln L	5253.529	5385.608	5998.695	5191.258	4901.651	4741.537	4670.389	5340.717
$Q_b(10)$:	36.664	28.450	46.172	29.640	34.874	49.125	43.460	25.080
$\chi^2(40)$	{0.621}	{0.914}	{0.232}	{0.885}	{0.700}	{0.153}	{0.326}	{0.969}
$Q^2_b(10)$:	24.361	30.391	34.897	49.947	35.845	32.400	17.131	45.467
$\chi^2(40)$	{0.121}	{0.864}	{0.699}	{0.135}	{0.216}	{0.798}	{0.999}	{0.255}

Whilst the conditional volatility of stock market returns display significant asymmetric and volume effects with the appropriate signs for its own return shocks, bond market conditional volatility generally does not exhibit an asymmetric response to its own unexpected shocks. This was also discovered by Scruggs and Glabadanidis (2003) and Cappiello et al. (2003) but the bivariate EGARCH methodology is better able to quantify both asymmetric (sign) and volume (magnitude) effects on conditional variances as estimated EGARCH parameters can be directly interpreted instead of relying on the shape of news impact surfaces (for example, see Kroner and Ng, 1998 and Engle and Ng, 1993). Fundamentally, the results presented are consistent with these previous studies on conditional stock-bond comovements but new findings emanate in this chapter due to different time periods, sample countries and methodologies used from existing studies. Like Scruggs and Glabadanidis (2003), this study finds that conditional stock market volatilities are relatively more responsive to bond market return shocks than conditional bond market volatilities are to stock market return shocks, but bond market conditional variances are not completely unresponsive to stock market return shocks. The asymmetric effect is significantly positive for Japan and the US and the volume effect is significantly negative for Spain and the UK which is contrary to the well-known findings for stock markets and is a new result with an international aspect. This pattern in cross-market return shocks is repeated more strongly for conditional stock market variances. This means that generally, an unexpected rise in one asset market has a bigger stabilizing effect on the other asset market's conditional volatility than unexpected falls but this is offset to some extent by systemic rises in financial market volatility when there is a shock in either market. This new result on cross-market volatility interdependence sits well with the flight to quality hypothesis as it provides indirect evidence that when positive news hits one asset market, volatility is dampened in the other as investors tend to stick with their asset allocations but when negative news hits, investors tend to switch towards perceived 'quality' investments thereby increasing cross-market volatility.

Furthermore, it is revealed that cross-market volatility spillovers are mostly unilateral for Euro zone markets in that only shocks in bond market returns affect stock market volatility and not vice versa. However, for non-Euro financial markets, volatility spillovers are bilateral in that unanticipated return shocks in both bond and stock markets affect the other. This is another new finding in this country level study and suggests that common information affects non-Euro stock and bond markets simultaneously whilst in the Euro zone, information appears to change expectations in the bond market initially and this is then transmitted to stock markets, perhaps through portfolio rebalancing. A key explanation for this is the common sensitivity of EMU bond markets to the official level of interest rates (monetary policy stance) set by the European Central Bank (ECB) for all EMU members and this result has clear policy implications.

In Table 5.4, the coefficients on lagged mean cross-market returns are generally significant and positive indicating positive return spillover effects between bond and stock markets. This is also consistent with the flight to quality phenomenon as when stock market returns fall, investors tend to flock and bid up the price of government bonds and the inverse relationship with yields will cause a subsequent fall in bond returns to result. Hence, there is compelling support for the flight to quality explanation for the observed financial segmentation between stock and bond markets over the sample period on the basis of estimated return and volatility linkages in the bivariate EGARCH-*t* model.

The remainder of this chapter will investigate the underlying macroeconomic forces at play in driving the international stock and bond market segmentation process, as evidenced by declining conditional correlations estimated between country level stock and bond returns over the sample period associated with the formation of the EMU.

5.5 Determinants of International Stock-Bond market integration

This section builds on the work already presented in this chapter as part of an overall two-step estimation methodology to determine the EMU's influence on international stock and bond market segmentation (similar to that used in Chapter 3). First, tests for causality between the European currency unification experience and international stock-bond market integration are conducted to facilitate the context and subsequent modelling strategy. Finally, the secondary systems regression step will be discussed and results provided and then confirmed with a robustness check using a stock market uncertainty measure.

5.5.1 Causality: Financial Market Integration and Currency Union Formation

The state of uncertainty surrounding the causality link between financial market integration and currency union formation has already been illuminated in Chapter 3. As previously stressed, it is important to establish the sequence of events in financial market integration/segmentation in order to facilitate the econometric model selection and more importantly, the validity of this investigation. This chapter will extend Chordia et al. (2004)'s investigation on Granger-causality between spreads, returns, volatility and order flows in US stock and bond markets since causality has not been previously addressed in international financial market integration studies. This chapter provides Granger causality evidence using the correlations in short term (1 month LIBOR) interest rates with the equivalent for the Euro region, as a proxy for the currency union formation (EMU_t)[20] and the estimated time-varying conditional correlations (discussed in section 5.4.1) to proxy inter-stock-bond market integration ($\rho_{BS,t}$). It is obvious that next to a Euro dummy tested in Chapter 3, changes in the short term interest rate is the time-series that would capture the introduction of the EMU most directly as confirmed by near perfect correlations for the sample EMU members since the formal launch of the Euro at the beginning of 1999.

Based on the premise that the future cannot cause the present or the past, the Granger-causality test is based on whether the coefficients of (lagged) EMU_{t-i} are all significantly different from zero in equation (5.6), ie. H_0: $\sum_{i=1}^{p} \alpha_i = 0$. Similarly, it also tests whether the coefficients of $\hat{\rho}_{BS,t-i}$ are different from zero in equation (5.7), ie. H_0: $\sum_{i=1}^{p} \gamma_i = 0$.

[20] The time window over which correlations are computed has been varied from a quarter, to 6 months and then a year as robustness checks of the causality conclusions. The results do not qualitatively differ.

$$\hat{\rho}_{BS,t} = \sum_{i=1}^{p} \alpha_i EMU_{t-i} + \sum_{i=1}^{p} \beta_i \hat{\rho}_{BS,t-i} + u_{1t} \qquad (5.6)$$

$$EMU_t = \sum_{i=1}^{p} \gamma_i \hat{\rho}_{BS,t-i} + \sum_{i=1}^{p} \delta_i EMU_{t-i} + u_{2t} \qquad (5.7)$$

The Granger-causality test results between these two time series are presented in Table 5.5. The F and p values associated with these tests for each sample country are shown.

Table 5.5
Granger Causality Test Results for Inter-Stock-bond Market Integration

In panel A of this table, results of the Granger-causality tests between inter-stock-bond market integration (ρ_{BS})and the implementation of the EMU (*EMU*) are reported for all countries in the Euro zone and the results for the UK, Japan and the US (Non-Euro zone) are reported separately in panel B. $\rho_{BSi,t}$ are the estimated conditional correlation time series and EMU_t are the correlations in nominal short term interest rates with the Euro zone equivalent. The tests involve estimations of equations (5.6) and (5.7), defined as $\hat{\rho}_{BS,t} = \sum_{i=1}^{p} \alpha_i EMU_{t-i} + \sum_{i=1}^{p} \beta_i \hat{\rho}_{BS,t-i} + u_{1t}$ and $EMU_t = \sum_{i=1}^{p} \gamma_i \hat{\rho}_{BS,t-i} + \sum_{i=1}^{p} \delta_i EMU_{t-i} + u_{2t}$

Asymptotic p-values are shown in the brackets. *, **, *** denote statistical significance at the 10, 5 and 1% level respectively. Test results are shown for 2 lags, F(2,2458) but tests for longer lag lengths yielded similar conclusions.

	Direction of Causality				Conclusion
	EMU→ ρ_{BS}		ρ_{BS} → EMU		
	F value	{p value}	F value	{p value}	
Panel A: Eurozone					
FRA	2.194*	{0.053}	0.453	{0.636}	EMU Granger-causes ρ_{BS}
GER	2.684*	{0.068}	1.200	{0.301}	EMU Granger-causes ρ_{BS}
ITA	0.364	{0.695}	0.271	{0.762}	No relationship
SPA	4.623***	{0.010}	1.008	{0.365}	EMU Granger-causes ρ_{BS}
Panel B: Non-Eurozone					
UK	2.555*	{0.078}	0.194	{0.824}	EMU Granger-causes ρ_{BS}
JAP	0.187	{0.829}	0.070	{0.932}	No relationship
US	1.553	{0.212}	0.039	{0.962}	No relationship

Various lag structures (2, 4, 6 and 8) have been used for each of the individual countries and the results reveal that there exists uni-directional causality from the EMU to inter-stock-bond market integration in only European countries. The first null hypothesis (EMU_t does not Granger-cause $\rho_{BS,t}$) was rejected for all sample Euro countries (except Italy) and also the UK but not for other non-Euro countries at the 10% significance level. However, the second null hypothesis ($\rho_{BS,t}$ does not cause EMU_t) could not be rejected for all sample countries at all meaningful significance levels. The Italian stock and bond markets have not exhibited segmentation dynamics like those in the other Euro zone members and it is interesting that the formation of the EMU has not been necessary for its inter-stock-bond market developments. The causality result for the UK is largely consistent with the EMU members and this is not surprising given that many common economic factors which affect European countries, whether inside or outside of the EMU help to dictate monetary policy decisions of both the ECB and the Bank of England. The implications of these results for policy makers is that by conforming with the new exchange rate regime, they have created improved diversification benefits in international stock and bond markets and potentially a flight from stock investments as suggested by the causal relationship with the observed declining integration series.

