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Measures and drivers of financial integration in Europe

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Measures and drivers of financial integration in Europe

The report contains a review of the literature on price based measures of financial markets integration and computes three indicators of financial integration in the EU28 equity and bond markets. Following the idea that in more integrated markets shocks transmit more easily, the common rationale for the three indicators is that of measuring the extent to which domestic stock (bond) market volatility incorporates external shocks. We use a multivariate GARCH and a common factor portfolios models to derive the indicators providing also a battery of robustness checks to test the validity of our results and the assumptions of the models. Finally, we investigate the drivers of integration in the equity market by estimating a panel regression relating integration, as measured by common factor portfolios, with many macro and institutional variables.

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Executive summary

The report contains a **review of the literature on price based measures of financial markets integration**. We survey different approaches, all based on the idea that integration exists when the *law of one price* holds. This golden rule of financial integration literature claims that with markets integration, there should not be space for unexploited international arbitrage and the prices of the same item in different currencies would only reflect the differences in exchange rates.

Several variables have been traditionally used to verify the *law of one price*: the cost of interbank funds denominated in the same currency; the covered interest-rate parity (no interest rate arbitrage opportunities between two currencies) or the co-movements of stock prices or volumes across countries. In this report we follow that latter approach and confine our analysis to stock and bond markets. **The report proposes** two methods to derive **indicators of financial integration** based on the sensitivity of domestic European stock (sovereign bond) markets to global, US or European shocks. Our time frame goes from 2000 to 2015. The common rationale is to measure the extent to which domestic stock (bond) market volatility incorporates external shocks, following the idea that in more integrated markets shocks transmit more easily. The first method, based on correlation of stock market returns, estimates two measures of integration. Firstly, the proportion of shocks generated in EU and US markets that actually hit EU domestic markets and secondly domestic sensitivity to foreign shocks (spill over intensity). We find that during the EU sovereign crisis over 30 (20) percent of the EU (US) originated shocks were shifted into domestic volatility in distressed countries while they had little impact in Eastern countries. For Denmark, Sweden and UK the proportion of variance in domestic returns that could be explained by US-generated shocks was similar to that of the EA core countries (about 45%), while the EU influence was about 10 percentage points smaller. Spill over intensity originating from EU is larger for distressed Euro area countries than for the core ones while the reverse occurs for that originated from US. For eastern countries spill over intensity (either from EU or from US) is negligible.

The third method, based on common factor portfolios, identifies a set of recurrent common factors in EU and World stock and bond markets, interpreted as integration drivers, and derive a measure of domestic integration by calculating to what extent domestic returns reflect the common factors. For the equity market results indicate that Euro area distressed countries present lower integration for all the period analysed. Denmark, Sweden and UK show patterns similar to core EA countries with higher sensitivity to idiosyncratic effects after 2009. Local influences dominate for Eastern countries where, with the exception of 2008, global factors have little explanatory power. The disintegration phase after 2008 is much more evident in the bond market where idiosyncratic effects prevail especially for distressed Euro area countries.

Finally, we discuss the **drivers of integration in the equity market** by estimating a panel model relating integration, as measured by common factor portfolios, with many macro and institutional variables. Our analysis shows that macro-economic variables reflecting the country's economic prospects (eg. GDP, deficit and inflation) and the development of the domestic financial market have an impact on the degree of integration. Credit ratings, trade openness and measures of governance overall do not affect financial integration.

This policy report merges the JRC contribution to the European Financial Stability and Integration Review[1] (EFSIR) with a more in depth analysis on the issue of financial integration. The policy context of our work relates to the EFSIR which provides a general view on how financial markets performed in the previous year and identifies indicators relevant to the key objectives in the Capital Markets Union (CMU) Action Plan[2]. The Action Plan sets out a set of measures[3] to achieve a single market for capital in the European Union, aiming to mobilise capital, to foster economic growth and create jobs. CMU also aims at promoting financial stability by complementing the actions undertaken under the Banking Union[4] initiative.

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[1] EFSIR, SWD(2016)146, Brussels 25 April 2016

[2] COM(2015) 468 final, http://ec.europa.eu/finance/capital-markets-union/docs/building-cmu-action-plan_en.pdf

[3] http://ec.europa.eu/finance/capital-markets-union/index_en.htm

[4] http://ec.europa.eu/finance/general-policy/banking-union/index_en.htm

1 Introduction

The traditional role of capital markets is that of channelling resources from savers (households, firms, governments) to investors, loosening the constraints imposed by self-financing and enabling an increase in productivity of investments and consumption smoothing. In a nutshell, capital markets are called to provide liquidity, allocate and diversify risk, and increase economic system's efficiency. The past 30 years have shown a growing liberalization of world financial markets. The progressive dismantling of capital and exchange controls, the sharp decrease in costs of telecoms and improved technology, together with increased cross border trade, the intensification in securitization and institutionalization of savings[5] and investments, and the improvement of payment and settlement system (Mussa-Goldstein, 1993), all contributed to increase the international circulation of capital. In Europe, the Economic and Monetary Union (EMU) has been an important driver for financial market liberalization (Berben and Jansen, 2005).

But financial liberalization does not necessarily mean integration. In fact large share of domestic investment is still financed by domestic savings (Darvas, et al., 2015), and retained earnings are important source of financing for firms (Giovannini et als. 2015). A non-trivial share of household financial assets in the major countries is hold in non-intermediated form (e.g. equities in self owned business). The question is then to what extent are financial markets integrated? How financial integration can be monitored?

The answer of the literature is not unanimous and monitoring spans from indirect measures of financial integration based on the relationship between domestic investments and savings (Darvas, et al., 2015, Blanchard and Giavazzi, 2002, and the seminal paper of Feldstein and Horioka, 1980) to direct measures which look at barriers to financial integration or at the divergence from the *law of one price* (Adam et al., 2002). The *law of one price* postulates that identical assets should be traded at the same price in different locations. In other terms, with financial markets integration, there should not be space for unexploited international arbitrage and the prices of the same item in different currencies would only reflect the differences in exchange rates. Several variables have been used to verify the *law of one price*: the cost of interbank funds denominated in the same currency (Enoch et al. 2014); the covered interest-rate parity (no interest rate arbitrage opportunities between two currencies; see for example Ferreira and Dionisio, 2015); or the co-movements of stock prices or volumes across countries (ECB, 2014, 2015). In this report we follow that latter approach and confine our analysis to stock and bond markets.

This technical report complements and extends the JRC contribution to the European Financial Stability and Integration Review[6]. This contribution, collected in the JRC Technical Report - Measuring Financial Integration in Europe: a price-based approach for equity and bond markets, EUR 27792, is presented here as Section 3. This report is the final delivery of the Administrative Arrangement FISMA/2015/124/B2/ST/AAR.

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(5) Increased concentration of savings in institutional funds, i.e. mutual funds, pension funds, insurance companies, unit trusts and hedge funds.
(6) EFSIR, SWD(2016)146, Brussels 25 April 2016.

The report is organized as follows. Section 2 contains a review of the literature on price based measures of integration. We survey different approaches, all based on the idea that integration exists when the *law of one price* holds. We are interested in the methodologies, rather than in the results, as methodologies determine the validity of the results obtained. The latter are summarized in table A1.1 and A1.2 in Annex 1.

Section 3 presents and discusses the estimations of two models: The first method, based on correlation of stock market returns, offers two measures of integration. Firstly, the proportion of shocks generated in EU and US markets that actually hit EU domestic markets and secondly domestic sensitivity to foreign shocks. The third measures of integration stems from a second method based on common factor portfolios, which identifies a set of recurrent common patterns in EU and World stock and bond markets. Domestic returns are then matched against these global factors to see the degree of co-movement. This section also presents robustness checks for the models, extending those for that based on the factor portfolios. The validity of this model is, in fact, instrumental to the work presented in section 4. There, we discuss the drivers of integration by estimating a panel model relating integration with many macro and institutional variables. Our analysis shows that macro-economic variables reflecting the country's economic prospects, such as GDP, deficit and inflation indeed have an impact on the degree of integration. Instead, county credit ratings, trade openness and various measures of governance overall do not affect financial integration in the equity market. The development of a domestic financial market turns out to be an important driver of integration too. Finally, various annexes with additional tables and figures conclude the report.

2 Financial market integration: theoretical literature

Do the savings originated in a country remain to be invested there or does capital flow among world countries so as to equalize the investors' yields? If capital markets were perfectly flexible domestic investments would not depend on domestic savings: incremental savings would either leave the country - if that country is a capital exporter, or would compete with foreign capital flows to be invested domestically - if the country is a capital importer (Feldstein and Horioka, 1980). Likewise, domestic investments would be financed by borrowing from the cheapest lender be it abroad or in the home country. With perfect world capital mobility, or in other terms frictionless market integration, there should be no relation between domestic saving and domestic investment: domestic saving flows would depend on worldwide opportunities and domestic investment would be financed by the worldwide pool of savings. Vice versa if domestic saving tends to be reinvested in the country of origin, then differences among countries in saving rates should correspond to differences in investment rates[7]. This is the *home bias*. In the absence of direct observations on the possible market frictions and their consequences in cross-country movements of aggregate domestic savings and investments, the estimation of the home bias has constituted an indirect way to analyse the degree of financial market integration[8].

The ECB (2007) has adopted a more detailed definition of financial integration: "it considers the market for a given set of financial instruments or services to be fully integrated when all potential market participants in such a market (i) are subject to a single set of rules when they decide to deal with those financial instruments or services, (ii) have equal access to this set of financial instruments or services, and (iii) are treated equally when they operate in the market". In line with this definition the indicators used to measure financial integration are based on quantities (e.g. number and market share of cross-border intermediaries, cross-border stock and flows of investments, etc. see ECB, 2016, Adam et al. (2002)) and prices (e.g. interest rates, yields). The literature on both types of indicators (and on the associated models) is large and growing. This section principally reviews models testing the co-movements of expected returns on stock or bond markets.