The simple analysis provides new findings for inter-financial market integration both in and outside of the EMU. These results are not only illuminating but also helpful for finding a suitable model specification to determine the true extent to which the EMU has driven the time-varying integration process between stock and bond markets. This one-way direction of causality (that is, predictive ability of the EMU) will be accommodated in the next section by replacing the EMU proxy with variables adopted from the Optimal Currency Area (OCA) literature in a seemingly unrelated regression estimation (SURE).

5.5.2 Seemingly Unrelated Regression Analysis: EMU influences

As discussed in Chapters 2 and 3, it has been recognised in the literature that what drives time variations in financial market integration may not be a country's own fundamentals but also the degree of real and financial convergence with other economies (for example, see Ragunathan et al., 1999 and Phylaktis and Ravazzolo, 2002). The EMU has involved tremendous convergence on many different macroeconomic facets and these are well captured by the range of assessment criteria used in Optimal Currency Area (OCA) analyses, some of which have been applied by Fratzscher (2002) and Baele (2004) to assess European stock market integration and volatility spillovers. This chapter extends this body of work and conducts principal component analyses for the broad economic channels through which the EMU may have played a role on financial market integration: real economic integration, monetary policy convergence and exchange rate risk reduction. It is anticipated *a priori* on the basis of OCA theory that as economies become more alike, the benefits of joining a monetary union increases. Specifically, real economic integration should lead to a convergence in cash flow expectations and monetary policy integration leads to a convergence in real interest rates. Hence, a positive effect on inter-market integration is expected for both channels due to a similar valuation effect through the expected cash flow stream and discount rate respectively. Furthermore, a negative effect on inter-market integration is expected from exchange rate volatility as currency risk poses a barrier on financial market integration. As Mamaysky (2002) notes, if a given set of explanatory variables is truly important for determining joint stock-bond returns, they must represent a risk that is priced in the economy and it is on this ground that these may be potential determinants of stock-bond integration dynamics. These economic channels can all systematically affect asset returns as they provide priced information on economic conditions.

It has been confirmed in some preliminary correlation analyses for each sample country that there is a high degree of multicollinearity between the various OCA criteria adopted in this chapter. This is not surprising given that the convergence in particularly the real economies and monetary policies did not occur in isolation during the currency unification process. As suggested by Fratzscher (2002), potentially spurious regression results can be minimised by forming two principal components to represent the variables which combine to proxy these two different facets of economic integration. Through principal component analysis, the time-series variables are linearly transformed into an equal number of principal components that are orthogonal and each principal component is a weighted average of the proxy variables reflecting the maximum possible proportion of the total variation within the set. However, it is common to use only the first principal component as it usually captures enough of the variation in the set to be an adequate proxy.

The two principal component variables (see Table 5.3 for component data sources), along with exchange rate volatility and a January dummy variable are subsequently incorporated into a cross-sectional time-series seemingly unrelated regression (SUR) model to estimate the influence of macroeconomic convergence on inter-financial market integration. This is a technique which has not been previously applied to explain bond-stock comovements but it makes intuitive sense for this investigation. As explained in Chapter 3 (section 3.3.3), The implicit assumption made by using SURE is that the residuals in the system of linear equations are contemporaneously correlated at any point in time because they are capturing similar omitted factors on each country's financial integration process. These may include regulatory barriers, political, institutional, legal, social and cultural factors, posing additional information normally omitted from separate ordinary least squares (OLS) estimation. Hence, this contemporaneous correlation assumption is utilised and a system of seven equations (one for each sample country) is jointly estimated within a generalised least squares (GLS) framework to improve coefficient estimates. The correlation matrix for residuals from each individual country in the SUR system of equations is shown in Table 5.8. The correlations are of reasonable magnitude to warrant SUR over separate least squares estimation and the negative signs involving Italy, Japan and the US simply differentiates their stock-bond integration process from the majority of Euro zone countries.[21] The SURE results for the following model over the full sample period are shown in panel B of Table 5.6 (and over pre- and post-Euro sample periods in Table 5.7) and the OLS estimates are provided in panel A for a comparison:

$$\rho_{BSi,t} = \alpha_{1i} + \alpha_{2i} EX\_VOL_{i,t-1} + \alpha_{3i} REAL\_INT_{i,t-1} + \alpha_{4i} MON\_INT_{i,t-1} + \alpha_{5i} JAN\_DUM_{i,t} + \alpha_{6i}\,\rho_{BSi,t-1} + \alpha_{7i}\,\rho_{BSi,t-2} + u_{it} \quad (5.8)$$

where the dependent variable ($\rho_{BSi,t}$) is the conditional bond-stock correlation series for each country *i {France, Germany, Italy, Spain, UK, Japan, US}*, $EX\_VOL_{i,t-1}$ = lagged conditional exchange rate volatility, $REAL\_INT_{i,t-1}$ = lagged real economic

[21] On this basis, separate 4 and 3 equation SURs have been estimated with qualitatively similar results.

convergence, $MON\_INT_{i,t-1}$ = lagged monetary policy convergence and JAN_DUM is the January dummy variable, and $\rho_{BSi,t-1}$ and $\rho_{BSi,t-2}$ are the first and second lags of the dependent variable. Two lags of the dependent variable are chosen on the basis of the smallest Akaike Information Criterion (AIC) statistics for the most number of countries in the sample. [22] It should be noted that this model controls for the predictability of integration levels (based on Granger causality test results in section 5.5.1) by including lagged instead of contemporaneous explanatory variables. Finally, Augmented Dickey Fuller (ADF) test statistics on inter-stock-bond integration levels shown in Table 5.6 rejected the presence of a unit root at the conventional 5% level of significance indicating stationarity of the dependent integration series in all cases.

Information variables (dividend yield - DIV, short-term interest rate - ST_IRATE and term structure - TERM) have also been used as control variables in this regression model because of their well-known predictive ability for stock and bond returns in the literature (see Keim and Stambaugh, 1986, Fama and French, 1989, Li, 1998 and Scruggs and Glabadanidis, 2003, among others). However, the results are not significantly different without them as can be seen as part of the Appendices in Table A.3. Their omission overcomes the problem of multicollinearity as they are also used in constructing the macroeconomic convergence principal components.

[22] To address serial correlation, the Newey-West (1987) correction for heteroskedasticity and serial correlation in the residuals has been used to minimize bias in the multivariate estimates. Ljung-Box Q tests for serial correlation are also presented as it can be used in the presence of lagged dependent variables without any bias towards the finding of no serial correlation. On the basis of these Q statistics it can be seen that serial correlation has been successfully removed in most equations with two auto-regressive terms consistent with AIC indications on goodness of fit.

Table 5.6
Regression results for the sample period 1/4/1994 to 19/9/2003

In panel A of this table, the OLS results are reported for each country. The OLS estimates are corrected for autocorrelation and heteroskedasticity following Newey-West (1987). In panel B, the seemingly unrelated regression (SUR) estimates are shown. The model estimated by both methods, as defined in equation (5.8) is:

$$\rho_{BSi,t} = \alpha_{1i} + \alpha_{2i} EX\_VOL_{i,t-1} + \alpha_{3i} REAL\_INT_{i,t-1} + \alpha_{4i} MON\_INT_{i,t-1}$$

$$+ \alpha_{5i} JAN\_DUM_{i,t} + \alpha_{6i}\, \rho_{BSi,t-1} + \alpha_{7i}\, \rho_{BSi,t-2} + u_{it}$$

where the dependent variable ($\rho_{BSi,t}$) is the estimated conditional correlation series for each country i, $EX\_VOL_{i,t-1}$ = lagged conditional exchange rate volatility, $REAL\_INT_{i,t-1}$ = lagged real economic convergence, $MON\_INT_{i,t-1}$ = lagged monetary policy convergence and JAN_DUM is the January dummy variable, and $\rho_{BSi,t-1}$ and $\rho_{BSi,t-2}$ are the first and second lags of the dependent variable.