The literature analysed here, more or less explicitly, goes back to two types of models. The first group is composed by equilibrium models such as Capital Asset Pricing models (CAPMs, Luenberger 1998). CAPM exploits the idea that equity risk premium (i.e. the incentive to invest) can be decomposed into a global risk premium and a domestic risk premium. In fully

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(7) Complete arbitrage is probably an extreme case in portfolio theory as several frictions could hamper the free movements of capital. Long-term capital movements could be less liquid than short term capital flows due to risk aversion arguments. There could be institutional rigidities that keep a large fraction of savings at home and hinder foreign investments. International differences in tax rules introduce differentiated net returns modifying investment incentives and generating uncertainties. Moreover the high correlation savings-investments with perfect capital mobility could be due to general equilibrium effects: a shock affecting global savings produces imbalances in the capital market, a decrease in interest rates and an increase in investments. See Giannone and Lenza (2008) for a detailed explanation.

(8) On home bias see French and J. Poterba (1991). On financial market integration and home bias see Baele et al. (2007), Adam et al, 2002, and Hobza and Zeugner, 2013 among others.

integrated (segmented) markets only the global (local) risk is priced. The literature falling into this area is trying to estimate the magnitude of the risk premium.

Examples of the second group relate to simple bivariate correlation or with multivariate measures such as GARCH or factor models. Originally both types of models were employed to test the degree of integration of emerging countries with the world market, more recently studies also focus on EMU or EU countries. Notice that integration is always the result of a bivariate relation: the literature aims to quantify the link between two countries or between one country and a group of others. Any global result is calculated as an average of bivariate relationships. To the best of our knowledge a truly multilateral approach has never been proposed and should probably be based on non-parametric statistical methods (such as network analysis). With few exceptions[9] integration is analysed using stock or bond markets values (returns/prices). Clearly, stock/bond market returns only partially reflect economic fundamentals within each country (Dumas et al., 2003). With this in mind, in the following sections we will briefly report on the theoretical approaches and how they face the issue of measuring integration, its limitations and way forward.

We start from models based on portfolio selection theory that test empirically the provisions of a theoretical model or its implications, we then move to more empirical approaches based on correlation and co-movements. This section hosts very different approaches, from those based on time-series co-evolution of prices to others based on the idea that integration is a latent variable that can be captured using non parametric statistical methods. Tables at the end of the document will detail assumption, scope, coverage and results of the analysed literature.

2.1 Equilibrium models: Capital Asset Pricing and Arbitrage Pricing

A part of the literature on price-based financial integration is framed within the Capital Asset Pricing Model. The idea is that there exists an equilibrium relationship between portfolio risk and expected return for assets. In CAPM models the expected return of a portfolios decomposed into a rate on a risk-free security plus a risk premium. Clearly several factors could hamper the possibility to freely invest cross-border and influence the risk premium: transaction costs, taxes, limited information, physical and institutional barriers, and variable degrees of risk aversion are some of them. In this framework of imperfectly functioning capital markets, estimating integration mainly implies testing the existence of a risk premium different from what the theory would predict. Notice that, in the earliest literature, financial integration is intended as an on-off process: markets are either fully segmented[10] or fully integrated[11]. More recently the literature started to model integration as a gradual phenomenon, looking more to the dynamics of the integration process.

(9) e.g. in ECB 2010-2015 were money markets and banking markets are also analysed or in Karolyi (2003) were American Depositary Receipts are used.

(10) This literature applies Asset Pricing Models to a single country (e.g. Sharpe, 1964; Lintner, 1965; Black, 1972).

(11) By assuming a world CAMP (e.g. Harvey, 1991); a CAPM with exchange risk (Dumas & Solnik, 1995), a consumption-based model (Wheatley, 1988), arbitrage pricing theory (Solnik, 1983), multi-beta models (Ferson &

One of the first papers conveying the theoretical notion that capital markets are neither fully segmented nor fully integrated is that of Errunza and Losq (1985). The authors assume a two-country capital market model and an asymmetric segmentation: country A investors cannot hold securities in country B while country B investors can hold securities in country A. Ineligible securities thus require a "super risk premium" i.e. an additional compensation which is proportional to the differential risk aversion and the conditional market risk. The authors prove that asymmetric segmentation has some statistical grounding by using stock data from nine emerging countries and a random sample from the US for the period 1976-1980.

Although the Errunza and Losq (1985) model is static in nature, it paved the way for comparing asset prices within a dynamic equilibrium framework. The first empirical study that allows the degree of integration to change across time is authored by Bekaert and Harvey (1995). The dynamic nature of the integration process is captured using a conditional regime switching model[12]: countries are allowed to shift from segmentation to integration according to transition probabilities which are ideally a function of policies favoring financial market integration (and proxied by e.g. lagged divided yields and market capitalization as a percentage of the GDP). They test the model with equity markets data for developed and emerging markets (with different time coverage) finding that that some emerging countries are more segmented than integrated (e.g. Colombia or India) while others are well integrated to the world market (e.g. Greece and Thailand).

A European focus is explicitly analysed by Hardouvellis et al. (2006). The authors examine whether convergence towards the single currency affected the integration process of European countries by analysing stock market data for 11 euro-area countries plus the UK from 1992 to 1998. As in Bekaert and Harvey (1995) the degree of integration is time-varying. Additionally, Hardouvellis et al. (2006) make the degree of integration conditioned to a set of monetary, currency, and business cycle variables, proxies of European convergence. The movements of forward interest rate differentials with Germany (used as indicator of the probability to join the common currency) turned out to be the variable closely associated with integration. Authors also show that integration among European countries significantly increased in 1995 and stock markets appeared to be fully integrated by the end of 1998 with the only exception of UK that exhibited no signs of integration with the rest of European stock markets.