P values are shown in brackets. The ADF test included a constant, trend and 4 lags and the critical value at the 5% significance level for the null hypothesis of a unit root is -3.410. The Ljung-Box Q test is for a null hypothesis of no serial correlation up to the 20th order. The χ^2 distributed Chow test conducted using OLS is for a null hypothesis of no structural change in estimated parameters from the 1st January 1999.

	Euro zone				Non-euro zone		
	FRA	GER	ITA	SPA	UK	JAP	US
Panel A: Single Equation Least Squares							
CONSTANT	0.0179***	0.0118*	0.0032***	0.0101***	0.0005	-0.0406***	0.0010
	{0.0012}	{0.0534}	{0.0014}	{0.0026}	{0.8473}	{0.0000}	{0.6853}
EX_VOL_{t-1}	-0.0038	-0.0056	-0.0002	0.0005	0.0021	-0.0027***	0.0029
	{0.2820}	{0.2291}	{0.7261}	{0.8141}	{0.3633}	{0.0000}	{0.5519}
$REAL\_INT_{t-1}$	0.0116***	0.0020	0.0001	0.0058***	0.0013	0.0009**	0.0022
	{0.0024}	{0.5311}	{0.7929}	{0.0046}	{0.5494}	{0.0432}	{0.1327}
MON_INT_{t-1}	-0.0016	0.0026	0.0017	0.0001	0.0004	0.0003	0.0011
	{0.4697}	{0.1404}	{0.1095}	{0.9230}	{0.6437}	{0.3553}	{0.3884}
JAN_DUM	-0.0004	0.0003	0.0009	-0.0021	-0.0006	0.0004	-0.0040
	{0.9069}	{0.9329}	{0.3221}	{0.4923}	{0.8135}	{0.6688}	{0.3157}
$\rho_{BSi,t-1}$	1.1333***	0.7375***	1.301***	0.8829***	1.1674***	0.7372***	0.9268***
	{0.000}	{0.000}	{0.000}	{0.0000}	{0.000}	{0.000}	{0.0000}
$\rho_{BSi,t-2}$	-0.1607***	0.2403***	-0.3246***	0.0857***	-0.1766***	0.0322	0.0576***
	{0.000}	{0.000}	{0.000}	{0.0001}	{0.000}	{0.1139}	{0.0029}
ADF Test Statistic	-5.5404**	-5.4901**	-6.4788**	-5.7078**	-4.2833**	-13.1336**	-5.6143**
Adj. R^2	0.9647	0.9526	0.9683	0.9459	0.9855	0.6136	0.9741
Q Test	38.4280***	13.0763	13.1284	12.9506	17.1915	38.1126***	29.4304*
$(\sim\chi^2_{20})$	{0.0078}	{0.8741}	{0.8718}	{0.8795}	{0.6405}	{0.0086}	{0.0796}
Chow test	15.3671**	30.3336***	27.3391***	8.7813	13.0759*	68.5809***	19.9231***
$(\sim\chi^2_7)$	{0.0316}	{0.0001}	{0.0003}	{0.2687}	{0.0703}	{0.0000}	{0.0057}
No. obs.	2469	2469	2469	2469	2469	2469	2469
Panel B: SURE							
CONSTANT	0.0112***	0.0113***	0.0046***	0.0064**	-0.0002	-0.0402***	0.0011
	{0.0067}	{ 0.0028}	{0.0000}	{0.0199}	{0.9520}	{0.0000}	{0.5991}
EX_VOL_{t-1}	-0.0024	-0.0035*	-0.0005	0.0009	0.0024	-0.0027***	0.0029
	{0.1368}	{0.0520}	{0.3557}	{0.5925}	{0.2410}	{0.0000}	{0.4753}
$REAL\_INT_{t-1}$	0.0060**	0.0036	0.0009**	0.0022	0.0004	0.0010**	0.0023*
	{0.0456}	{0.1426}	{0.0176}	{0.2144}	{0.8493}	{0.0167}	{0.0898}
MON_INT_{t-1}	-0.0015	0.0017	0.0006*	0.0003	0.0001	-0.0003	0.0009
	{0.3644}	{0.1933}	{0.0666}	{0.7315}	{0.9313}	{0.3137}	{0.3904}
JAN_DUM	-0.0012	0.0007	0.0009	-0.0017	-0.0006	0.0004	-0.0040
	{0.6931}	{0.8317}	{0.1929}	{0.4833}	{0.7956}	{0.6202}	{0.1736}
$\rho_{BSi,t-1}$	1.0924***	0.7179***	1.2900***	0.8417***	1.1365***	0.7397***	0.8599***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\rho_{BSi,t-2}$	-0.1276***	0.2460***	-0.3162***	0.1222***	-0.1508***	0.0315	0.1218***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.1122}	{0.0000}
Adj. R^2	0.9652	0.9533	0.9688	0.9467	0.9857	0.6211	0.9745
Q Test	42.1518***	21.4509	14.0052	21.1950	19.7899	37.5019**	41.6225***
$(\sim\chi^2_{20})$	{0.0026}	{0.3710}	{0.8302}	{0.3859}	{0.4711}	{0.0102}	{0.0031}
No. obs.	2469	2469	2469	2469	2469	2469	2469

Table 5.7
SURE results for pre- and post- Euro sub-sample periods

In panel A of this table, the SURE results for the pre-Euro sub-sample period (1/4/1994 - 31/12/1998) are reported for each country and in panel B, the post-Euro (1/1/1999 – 19/9/2003) estimates are shown. The regression model is the same as in Table 5.6.

	Euro zone				Non-euro zone		
	FRA	GER	ITA	SPA	UK	JAP	US
Panel A: Sub-sample period 1: 1/4/1994 - 31/12/1998							
CONSTANT	0.0047	0.0142**	0.0036***	0.0095**	0.0000	-0.0385***	0.0010
	{0.5281}	{0.0149}	{0.0002}	{0.0481}	{0.9911}	{0.0000}	{0.5833}
EX_VOL_{t-1}	-0.0049*	-0.0071**	0.0004	0.0016	0.0034	-0.0032***	0.0029
	{0.0720}	{0.0111}	{0.5472}	{0.5737}	{0.2405}	{0.0000}	{0.1335}
$REAL\_INT_{t-1}$	-0.0001	0.0002	-0.0018*	0.0036	-0.0012	0.0003	0.0022
	{0.9828}	{0.9674}	{0.0571}	{0.3820}	{0.7933}	{0.5711}	{0.3486}
MON_INT_{t-1}	-0.0084***	0.0023	-0.0003	0.0012	-0.0005	-0.0002	0.0011
	{0.0064}	{0.2899}	{0.5585}	{0.4856}	{0.7149}	{0.7026}	{0.6752}
JAN_DUM	0.0015	0.0017	0.0011	-0.0006	0.0030	0.0003	-0.0040
	{0.7775}	{0.7643}	{0.2515}	{0.8847}	{0.4567}	{0.8146}	{0.5081}
$\rho_{BSi,t-1}$	1.0750***	0.7777***	1.3712***	0.8812***	1.1018***	0.7498***	0.9268***
	{0.000}	{0.000}	{0.000}	{0.0000}	{0.000}	{0.000}	{0.0000}
$\rho_{BSi,t-2}$	-0.1212***	0.1846***	-0.4058***	0.0800***	-0.1192***	0.0209	0.0576**
	{0.000}	{0.000}	{0.000}	{0.0010}	{0.000}	{0.4534}	{0.0108}
Adj. R^2	0.9550	0.9469	0.9704	0.9447	0.9802	0.6634	0.9633
No. obs. (T)	1238	1238	1238	1238	1238	1238	1238
Panel B: Sub-sample period 2: 1/1/1999 – 19/9/2003							
CONSTANT	0.0006	0.0023	0.0049***	0.0064	-0.0023	-0.0562***	0.0011
	{0.9125}	{0.6606}	{0.0008}	{0.4494}	{0.4478}	{0.0000}	{0.3765}
EX_VOL_{t-1}	0.0013	0.0020	-0.0009	0.0009	0.0010	-0.0045***	0.0029
	{0.3451}	{0.2643}	{0.1431}	{0.7433}	{0.7131)	{0.0009}	{0.8282}
$REAL\_INT_{t-1}$	0.0023	0.0078**	0.0003	0.0022	-0.0006	0.0001	0.0023
	{0.3985}	{0.0248}	{0.7571}	{0.9492}	{0.7842}	{09063}	{0.6663}
MON_INT_{t-1}	-0.0011	-0.0014	-0.0007*	0.0003	0.0002	-0.0006	0.0009
	{0.6286}	{0.3149}	{0.0766}	{0.5589}	{0.7872}	{0.1459}	{0.6836}
JAN_DUM	-0.0030	0.0019	0.0007	-0.0017	-0.0025	0.0009	-0.0040*
	{0.2973}	{0.5676}	{0.4785}	{0.4600}	{0.2768}	{0.4564}	{0.0594}
$\rho_{BSi,t-1}$	1.1049***	0.5657***	1.1854***	0.8417***	1.1986***	0.6904***	0.8599***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
$\rho_{BSi,t-2}$	-0.1463***	0.3613***	-0.2170***	0.1222***	-0.2205***	-0.0019	0.1218***
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.9471}	{0.0000}
Adj. R^2	0.9583	0.8981	0.9680	0.9256	0.9779	0.5160	0.9376
No. obs. (T)	1231	1231	1231	1231	1231	1231	1231

Table 5.8
Correlation Matrix of Residuals from SURE

This table presents the correlation matrix of the residuals from each of the 7 equations in the seemingly unrelated regression (SUR) reported in Table 5.7, panel B.

	FRA	GER	ITA	SPA	UK	JAP	US
FRA	1.0000	0.5852	-0.4554	0.5451	0.4629	-0.0774	0.1520
GER		1.0000	-0.4357	0.5077	0.5027	-0.1118	0.1855
ITA			1.0000	-0.5023	-0.3227	0.0747	-0.1477
SPA				1.0000	0.4020	-0.0931	0.1454
UK					1.0000	-0.1030	0.3104
JAP						1.0000	-0.0633
US							1.0000

As with most cross-country studies, there are slight differences with respect to the significance of the explanatory variables across sample countries in the SUR system. However, the fact that the three macroeconomic variables of interest are not all significant for each individual country suggests that the EMU's channels of influence have been successfully orthogonalised to some extent. Firstly, reductions in conditional foreign exchange volatilities have only been important to bond and stock market interdependencies in Germany and Japan. As argued in Chapter 3, this makes intuitive sense given that exchange rates have been required to fluctuate within narrow bands from a basket of European currencies known as the European Currency Unit (ECU) since 1979 under the European Monetary System (EMS) and this already made the Euro a close substitute for the currencies of most European countries. However in line with one's expectations based on OCA theory and Fratzscher (2002)'s and Baele (2004)'s stock market findings, reductions in exchange rate volatility have only been effective in stimulating stock and bond market integration (and not segmentation) in the sample countries (as indicated by their significant and negative coefficients). The weak contribution of exchange rate risk reduction to the integration of stock and bond markets is also consistent with Bodart and Reding (1999)'s finding that correlations in stock and bond returns in Europe were not very sensitive to changes in the Exchange Rate Mechanism (ERM) and also De Santis et al. (2003)'s finding that the adoption of the Euro did not have a large impact on aggregate currency risk premia. Secondly, real economic integration also appears to have played a significant role in steering stock and bond markets towards further integration within the EMU and with Japan and the US as OCA theory would dictate (as indicated by the positive coefficients). Thirdly, monetary policy convergence (inferred from inflation, nominal and real short term interest rates) is only a positively significant determinant of inter-bond and stock market integration in

Italy (where there has been the only sign of an upward trend in integration between these two financial segments as Figure 5.1 revealed). This suggests that a combination of monetary policy changes in the past decade may be the culprit in inducing investor uncertainty on the future of the EMU, thereby creating a flight to quality investments in other sample countries. This possibility is further supported in sub-sample estimations (shown in Table 5.7) where negative signs are found on most significant coefficients and in a subsequent section of analysis specifically on economic uncertainty (section 5.5.3). However, corroborating with this argument is the finding by Chordia et al. (2004) that comovements in stock and bond market liquidities are driven by monetary shocks and also Li (2002)'s empirical results indicate that the major trends in stock-bond correlations are determined by uncertainty on expected inflation. Fourthly, there appears to be no evidence of seasonality (January or day of the week effects) in bond and stock market integration dynamics, especially outside of the US. This finding is not surprising given the amount of mixed evidence on seasonality outside of equity markets (for example, see Smith, 2002 on government bond markets) but this is still a new international result given that calendar regularities have been found in comovements between stock and bond market liquidities by Chordia et al. (2004) using intraday US data. Finally, like stock market integration behaviour analysed in Chapter 3, stock and bond market integration/segmentation is also a persistent process, as indicated by the highly significant lagged dependent variable terms for most sample countries.[23] This is corroborated by Li (2002)'s finding of serial correlation in stock-bond correlations.

[23] However, as discussed in Chapter 3, these estimates may be highly inconsistent as they sum closely up to one.

A Chow test was conducted to test for structural change in estimated parameters pre- and post-Euro introduction. The Chow test involved a test of the joint significance of the entire set of additional interactive dummies in the regression previously shown in equation (5.8) (regressors multiplied by a Euro time dummy that took the value of one from 1 January 1999 onwards and zero prior to that). The null hypothesis of no structural change in the estimates was rejected, justifying separate regressions for a pre- and post-Euro sub-sample period to gauge the changing importance of the three main economic channels in explaining bond and stock market integration/segmentation.[24] The pre-Euro sample SURE results are presented in panel A, Table 5.7 and the post-Euro results follow in panel B. The sample split is informative in that it reveals that the reduction in exchange rate volatility was effective in fostering some European inter-bond and stock market integration in the lead up to the Euro's introduction but not since then. On the other hand, real economic integration has only been stimulatory for inter-stock-bond market integration in the post-Euro era, as prior to the introduction of the single currency it had generally contributed to the segmentation of stock-bond markets. As mentioned before, monetary policy convergence has been a pervasive deterrent to stock-bond market integration as suggested by the negative coefficients in both pre- and post-Euro sub-samples. Segmentation between bond and stock markets is now a persistent process in most of Europe and the rest of the world driven perhaps by continued uncertainty in the economic and financial future of the International Monetary System. The following section will attempt to test the validity of this hypothesis.

[24] A Euro dummy was found to be significant in a full sample regression but the results have been omitted due to the additional information provided by the sub-sample analysis reported in Table 5.7 and also to prevent multicollinearity between regressors.

5.5.3 Role of Economic Uncertainty

In the financial economics literature, implied volatilities are generally accepted as a good proxy for the time-varying uncertainty associated with the expected future stochastic stock volatility. Connolly et al. (2004) provides convincing empirical evidence on the influence of stock market uncertainty measures on time-variations in the comovements of stock and government bond returns. His work is motivated by the seminal work of Veronesi (1999) on time-varying stock market uncertainty being a reflection of economic uncertainty.

Extending Connolly et al. (2004), a stock market uncertainty measure is applied to investigate the influence of economic state uncertainty on time-variations in stock and bond market integration/segmentation dynamics. The Chicago Board of Options Exchange (CBOE)'s Volatility Index (VIX) and the implied volatility index from the DAX (VDAX) are used as a proxy for economic uncertainty in sample Non-European and European countries respectively. As an increase in these implied volatility indices are generally viewed by market participants as a sign of increasing aversion to uncertainty, one expects *a priori* a negative relationship between the lagged levels of economic uncertainty and the integration between stock and bond markets. Hence, the following model in equation (5.9) is estimated for each country to investigate the explanatory power of economic uncertainty in driving inter-stock-bond integration dynamics:

$$\rho_{BSi,t} = \beta_{1i} + \beta_{2i} Ln(uncert_{t-1}) + \beta_{3i}\rho_{BSi,t-1} + \beta_{4i}\rho_{BSi,t-2} + \mu_{i,t} \tag{5.9}$$

where the dependent variable ($\rho_{BSi,t}$) is the conditional bond-stock correlation series for each country *i {France, Germany, Italy, Spain, UK, Japan, US}*, Ln($uncert_{t-1}$) is the natural logarithm of the lagged implied volatilities from equity index options and $\rho_{BSi,t-1}$ and $\rho_{BSi,t-2}$ are the first and second lags of the dependent variable to reduce serial correlation.

The results for the OLS estimations are provided in Table 5.9. For all countries except Italy, the coefficient on the uncertainty variable is negative and significant at the 1% level lending further support to the hypothesis that it is uncertainty on the economic future of the international financial system which is driving segmentation in international stock and bond markets. In the EMU, the recent change in exchange rate regime is more than likely to have contributed to the region's economic and financial uncertainties but it is clear that its influence reaches internationally. This is a new interpretation and confirms Connolly et al. (2004)'s results using the US and other G7 countries, that there is an international aspect to the inverse relationship between stock market uncertainty and stock-bond market comovements. Economic uncertainty in the European financial system is contributing to a prolonged flight to quality investments (less extreme than investor reactions in financial crises). This is consistent with recent anecdotal evidence from surveys of European investment decision makers for *The Wall Street Journal Europe* (see Spikes, 2004) as investors are increasingly choosing to store their money in bank deposits and bonds because of their concerns on future economic growth in the EMU. Ironically, whilst investors are pulling their money out of stocks, this is improving the diversification benefits between stocks and bonds at the country level. Italy is the only country where inter-stock-bond market integration has recently increased and the coefficient on the uncertainty variable is positively significant suggesting that economic uncertainty associated with the EMU has not triggered the same response across its government bond and stock markets.