Although equity markets integration is privileged, the literature also touched upon bond markets integration, especially in the European context. Abad et al. (2010) adopt the Bekaert and Harvey (1995) model to study the impact of the introduction of the common currency on the degree of integration of European government bond markets. In contrast to Hardouvellis et al. (2006) the focus is on the time period after the introduction of the common currency. Their analysis is based on weekly 10-year sovereign benchmark yields from 1999 to 2008 for 13 EU countries (10 EMU and 3 non-EMU). Three effects are proven to govern domestic bond returns: a local effect, a Eurozone effect, and a world effect. The authors conclude that

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Harvey, 1993) and latent factor models (Campbell & Hamao, 1992). For a description of this early literature see Bekaert and Harvey (1995).

(12) Their integration measure is a time-varying weight applied to the covariance of domestic market returns and world returns and to the variance of domestic returns.

sovereign bonds markets home bias persists as domestic returns could be predicted essentially by using only domestic instruments (e.g. among others: lagged index returns, difference between the 10-year bond and the 3-year T-bill). Their analysis highlights that the integration process differs among EMU and non-EMU countries, with EMU countries more influenced by EU risk factors, and non-EMU countries more sensitive to world risk factors.

A stream of research that reconciles the equilibrium approach (although deviating from the CAPM theoretical framework) with the empirical time-series analysis on barriers is that of Carrieri et al. (2007). They focus on emerging markets' integration by using a GARCH-in-mean methodology to estimate the Errunza and Losq (1985) model. The integration index is constructed by distinguishing between fully integrated markets where only global risk is priced, and fully segmented markets where only the local market risk is priced (intermediate states are also considered). This methodology is tested in eight emerging markets from 1997 to 2000, where different types of barriers are imposed. While the degree of integration significantly varies across countries, none of them appears to be fully segmented. Among the factors that could potentially affect integration, financial market developments and liberalization policies are found to be statistically significant. In a subsequent paper, Carrieri et al. (2013), apply the "integration index" methodology to twenty-two emerging markets and six developed ones from 1989 to 2008, investigating the role of implicit barriers in emerging markets. They show that only developed markets are fully integrated, while emerging markets are not.

Arbitrage Pricing Theory (APT), originally proposed by Ross (1976), is another type of theoretical approach extensively associated to price measures of financial integration. In contrast to the CAPM where the market portfolio is the only systematic source of risk, with APT models stock prices can be affected by several economic factors additional to the market risk. The pioneering theoretical contribution in this stream of works is that of Chen and Knez (1995). They propose a general arbitrage approach for testing integration that does not require specifying an asset model. The authors develop two measures for market integration (weak and strong) starting from the assumptions that (i) the law of one price cannot be violated[1] and (ii) there are cross-market arbitrage opportunities. Chen et al. (1986) specifies and test the economic factors influencing stock prices within the APT framework, proposing variables such as the differences in short term interest rates, the risk premium, the term structure, industrial production, and market returns.[13] However, probably the most interesting application of APT is that related to the use of Factor Models to derive economic drivers. As it deals with co-movements, that literature is reported in the following section. Interestingly, Mittoo (1992) compares the performance of CAPM and the APT framework when examining the integration among the Canadian and the US market. The author uses the same pre-specified factors as the ones proposed in Chen et al. (1986) and finds that both models supply essentially the same conclusions.

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(13) For additional applications of APT see also Korajczyk and Viallet (1989), Xu (2003).

2.2 Correlation and co-movements

The most abundant literature on price integration exploits the idea that co-movements of stock market prices/returns are indeed an indicator of integration (Kearney and Lucey, 2004). The easiest way to measure co-movements is to calculate correlations between prices or returns. Simple (unconditional) correlation measured by the Pearson correlation coefficient, however, suffers from a number of drawbacks (Carrieri et al. 2007). It tends to underestimate integration as proved by Pukthuanthong and Roll (2009) and Billio et al., (2012) and it is sensitive to outliers. It has also been observed that, in periods of high common volatility, correlations tend to be higher.[14] In particular volatility rises during crises and leads to an artificial over-estimation of average correlation - hence of integration (Forbes and Rigobon, 2002[15]).

An interesting indicator for investigating co-movements of stocks returns that takes into account long term trends and short term fluctuations is that proposed by Graham et al. (2012). The indicator is based on wavelet analysis, a technique for decomposing a signal into frequencies. By using a continuous wavelet transform and employing the notion of wavelet coherency the authors construct a wavelet squared coherence measure that can be thought to be equivalent to a correlation coefficient when both long and short term (volatility) effects are taken into account. This measure is applied to 22 emerging countries (2001-2010) for investigating their co-movements with the US-market. Results show that the strength of co-movement varies across countries. A higher degree of co-movement across countries is evident for long term fluctuations (lower frequencies), while co-movement at highest frequencies (short term fluctuations) is weak. In other terms short term fluctuations tend to be idiosyncratic while longer terms fluctuations tend to be more coordinated.