Table 5.9
OLS results for Stock market uncertainty

In this table, the OLS results for the full sample period (1/4/1994 - 19/09/2003) are reported for each country. The OLS estimates are corrected for autocorrelation and heteroskedasticity in accordance with Newey-West (1987). The model estimated as defined in equation (5.9) is

$$\rho_{BSi,t} = \beta_{1i} + \beta_{2i} LN(uncert_{i,t-1}) + \beta_{3i}\rho_{BSi,t-1} + \beta_{4i}\rho_{BSi,t-2} + u_{it}$$

where the dependent variable ($\rho_{BSi,t}$) is the estimated conditional correlation series for each country i, LN($uncert_{i,t-1}$) = natural logarithm of lagged implied volatility from stock options and $\rho_{BSi,t-1}$ and $\rho_{BSi,t-2}$ are the first and second lags of the dependent variable.

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Countries	Constant	Ln($uncert_{t-1}$)	$\rho_{BSi,t-1}$	$\rho_{BSi,t-2}$	Q Test ($\sim\chi^2_{20}$)	Adj. R^2
Panel A: Euro zone						
FRA	0.0808***	-0.0241***	1.1173***	-0.1700***	35.8678**	0.9654
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0159}	
GER	0.1158***	-0.0363***	0.7078***	0.2155***	34.7701**	0.9540
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0214}	
ITA	-0.0003	0.0014***	1.2991***	-0.3254***	13.0299	0.9683
	{0.8551}	{0.0074}	{0.0000}	{0.0000}	{0.8761}	
SPA	0.0457***	-0.0129***	0.8726***	0.0816***	16.0228	0.9465
	{0.0000}	{0.0000}	{0.0000}	{0.0001}	{0.7152}	
Panel B: Non-Euro zone						
UK	0.0613***	-0.0189***	1.1482***	-0.1797***	20.3451	0.9858
	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.4365}	
JAP	-0.0326***	-0.0035***	0.7393***	0.0315	34.6820**	0.6119
	{0.0000}	{0.0000}	{0.0000}	{0.1261}	{0.0219}	
US	0.1650***	-0.0534***	0.8703***	0.0627***	86.9528***	0.9757
	{0.0000}	{0.0000}	{0.0000}	{0.0007}	{0.0000}	

*Notes: P values are shown in brackets and *, **, *** denote significance at the 10%, 5% and 1% level respectively. The Ljung-Box Q test is for a null hypothesis of no serial correlation up to the 20th order.*

5.6 Conclusions

The aim of this chapter has been to investigate whether time-varying comovements between daily government bond and stock returns over the past decade have been affected by the introduction of the Euro under the EMU. It has achieved much more than this as it contributes new major findings for two strands of previously separate literature. It reveals that as intra-stock and bond market integration with the EMU has strengthened in the sample period, inter-stock-bond market integration at the country level has trended downwards to zero and even negative mean levels in most European countries, Japan and the US, consistent with a flight to quality phenomena in international financial markets. There is compelling empirical evidence to support this in estimated sign and volume effects on cross-market volatility spillovers in a bivariate EGARCH model and it is found that bond market return shocks have more influence than stock market shocks consistent with the existing stock-bond comovement literature. There is also convincing evidence that the introduction of the monetary union has indeed Granger caused the apparent segmentation between bond and stock markets within Europe but not outside. Moreover, real economic integration with the EMU and reduction in currency risk with the Euro have generally stimulated inter-financial market integration but the adoption of a common monetary policy may have brought about investor concerns on the future of macroeconomic fundamentals in Europe and the international financial system, inducing a flight to government bonds (a perceived safe haven asset). To this end, the EMU has increased benefits of diversification across stocks and government bonds at the country level. There are no clear seasonal patterns in inter-market integration/segmentation dynamics between daily government bond and stock returns in this international study.

In this chapter, significant contributions have been made to the broad finance literature on many levels, including: i) providing a new application of stock-bond comovements to proxy inter-financial market integration over time; ii) illustrating a two-step methodology that is suitable for this new application; iii) using higher frequency (daily) data to investigate international stock-bond comovements; iv) improving the current understanding on cross-market conditional volatility interdependencies and correlations at the country level; v) establishing the direction of causality for inter-financial market integration and monetary union adoption; and vi) providing an alternative theoretical explanation for stock-bond comovements by using macroeconomic convergence criteria associated with optimal currency area studies and reinforced with a robust stock market uncertainty measure to study international inter-stock-bond market integration.

The findings in this chapter have important implications for both investors and policy makers. For investors, inter-stock-bond market segmentation at the country level means that diversifications benefits have increased for even domestic asset allocations. For policy makers, the process of monetary policy coordination is creating heightened economic uncertainty in international financial markets and financial system instability may become more pronounced as asset markets of the same type become more interdependent and asset markets in the same jurisdiction continue to react to those developments.

Chapter 6

Conclusions and Future Research

6.1 Concluding Remarks for this thesis

Over the past two decades, currency unification in Europe has clearly demonstrated the changes that macroeconomic convergence (necessitated by the efficacious realization of a monetary union) can bring about for continental financial market developments. This thesis has effectively assessed both the current state and the progress of stock and bond market integration in EU markets at different stages of economic integration towards the EMU from both intra-market and inter-market perspectives and at intra-regional and inter-regional levels. It has also increased the level of understanding on the economic roles of the EMU in stimulating stock and bond market integration. On a broader level, this thesis also sheds light on the development of continental Europe from an intermediated financial system to a market-based one. It is clear that stock and government bond markets are two financial segments that have and will continue to grow in importance.

The first inquiry presented in Chapter 3 focuses on the issue of pre-enlargement European stock market integration and the driving forces of the EMU. The research work in this chapter contributes to the existing studies on European stock markets by addressing the gaps and disparities that currently exist on the impacts from currency unification. This chapter provides investigations on how European stock market linkages and integration dynamics have evolved on both a regional and global scale in response to the changes in the economic and monetary environment associated with the implementation of the EMU. The innovation of this chapter is in the explicit modelling of the time-varying nature of stock market integration amongst EU member countries via a two-step methodology involving conditional correlations and linear systems estimations. Within this empirical framework, the causal relationship between the implementation of the EMU and stock market integration is also tested. The results show that international stock markets have become increasingly integrated with the Euro zone but regional integration in all EU member stock markets have undergone a structural change since 1996-97 (a few years prior to the introduction of the Euro) towards a more complete and stable phase of integration. This chapter also provides additional evidence directly linking the developments in stock market integration over time to the political and economic changes shaping the creation of the EMU. Moreover, it finds that stock market integration is a self-perpetuating process that is also determined by financial market development.

The findings of Chapter 3 have direct implications for portfolio construction and risk management strategies given their reliance on inputs for correlations and volatilities in asset returns. The integration results indicate that a new regime has emerged in time-varying correlations between national stock markets and that of other markets in the Euro zone. This suggests that in the new pan-European investment paradigm, traditional cross-country diversification strategies will be less effective. As diversification benefits have reduced across national borders, alternative allocations based on sectors or industries should prove more popular. There is also good reason to invest in regions that are less driven by common information, such as Asia or Central and Eastern Europe. The irony is that whilst European investors have increasing opportunities to invest in other developed European stock markets, it has become less attractive to do so. However, on the financing side, European companies can access a much larger pool of capital at similar cost levels. This can potentially boost aggregate European investment levels and economic growth in the long-run. The directive of policy makers to achieve a single European stock market has been largely successful. Underlying stocks in each national market now react almost homogeneously to new information (economic shocks) suggesting that changes in monetary policy would be transmitted effectively across the EU.