Another and more subtle shortcoming of standard correlation arises when financial markets are hit by a common shock (this is a general problem common to all measures based on co-movements). When this happens the correlation among countries might be high even without integration (Obstfeld and Taylor, 2003). In this case one could not distinguish between common shocks and real integration when using correlation.

(14) Positive link between correlation and volatility can be found in King et al. (1994), Longin and Solnik (1995), Ramchand and Susmel (1998), Goetzmann et al. (2005), Morana and Beltratti (2008).
(15) Volatility implies non constant variance of market returns, i.e. heteroscedasticity. The literature distinguishes between conditional and unconditional heteroscedasticity. The first happens when volatility cannot be predicted in advance (i.e. future periods of high/low volatility cannot be identified ex ante, see Forbes and Rigobon, 2002 for a review of the relevant literature). The second occurs when volatility can be predicted with anticipation such as with seasonal variation or the periodical publication of firms' balance sheets (see Billio et al., 2015 for a discussion).

2.2.1 Integration as long-run stock market relations: cointegration techniques

A more sophisticated way to check comovements of financial market returns, focusing on the long-run stock market relations, is using cointegration techniques.[16] The idea is to test plausible economic relationships, under the hypothesis of a long-run equilibrium between non-stationary time series.

One of the first studies using this techniques is that of Kasa (1992) who provides evidence for a single common stochastic trend driving the five major stock markets (U.S., Japan, England, Germany, and Canada). An application for developed markets is offered by Arshanapalli and Doukas (1993) who examine the linkage and dynamic interactions among the stock markets of US, Japan, France, Germany, and UK. For the post-crash period, the US stock market is found to have a considerable impact on the French, German and UK markets, while, the Japanese has no links with any other market during the pre-and post-crash period. Pretty much the same result is obtained by Bessler and Yang (2003) for an heterogeneous set of countries (Australia, Japan, Hong Kong, United Kingdom, Germany, France, Switzerland, United States, Canada), while the US is the only market consistently and strongly impacting on price movements elsewhere in the longer-run. Ratanapakorn and Sharma (2002) enlarge the set of analysed countries[17] and look at both short- and long-term relationships distinguishing the pre-Asian crisis from the crisis period. Results indicate that, while no long-run relationship is observed among these indices during the pre-crisis period, during the crisis period, one significant cointegrating vector is observed. The literature employing cointegration techniques to investigate links in the emerging Asian markets is abundant (e.g. Phylaktis, 1999; Fernandez-Serrano and Sosvilla-Rivero, 2001; Manning, 2002; Click and Plummer, 2005) such as the literature on the effects of EU enlargement process on capital markets. For example, Voronkova (2004) and Syriopoulos (2004) analysed the linkages among Central European stock markets (i.e. Poland, Czech Republic, Hungary and Slovakia) and developed markets, concluding that they have become more integrated with global markets. Overall, the literature confirms the presence of cointegration in a regional level and for certain time periods.

2.2.2. GARCH framework

A bulky part of the literature on price integration is not interested in long-run stock market relations but rather in the volatility spillovers across financial markets and in speed of transmission of cross-border shocks. Volatility transmissions can be asymmetric as in Koutmos and Booth (1995) where the impact of good news and bad news on volatility transmission is described using an EGARCH[18] model. With daily stock data from USA, UK and

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(16) See Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990) on cointegration theory.
(17) US, Europe, Asia, Latin America, Eastern Europe, Middle East.
(18) Exponential Generalized Autoregressive Conditionally Heteroskedastic (EGARCH)

Japan the authors proof that volatility spillovers originating from bad news are more intense. Baele (2005) examines to what extent global (US) and regional (European) shocks are transmitted to a domestic market by allowing regime switches in the spillover parameters. The focus is on the European equity markets and the time period covers mostly the pre-EMU phase (1980-2001). Domestic volatility is decomposed into a global, a regional and a domestic component and ratios that measure the proportion of domestic variance explained by global and regional shocks are estimated. Baele (2005) finds that the intensity of volatility spillovers is increasing in time, especially in Europe. In a similar work Christiansen (2007) examines the volatility spillover intensity in the European bond markets by using various specification models for the volatility parameters. For EMU countries regional (i.e. aggregate Europe) spillovers are large, while, global ones are negligible pointing to a well-integrated market (the result is confirmed for the bond market by Skintzi and Refenes, 2006). In contrast for EU non-euro area countries, global spillovers seem to be larger as compared to regional ones. Pungulescu (2013) applies the same volatility spillover measure to a battery of indicators to investigate integration improvements of the credit, bond markets and stock markets in the EU before and after the 2000 enlargement[19]. The author concludes that the ultimate goals of financial market integration, perfect capital mobility and full international risk sharing, remain out of reach.