The second inquiry in this thesis moves the focus to government bond markets and contributes a timely and comprehensive assessment on the extent of integration between new and established EU members in the lead up to the EU's recent enlargement. This chapter focuses on government bond markets as there is compelling evidence to suggest that they are one of the first financial segments to integrate via economic transmission channels. This chapter combines a set of complementary dynamic cointegration and conditional correlation methodologies to examine different aspects of bond market integration at the (European) regional level. It is revealed that the established EU markets are more integrated within the EU region than the new EU markets. Within the sample of new EU markets, the results are consistent with the development of the EU's pre-accession funding initiatives prior to the recent round of EU enlargement. Specifically, the PHARE (Poland-Hungary Aid for Economic Restructuring) program was first created in 1989 to fund economic and political restructuring in Poland and Hungary but it was later expanded to include other candidates for the EU. Poland and Hungary are found to be more financially integrated with the established EU markets than the Czech Republic, perhaps because they have benefited from the EU's pre-accession financial support for a longer period than other Central and Eastern European members. The clear implication of the findings in this chapter for policy makers is that the new EU members are not yet ready for immediate membership to the EMU as suggested by their weak financial convergence with core EMU markets. The transmission of common monetary policy would no doubt be hampered at this early stage by the heterogeneous reaction of the new EU markets. Thus, the requirement to first operate successfully within ERM II (in order to qualify for EMU membership) should not be violated for this transition group to speed up their participation in the EMU.

The third inquiry provides a better understanding of the time-varying integration *across* international stock and government bond markets. The innovation in this chapter is the merger of two previously separate strands of literature in Finance to advance knowledge across the discipline. This chapter builds on the two-step empirical methodology introduced in Chapter 3 to focus on the pricing of common information in stock and bond markets at the country level. It finds a decline in inter-market integration during the past decade, consistent with a flight to quality hypothesis. This is further supported by estimated asymmetric and volume effects on cross-market volatility spillovers. Importantly, this chapter provides extensive empirical evidence to reveal that the economic uncertainty on the implementation of the EMU, through its macroeconomic convergence channels, has caused and determined this international inter-stock-bond market phenomenon. In particular, whilst real economic integration with the EMU and the reduction in exchange rate risks have generally promoted inter-market integration, the realisation of a common monetary policy has not. These findings are clearly relevant for investors and policy makers as there appears to be a tendency to channel savings into safe haven investment assets like government bonds over risky stocks. This is consistent with recent anecdotal evidence from industry investment surveys featured in *The Wall Street Journal Europe* (see Spikes, 2004). Ironically, whilst there are increasing diversification benefits to investing across these two financial segments, investors on the whole are choosing not to take advantage of this.

Moreover, policy makers' prudent economic policy coordination may be increasing systemic financial instability instead of financial soundness.

To sum up, this thesis has presented evidence that over time, Europe's stock and government bond markets have integrated across borders but not across asset markets at the national level. This has in particular, been fan-forced by currency unification in continental Europe. The irony of European financial integration is that whilst the common currency and deregulations associated with the EMU allow investors to diversify across national borders, it has also reduced the diversification benefits of doing so within one asset class. However, this direction of financial market integration is consistent with the hopes and aspirations of the founders and theorizers of the EU who predicted a process of spillover and linkage through economic, monetary and political integration. Financial market integration is a dynamic process and the speed of the process is determined by the particular macroeconomic situation in each individual member of the EMU. In general, there is evidence to show that currency unions significantly contribute to financial market integration both inside and outside of the union. It exerts its influence through macroeconomic channels like exchange rate stability, real economic convergence and monetary policy integration. However, in the lengthy European experience, the reduction in exchange rate volatility is no longer a significant driving force, after many years of operating under an exchange rate mechanism. All in all, whilst a common currency is a *necessary* condition for the emergence of a pan-European capital market, it is by no means a *sufficient* one.

The European experience will undoubtedly have an influential effect on the choice of exchange rate regimes worldwide. However, the long-term political commitment to the European integration process must never be forgotten.

6.2 Directions for Further Research Work

This thesis has made substantial inroads into the important research area of exposing the range of opportunities for financial market participants afforded by integrated, deep and efficient stock and bond markets. However, more work needs to be done to better understand the full ramifications of financial market integration. Ideally, complete integration of all financial sectors should be attained in the near future and there is a need to continue monitoring financial market developments because they have real economic consequences for financial market participants.

Firm and Industry Level Research

Financial market integration undeniably involves integration of component markets at a microeconomic level that may not be fully reflected at the aggregate level. It is important that financial market integration and its link with economic integration be evaluated at the firm and industry level in order to improve current understanding in this relationship. Assessments of financial market integration at a disaggregated level may reveal underlying integration patterns that exist within sectors of national financial markets and help to identify the sources of aggregate financial market integration. Researchers like Brooks and Del Negro (2004) and Campbell et al. (2001) provide convincing evidence on the rising importance of firm and industry specific factors over country-specific ones in determining asset prices. From an investment and hedging perspective, this level of research into European financial market integration will enable multinational corporations and international portfolio managers to take advantage of the changes in diversification benefits and risk and return characteristics brought on by European unification.

Further EU enlargements and transition EU members

The EMU is still weighed down by much uncertainty. Whilst uncertainty about whether the EMU would take place dominated much of the 1990s, uncertainty on how it will continue to operate and enlarge has dominated this decade. Critics of the EMU remain cautious as economic convergence has proven more successful than they had anticipated. However, it is well understood that the collapse of the Euro could do immense cyclical and structural damage to the EU. Given the findings from the inter-market integration assessment in Chapter 5, it is important that further attention be devoted to integration across asset markets.

The impact of EU membership on the transition economies from Central and Eastern Europe will continue to be of interest for research in this area. These new EU countries continue to face the tremendous task of creating economic and social institutions consistent with established EU members as required by the Maastrict Treaty. This will lead to large differences in the risk levels borne by investors in transition and established market economies under the EU umbrella and thus differentials in the cost of capital for investments and ultimately, the pace of financial market integration. Invaluable insights into political and economic unification can be gleaned from integrative developments in this alternative set of emerging financial markets. The challenge of attaining and subsequently maintaining EMU membership will the biggest test for these transition economies. The future of the EU and the opportunities afforded by further expansion, rests largely on the political commitment and also the ability of new and old members to become more economically and financially integrated over time. Given the findings in Chapter 4, it is important to ensure that the new EU countries do not rush to join the EMU before they are ready.

International Monetary Order

There has been a clear trend towards currency consolidation in the international monetary system. Hence, it is important that there is further research on the linkage between monetary unions and financial market integration within International Finance. As the forces of economic integration intensify, the significance of financial market integration is unquestionable. The pan-European experience is important for understanding the potential viability of monetary unions in other parts of the world as the European model is the best guide for the architecture of monetary unions in other regions (see Hooper, 2001). Larger scale currency unions have been advocated by researchers in International Finance and it is not unreasonable for other countries to emulate the European experience, particularly if bouts of troublesome exchange rate instability arise in the near future. A dominant currency trio comprising the Euro, Yen and the US dollar has been touted as constituting an ideal international monetary order for the future by Rogoff (2001) whilst others have clear visions of a single world currency (see Cooper, 2000 and Moshirian, 2002). Yet, Frankel (1994) continues to argue that no single currency regime can be suitable for all countries at all times. Clearly, research in this area must remain ahead of these potential political developments towards a more interdependent global financial architecture as history can attest to the high costs of speculative attacks and currency crises.

Unprecedented financial integration issues will continue to face policy makers, regulators and market participants in the global financial community. Building upon the work initiated in this thesis, the contributions of further research work in these above mentioned areas are potentially enormous.

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Appendices

Table A.1 Key Political and Economic Events of the EMU Process

Date	Event
20 Sept. 1988	Margaret Thatcher, Prime Minister of the UK, delivers a heavily sceptical speech on the future development of the EU (*Bruges Speech*)
12 Apr. 1989	*Delors Report* lays out the future roadmap for the EMU
27 Apr. 1989	*Madrid Declaration* adopts the Delors Report and commits the EEC to the EMU
09 Nov. 1989	*Fall of Berlin Wall*
09 Dec. 1989	*Strasbourg Declaration* declares that the EEC will move towards the EMU. Start of Phase I of EMU
29 May 1990	European Bank for Reconstruction and Development (*EBRD*) established
19 Jun. 1990	*Schenegen I* agreement signed, providing for a common travel area in Europe
03 Oct. 1990	*German Re-unification*
15 Dec. 1990	*Rome Declaration* launches intergovernmental conference on EMU
10 Dec. 1991	*Treaty of Maastrict* agreed, transforming the EEC into the EU
21 Dec. 1991	*Soviet Union collapse*
02 Jun. 1992	*Danish Referendum rejects* Maastrict Treaty
18 Jun. 1992	*Irish Referendum accepts* Maastrict Treaty
20 Jun. 1992	*French Referendum accepts* Maastrict Treaty
12 Dec. 1992	*Edinburgh Declaration* amends Maastrict Treaty to assuage the Danish and endorses moves to the EMU
01 Jan. 1993	*Single European Market Act* (part of Maastrict Treaty) in force. This represents the culmination of the original aims of the EEC – the Common Market.
18 May 1993	*Second Danish Referendum accepts* Maastrict Treaty
02 Aug. 1993	*ERM bands widened* from 2.25% to 15% each direction
29 Oct. 1993	*Brussels Declaration* on the start of Phase II of the EMU
01 Nov. 1993	*EU created* with ratification of all elements of the Maastrict Treaty
01 Jan. 1994	*EMI* – forerunner of ECB is established, launching Phase II of the EMU
12 Jun. 1994	*Austria votes to join EU, including EMU*
16 Oct. 1994	*Finland votes to join EU, including EMU*
13 Nov. 1994	*Sweden votes to join EU, not EMU*
28 Nov. 1994	*Norway votes to not join EU*
26 Mar. 1995	*Schenegen II* extends common travel area
31 May 1995	*Green Paper* on practicalities of a monetary union (note transfer etc)
16 Dec. 1995	*Madrid Declaration II* adopts 1 Jan1999 for launch of Euro and start of Phase III of the EMU
14 Dec. 1996	*Dublin Declaration* outlines the legal mechanisms for Phase III of the EMU
02 Oct. 1997	*Treaty of Amsterdam* ratifies into law the Dublin Declaration
25 Mar. 1998	*Phase III membership notified*: 11 members that qualify to adopt the Euro and move to Phase III named
03 May 1998	*Determination Mechanism* for irrevocable conversion rates outlined
26 May 1998	*ECB Board agreed*
01 Jun. 1998	*ECB established*
01 Jan. 1999	*Euro launched*
22 Sep. 2000	*ECB intervention to support the Euro*
28 Sep. 2000	*Danish Referendum rejects joining EMU*
02 Jan. 2001	*Greece becomes the 12th EMU member*
01 Jan. 2002	*Euro replaces national currencies. Phase III ends. EMU complete*