A strengthened linkage among EMU countries after the introduction of the common currency is also found by Kim et al. (2005) with the use of a bivariate ARMA-EGARCH model for the period 1989-2003. The model allows for country and regional spillovers in mean and volatility and computes time-varying conditional correlations. To investigate variables influencing integration, the estimated conditional correlation series are regressed on various explanatory variables (e.g. exchange rate volatility, stock market capitalization as a percentage of the GDP, stock market turnover etc.). Not surprisingly, macroeconomic convergence and financial developments result to be the main drivers of the integration process. In a following paper, Kim et al. (2006) examine both bond and stock markets and their interlinkages. For EMU countries they find that shocks in bond returns affect stock market volatility but not vice versa. For non-Euro Area financial markets, instead, return shocks in both bond and stock markets affect each other. Fratzscher (2001) with a similar model finds that European equity markets have become highly integrated since 1996 due to the elimination of exchange rate volatility.

Strong interlinkages between Balkan and developed equity markets are confirmed by the literature. Amon others Kenourgios and Samitas (2011) analyse the time-varying correlation dynamics during the 2000-2009 (with a focus on the 2007-2009 financial crisis) by applying the Asymmetric Generalized Dynamic Conditional Correlation (AG-DCC) multivariate GARCH model of Cappiello et al. (2006). The correlation dynamics obtained by the AG-DCC GARCH model reveal increased dependence among Eastern and Western equity markets.

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(19) For the credit and bond markets the author uses the β-convergence and σ-convergence indicator similar to Adam et al. (2002), while for testing for international capital mobility and risk sharing employs Feldstein–Horioka model (Feldstein and Horioka, 2008)

2.3 Back to fundamentals Factor Models and systemic risk

2.3.1 Factor Models and systemic risk

An open issue, within Arbitrage Pricing models, is that of distilling general drivers representing integration from a potentially large set of economic factors representing economic fundamentals within each country. To this purpose the literature resorted to factor models, originally developed to characterize the best possible portfolio composition, i.e. the portfolio able to minimise idiosyncratic diversifiable risk, given the unavoidable and uncontrollable systemic risk (Luenberger, 1998). The use of factor models for analysing financial market integration goes back to the 2000s with the work of Pukthuanthong and Roll (2009).[20] The idea is that financial market integration can be measured by looking at the proportion of county's returns that can be explained by *global* factors[21]. If this proportion is small, then the country is dominated by domestic or regional influences and will not be *integrated*, if instead "a group of countries is highly susceptible to the same global influences, there is a high degree of integration" (Pukthuanthong and Roll, 2009, p.215).

With respect to the GARCH framework, which works with volatility in order to quantify the part of foreign volatility acknowledged by domestic markets, factor models are interested in linking domestic tendencies to an observable approximation of unknown international drivers. Drivers are obtained via Principal Component Analysis (henceforth PCA[22]) usually on a set of international stock (bond) market indices. PCA factors have the feature of being orthogonal (avoiding correlation of independent variables when used in regression) and are much less sensitive to outliers which plague the usual correlation coefficients, as outliers will be loaded separately in standalone factors (Jolliffe, 2002).

A measure of integration is derived by averaging, across countries, the R^2 of the regression of country *h* daily returns on the corresponding daily returns of the factor portfolios representing global factors. In absence of other explanatory variables, the average R^2 has a straightforward interpretation: the lower the average cross-country R^2, the higher will be the influence of idiosyncratic factors and the lower the ability of global factors to explain domestic returns, hence the lower the integration between the analysed countries.

But how many PCA factors are appropriate to capture global trends? The literature is divided. Pukthuanthong and Roll (2009) use 10 factors; ECB (2014-15), Billio et al. (2015) and Nardo et al. (2016) use 3 factors; whereas Volosovych (2011) and Zheng et al. (2012) only look at the first PC, that with the largest share of variance explained. On a selection of 135 US stocks, Kim and Jeong (2005), using spectral decomposition, find that the first principal component,

(20) See also Mauro et al. (2002) and Bordo and Murshid (2006). See also Berger et al. (2011), Berger and Pukthuanthong (2012).
(21) Such as the introduction of a common currency, a global shock, or common tendencies in the stock markets, etc.
(22) PCA transforms observed data into new variables named principal components (PC), which are linear combinations of the original variables. The weights of the linear combinations maximise the variance explained by that component (Jolliffe, 2002). The goal of the method is to capture most of the data variability with fewer components than original variables, filtering out noise.

that with the largest eigenvalue, represents the market-wide effect that influences all stocks (i.e. the systematic risk). A variable number of PCs (with lower eigenvalues) represent the synchronised fluctuations associated with group of stocks, while, the remaining PCs indicate randomness in price fluctuations, i.e. basically noise (including outliers). A qualitatively similar result is found in Nardo et al. (201623) with a standard PCA (3 factors) on daily stock exchange data for the EU28 countries.

A general limitation of the stream of literature based on co-movements is its interest in modelling the pace of integration rather than in explaining the reasons behind that pace. An interesting exception is offered by Christiansen (2014). Using daily sovereign bond data for 17 EU countries from 1994 to 2012, she replicates Pukthuanthong and Roll (2009) methodology and then estimates to what extent the R2 is affected by observable global and country specific variables. Among the explanatory variables she tests the participation to EMU, the Moody' domestic credit rating, and dummies for the financial and the sovereign debt crisis, concluding that EMU countries are more integrated than non EMU but also more sensitive to credit rating. A similar (in spirit) exercise is done by Volosovych (201124). He creates a set of indices of segmentation using a factor model and explains their behaviour using country specific macroeconomic variables such as trade openness, average inflation rate, average government deficit to GDP, average country risk, etc., plus a set of global dummies indicating the occurrences of international financial crises, cumulative decrees in consumption (real crises), and world wars. Volosovych (2011) proves that both the global environment and policy variables play a role in explaining both integration and segmentation.

An additional interesting stream of literature, related to the use of factor models for explaining financial market integration, is interested in the link between integration and systemic risk.25 This link is somehow implicit in the methodology as factor models have been originally framed to estimate systemic and idiosyncratic risks. Indeed, Berger and Pukthuanthong (2012) interpret the domestic exposure to global risk as a measure of systematic (not systemic) risk and try to link systematic with systemic risk by proposing a Fragility Index. They show that the frequency of market crashes increases with the level of the index.26 Periods of high exposure (high systematic risk) correspond to periods of high systemic risk as shocks to the international factor actually cause market declines across all countries within the system (page 567, note 2) where market decline is measured by drops in average stock returns. This approach, however, misses a clear definition of the link between systematic and systemic risk which is provided, instead, by Zheng et al. (2012). In Zheng et al. (2012) systemic risk is defined as the ratio between systematic and idiosyncratic risk. They show that the larger the change in the first principal component and the higher the increase in systemic risk. However, they are unable to provide a solid indicator of systemic risk as their measure (the monthly increase in the variance explained by the first PC) depends on some ad hoc model parameters.

[23] Daily trading data from 1 January 1999 to 4 December 2015 (source Bloomberg).

[24] Using monthly returns of the sovereign bond market of 15 industrialized economies from 1875 to 2009.

[25] System risk has several and fragmented streams of analysis and reporting them are beyond the scope of this survey. Integration is essentially related to the systemic risk literature interested in contagion and comovements see Giglio et al. 2016. For a survey on systems risk analytics see Bisias et al. 2012.

[26] Daily data for 82 countries and the period 1984-2010.

Another weakness of this approach is that indicators of systemic risk are measured as absolute change: we could have identical absolute changes starting from very different levels of the variance explained, from values near to one (for example when the domestic variability only depends on global shocks, i.e. countries are perfectly integrated) to values close to zero (i.e. when idiosyncrasies dominate). Kritzman et al. (2011) propose a to use as measure of implied systemic risk the absorption ratio measured as the proportion of total variance in assets returns explained (or absorbed) by a given number of principal components. They show that high absorption ratio implies relatively compact (integrated) markets, but fail to show that integrated markets are indeed fragile, as shocks propagate more quickly and broadly. To the best of our knowledge the link between integration and systemic risk remains to be fully explored.

2.3.2 Segmentation and economic fundamentals

An alternative way to link economic fundamentals to financial market integration is that of Bekaert et. al (2011), based on actual industrial data. The authors view each country as a portfolio of industries. An industry's portfolio weight corresponds to the relative equity value of the industry in the country portfolio). For each country, segmentation is calculated as the sum (across industries) of each weighted absolute differences between domestic and global earning yields (i.e the inverse of the price-earnings ratio). The advantage of this methodology that it is being based on the above mentioned ratio avoiding econometric estimations, the disadvantage is that these ratios are subject to accounting measurements and standards that could bias the results. An additional drawback is that the numbers of companies included should be high in order to have an accurate estimation as the measure is sensitive to outliers and temporary volatility movements[27]. Panel regressions are then used to investigate on possible market segmentation determinants across time and countries. Results show that emerging countries tend to have a higher and more volatile segmentation measure. Moreover, factors like barriers to foreign capital, political risk profile and market development are important segmentation determinants. Bekaert et al. (2013) refine the analysis calculating the segmentation measure for a set of EMU, EU non-EMU as well as six non-EU countries. As expected, results indicate that if both countries belong to the EU then their bilateral segmentation measures tend to be lower, and this is interpreted as a sign of convergence. Interestingly, it is the EU membership and not the euro adoption the factor leading the increase in financial integration in this analysis.

The pace of policy reforms eliminating barriers and favoring financial integration do not necessarily coincide with the exact timing of integration. Bekaert et al. (2002) offer an alternative framework for examining the timing of integration in world financial markets. Their methodology does not provide a quantitative measure for financial integration but instead examines for structural breaks in a set of the financial time series. The authors focus on the integration process of 20 emerging markets by using a set of various time series variables related to price levels, liquidity, financial flows, co-movement of returns and economic

(27) Bekaert et. al (2011) use annual data for the period 1980-2005 for 69 countries.

indicators. Although these variables do not provide a clear insight regarding the integration process when used solely, if they are tested simultaneously significant is disclosed. Authors apply a multivariate time series method to identify endogenous break points of the VAR parameters (see Bai et al., 1998) and report the existence of structural breaks in the emerging markets as well as an association between the integration process and the size and liquidity of the market, the credit rating and the volatility of the stock returns.