Source: Aggarwal et al. (2003)

Table A.2 Bivariate-ARMA-EGARCH Model Estimations for Bond markets assuming a joint normal distribution

In this table, the results of the bivariate EGARCH estimations for sample government bond markets are reported. The bivariate EGARCH model for each country, as defined in equations (A.1)-(A.3), is

$$R_{N,t} = c_N + \sum_{i=1}^{p_E} \alpha_{E,i} R_{E,t-p_E} + \sum_{j=1}^{q_N} m_{N,j} \varepsilon_{N,t-q_N} + \varepsilon_{N,t}$$
$$R_{E,t} = c_E + \sum_{i=1}^{p_N} \alpha_{N,i} R_{N,t-p2} + \sum_{j=1}^{q_E} m_{E,j} \varepsilon_{E,t-q_E} + \varepsilon_{E,t} \qquad \text{(A.1)}$$

$$\ln h_{N,t} = \beta c_N + \beta_{hN} \ln h_{N,t-1} + \left[\beta\varepsilon_{N1} \frac{\varepsilon_{N,t-1}}{\sqrt{h_{N,t-1}}} + \beta\varepsilon_{N2} \left(\frac{|\varepsilon_{N,t-1}|}{\sqrt{h_{N,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right] \qquad \text{(A.2)}$$

$$\ln h_{E,t} = \beta c_E + \beta_{hE} \ln h_{E,t-1} + \left[\beta\varepsilon_{E1} \frac{\varepsilon_{E,t-1}}{\sqrt{h_{E,t-1}}} + \beta\varepsilon_{E2} \left(\frac{|\varepsilon_{E,t-1}|}{\sqrt{h_{E,t-1}}} - \sqrt{\frac{2}{\pi}} \right) \right]$$

$$h_{NE,t} = \delta_0 + \delta_1 \sqrt{h_{N,t} . h_{E,t}} + \delta_2 h_{NE,t-1} \qquad \text{(A.3)}$$

	Euro zone				Non-Euro zone		
	FRA	GER	ITA	SPA	UK	JAP	US
Mean: R_N							
c_N	0.024***	-0.016*	0.032***	0.049***	0.034***	0.030***	0.039***
	{0.000}	{0.061}	{0.000}	{0.000}	{0.001}	{0.000}	{0.000}
α_{E1}	0.207***	0.036	0.091***	0.200***	0.054***	0.029***	0.048*
	{0.000}	{0.808}	{0.008}	{0.000}	{0.004}	{0.008}	{0.082}
P_E	1	1	1	1	1	2	1
Q_N	4	7	2	6	0	4	9
Vol.:R_N							
β_{cN}	-1.407***	-0.488***	-0.167***	-0.003**	-0.034	-0.048***	-0.095***
	{0.000}	{0.001}	{0.000}	{0.050}	{0.122}	{0.000}	{0.002}
β_{hN}	0.053***	0.573***	0.855***	0.999***	0.974***	0.969***	0.914***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{uN1}	0.009	0.036	-0.002	0.001	0.004	-0.027*	-0.028
	{0.463}	{0.120}	{0.914}	{0.353}	{0.864}	{0.081}	{0.243}
β_{uN2}	0.156***	0.079***	0.157***	0.002***	0.087***	0.203***	0.106***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.003}	{0.000}	{0.004}
Mean:R_E							
c_E	0.038***	0.002	0.027***	0.071***	0.046***	0.048***	0.040***
	{0.000}	{0.947}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
α_{N1}	-0.075*	-0.008	-0.035**	-0.057***	0.018	0.043*	0.175***
	{0.068}	{0.954}	{0.045}	{0.005}	{0.301}	{0.066}	{0.000}
P_N	1	1	1	1	1	2	1
Q_E	2	4	3	7	5	5	1
Vol.: $_{RE}$							
β_{CE}	-0.499***	-0.070	-1.512***	-0.552***	-0.036**	-0.031**	-0.076***
	{0.000}	{0.363}	{0.000}	{0.000}	{0.051}	{0.015}	{0.000}
β_{hE}	0.654***	0.947***	0.002***	0.640***	0.975***	0.977***	0.951***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
β_{uE1}	0.016***	-0.001	-0.003	-0.008	-0.006	-0.009	-0.036***
	{0.000}	{0.988}	{0.866}	{0.375}	{0.740}	{0.537}	{0.004}
β_{uE2}	0.091***	0.056	0.131***	0.014***	0.101***	0.121***	0.140***
	{0.000}	{0.493}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Covariance							
δ_0	0.175***	0.137***	0.160***	0.162***	-0.004	0.008	-0.019***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.479}	{0.366}	{0.000}
δ_1	0.062	0.407***	0.074***	-0.119***	0.450***	0.044	0.361***
	{0.676}	{0.000}	{0.000}	{0.000}	{0.001}	{0.523}	{0.000}
δ_2	0.020***	-0.039***	0.035***	0.138***	0.394***	-0.932***	0.324**
	{0.000}	{0.005}	{0.000}	{0.000}	{0.006}	{0.000}	{0.023}

Diagnostics							
Ln L	2810.993	2545.818	1944.207	3440.586	2123.805	1992.643	1220.737
$Q_b(10)$:	37.032	49.300	57.022**	52.609*	39.555	17.963	39.739
$\chi^2(40)$	{0.605}	{0.149}	{0.039}	{0.087}	{0.490}	{0.999}	{0.482}
$Q^2_b(10)$:	377.687***	241.358***	233.565***	312.488***	18.758	30.715	41.535
$\chi^2(40)$	{0.000}	{0.000}	0.000	{0.000}	{0.998}	{0.854}	{0.404}

*Notes: Ln L is the estimated value of log-likelihood. P-Values are shown in the brackets. *,**,*** denote significance at the 10%, 5% and 1% level respectively. $Q_b(10)$ and $Q^2_b(10)$ are the bivariate Ljung-Box tests for joint white noise in the linear and squared standardized residuals (z_t's and z^2_t's) up to the 10^{th} order*

Table A.3 Regression Analysis of Inter-Stock-Bond market integration including information variables

In panel A of this table, the OLS results are reported for each country and in panel B, the SURE results are shown. The model defined in equation (5.8) is supplemented here with additional information variables commonly used in the stock-bond comovement literature. P-Values are shown in the brackets. *, **, *** denote significance at the 10%, 5% and 1% level respectively.

	Euro zone				Non-euro zone		
	FRA	GER	ITA	SPA	UK	JAP	US
Panel A: Single Equation Least Squares							
CONSTANT	0.0097	0.0053	0.0035***	0.0061	-0.0105*	-0.0394***	-0.0166***
	{0.2701}	{0.5013}	{0.0075}	{0.4642}	{0.0749}	{0.0000}	{0.0022}
EX_VOL_{t-1}	-0.0034	-0.0057	-0.0003	0.0004	0.0027	-0.0028***	0.0036
	{0.3358}	{0.2302}	{0.6032}	{0.8302}	{0.2776}	{0.0000}	{0.4913}
$REAL\_INT_{t-1}$	0.0129**	-0.0007	-0.0004	0.0068*	0.0000	0.0009**	0.0011
	{0.0149}	{0.8562}	{0.5022}	{0.0538}	{0.9896}	{0.0304}	{0.4662}
MON_INT_{t-1}	-0.0037	0.0010	-0.0010**	-0.0001	0.0002	-0.0002	0.0012
	{0.2038}	{0.7134}	{0.0475}	{0.9249}	{0.7802}	{0.4218}	{0.3503}
JAN_DUM	-0.0003	0.0005	0.0009	-0.0014	-0.0003	0.0004	-0.0044
	{0.9088}	{0.8757}	{0.3018}	{0.6491}	{0.9107}	{0.7129}	{0.2585}
DIV	0.0024	0.0033	0.0002	0.0009	0.0029**	-0.0020	0.0094***
	{0.1473}	{0.1820}	{0.4648}	{0.5100}	{0.0261}	{0.3994}	{0.0001}
ST_IRATE	-0.0023	-0.0025	-0.0014	-0.0018	0.0002	0.0003	0.0035**
	{0.4487}	{0.4632}	{0.1967}	{0.5251}	{0.8547}	{0.4944}	{0.0391}
TERM	0.0032	-0.0037	-0.0004	0.0063	0.0013	0.0008	0.0008
	{0.4759}	{0.3806}	{0.4631}	{0.1913}	{0.4864}	{0.5581}	{0.8255}
	1.1321***	0.7358***	1.2995***	0.8822***	1.1653***	0.7366***	0.9180***
$\rho_{BSi,t-1}$	{0.000}	{0.000}	{0.000}	{0.0000}	{0.000}	{0.000}	{0.0000}
	-0.1622***	0.2405***	-0.3254***	0.0861***	-0.1774***	0.0313	0.0514***
$\rho_{BSi,t-2}$	{0.000}	{0.000}	{0.000}	{0.0001}	{0.000}	{0.1242}	{0.0085}
ADF Test Statistic	-5.5404**	-5.4901**	-6.4788**	-5.7078**	-4.2833**	-13.1336**	-5.6143**
Adj. R^2	0.9647	0.9526	0.9682	0.9459	0.9855	0.6133	0.9743
No. obs.	2469	2469	2469	2469	2469	2469	2469
Panel B: SURE							
CONSTANT	-0.0035	-0.0018	0.0064***	0.0045	-0.0144***	-0.0391***	-0.0170***
	{0.6447}	{ 0.7628}	{0.0000}	{0.4825}	{0.0068}	{0.0000}	{0.0001}
EX_VOL_{t-1}	-0.0022	-0.0035*	-0.0004	0.0001	0.0029	-0.0028***	0.0038
	{0.1839}	{0.0516}	{0.4067}	{0.9704}	{0.1649}	{0.0000}	{0.3646}
$REAL\_INT_{t-1}$	0.0080*	0.0021	0.0004	0.0037*	-0.0003	0.0011**	0.0012
	{0.0760}	{0.4656}	{0.4838}	{0.0872}	{0.8966}	{0.0103}	{0.4126}
MON_INT_{t-1}	-0.0030	0.0009	-0.0009**	-0.0003	-0.0001	-0.0003	0.0009
	{0.1821}	{0.6437}	{0.0180}	{0.7818}	{0.8513}	{0.3644}	{0.4041}
JAN_DUM	-0.0009	0.0013	0.0009	-0.0010	-0.0000	0.0003	-0.0039
	{0.7545}	{0.6826}	{0.1960}	{0.6806}	{0.9904}	{0.6966}	{0.1864}
DIV	0.0051***	0.0076***	-0.0003	0.0013	0.0040***	-0.0023	0.0097***
	{0.0021}	{0.0027}	{0.2618}	{0.2741}	{0.0013}	{0.2817}	{0.0000}
ST_IRATE	-0.0015	-0.0018	-0.0019**	-0.0027	0.0002	0.0005	0.0024
	{05155}	{0.4369}	{0.0439}	{0.2121}	{0.8466}	{0.3110}	{0.1382}
TERM	0.0044	-0.0022	0.0003	0.0048	0.0025	0.0011	0.0021
	{0.2037}	{0.5029}	{0.5515}	{0.2097}	{0.1474}	{0.4182}	{0.5073}
	1.0899***	0.7164***	1.2882***	0.8390***	1.1335***	0.7382***	0.8522***
$\rho_{BSi,t-1}$	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}
	-0.1304***	0.2454***	-0.3176***	0.1205***	-0.1520***	0.0296	0.1147***
$\rho_{BSi,t-2}$	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.0000}	{0.1357}	{0.0000}
Adj. R^2	0.9655	0.9537	0.9690	0.9472	0.9858	0.6240	0.9749
No. obs.	2469	2469	2469	2469	2469	2469	2469

Figure A.1 Time-varying stock market integration for CEECs, 1/1989-5/2003.

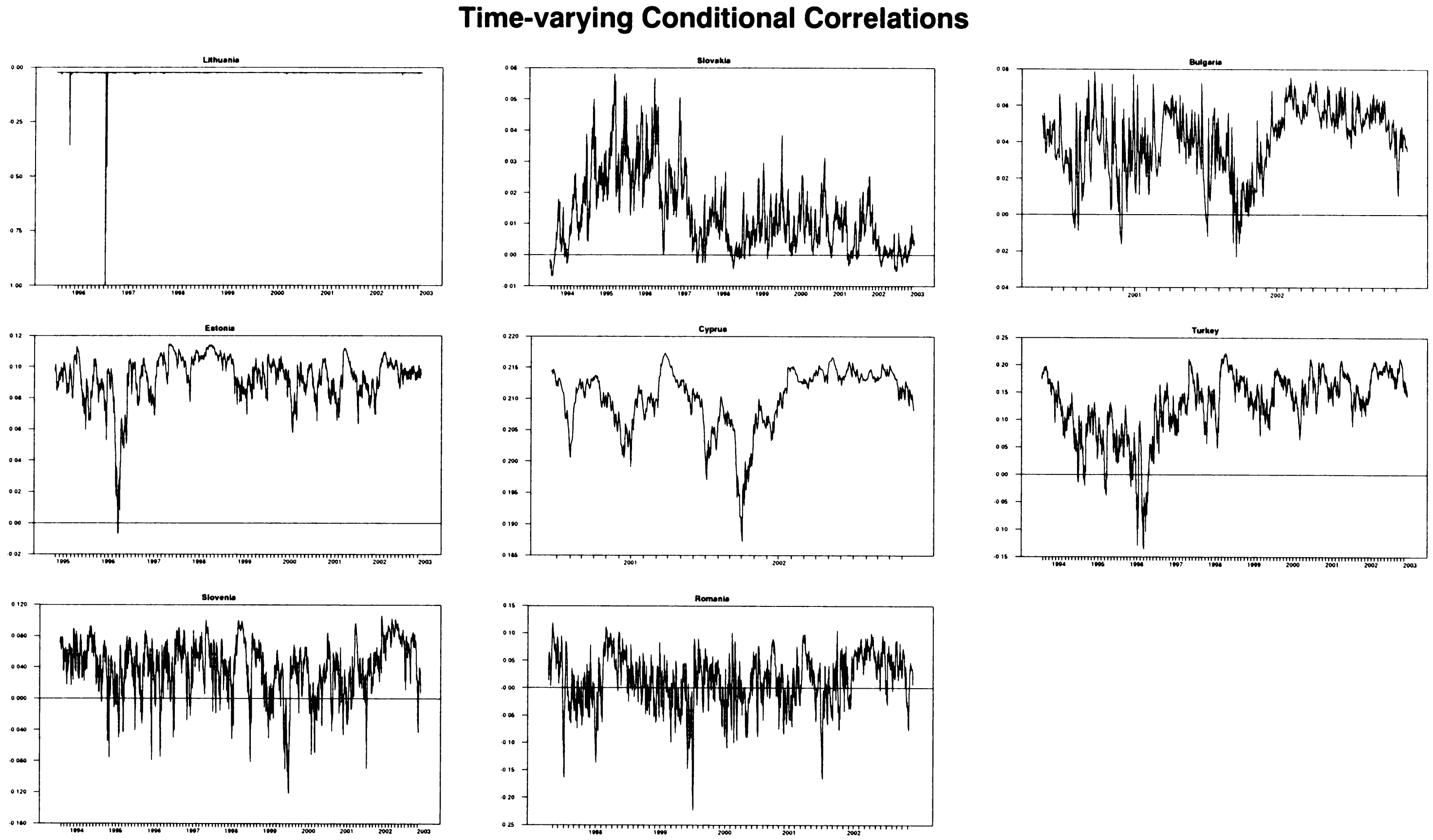

Figure A.2 Time-varying integration between bond returns and the Equity Risk Premia: 2/3/1994 – 19/9/2003.