3 Measuring integration: two applications

We compute three measures of financial integration based on the sensitivity of domestic European stock markets to global, US or European shocks, reproducing and updating the estimations of the European Central Bank (ECB 2014, 2015) based on the works of Baele et al. (2004) and Pukthuanthong and Roll (2009). The common rationale is to measure the extent to which domestic stock (bond) market volatility incorporates external shocks, following the idea that in more integrated markets shocks transmit more easily. The first method, based on correlation of stock market returns, offers two measures of integration. Firstly, the proportion of shocks generated in EU and US markets that actually hit EU domestic markets and secondly domestic sensitivity to foreign shocks. The third measures of integration stems from a second method based on common factor portfolios, which identifies a set of recurrent common patterns in EU and World stock and bond markets. Domestic returns are then matched against these global factors to see the degree of co-movement.

This section presents the analysis and is organised as follows. Section 3.1 presents the method based on correlation of stock market returns and Section 3.2 the method based on common factor portfolios. Section 3.3 concludes and the annex details the data used and provide additional results and tables.

3.1 Proportion of variance and spillovers intensity in equity markets across EU28

3.1.1 The model

For all EU28 countries, we analyze to what extent the volatility of domestic equity returns is driven by the volatility originated in the European market or by US-originated shocks (used as a proxy for global factors), the rationale being that in an integrated financial market foreign shocks should be fully transferred to domestic markets. To examine the degree of co-movement two indicators are calculated: (1) the proportion of US and European shock volatility incorporated in the domestic volatility of equity returns (proportion of variance, PV); (2) the sensitivity of domestic returns to EU and US shocks (spillover intensity, SI). The indicators are derived from the model proposed by Baele et al. (2004) and are similar to the indicators employed by the ECB in their annual financial integration report (ECB 2014 and 2015). Our daily dataset spans from the January 1, 1999 to December 4, 2015. In order to take in to account the gradual introduction of the Euro, the 2007-2008 global financial crisis and finally the EU sovereign crisis the estimated sample is split into three sub-periods (1999-2006, 2007-2011, 2012-2015). Data are obtained from Bloomberg and for each country a major index is selected (see Table A2.1 Annex 2 for a detailed list). Trading days with missing values have been removed from the corresponding domestic sample. Although the primary scope of this report is to test for financial integration across EU28 countries, the PV and SI indicators are also calculated for Canada, China, Japan and Switzerland due to their importance for the global financial system.

A vector autoregressive model (VAR) of the following form is estimated for European index returns $(R_{EU,t})$ and US index returns $(R_{US,t})$:

$$\begin{bmatrix} \mathrm{R_{US,t}} \\ \mathrm{R_{EU,t}} \end{bmatrix} = \begin{bmatrix} \mathrm{c_1} \\ \mathrm{c_2} \end{bmatrix} + \begin{bmatrix} \varphi_{11} & \varphi_{21} \\ \varphi_{21} & \varphi_{22} \end{bmatrix} \begin{bmatrix} \mathrm{R_{US,t-1}} \\ \mathrm{R_{EU,t-1}} \end{bmatrix} + \begin{bmatrix} \mathrm{e_{US,t}} \\ \mathrm{e_{EU,t}} \end{bmatrix} \tag{1}$$

Index returns are calculated as difference in logarithms at a weekly frequency.

The orthogonalized residuals for Europe $(u_{EU,t})$ and US $(u_{US,t})$obtained from the above VAR(1) are assumed to follow a bivariate GARCH(1 1) process with conditional variances $\sigma^2_{US,t}$ and $\sigma^2_{EU,t}$ respectively.[28]

At a second step, for country (c) returns (R^c_t) the following regression is estimated:

$$\begin{aligned} R_{c,t} = {} & a + \beta_{c,1} R_{c,t-1} + \beta_{c,2} D_1\, u_{US,t} + \beta_{c,3} D_2\, u_{US,t} + \beta_{c,4} D_3\, u_{US,t} + \beta_{c,5} D_1\, u_{EU,t} \\ & + \beta_{c,6} D_2\, u_{EU,t} + \beta_{c,7} D_3\, u_{EU,t} + e_{c,t} \end{aligned} \tag{2}$$

where D_1, D_2 and D_3 are time dummies covering 1999-2006, 2007-2011 and 2012-2015 respectively.[29]

The residuals $(e_{c,t})$ of equation (2) follow an asymmetric GJR-GARCH(1,1)[30] process with $h_{c,t}$ being the conditional variance of the local shock.

The total variance $(\sigma^2_{c,t})$ of country c is then given by:

$$\begin{aligned} \sigma^2_{c,t} = {} & h_{c,t} + (\beta_{c,2})^2 D_1\, \sigma^2_{US,t} + (\beta_{c,3})^2 D_2\, \sigma^2_{US,t} + (\beta_{c,4})^2 D_3\, \sigma^2_{US,t} + (\beta_{c,5})^2 D_1\, \sigma^2_{EU,t} + (\beta_{c,6})^2 D_2\, \sigma^2_{EU,t} \\ & + (\beta_{c,7})^2 D_3\, \sigma^2_{EU,t} \end{aligned}$$

Respectively, the proportion of variance of the domestic shocks that could be explained by EU shocks is given by:

$$PV^{EU}_{c,t} = \frac{(\beta_{c,5})^2 D_1\, \sigma^2_{EU,t} + (\beta_{c,6})^2 D_2\, \sigma^2_{EU,t} + (\beta_{c,7})^2 D_3\, \sigma^2_{EU,t}}{\sigma^2_{c,t}}$$

---

(28) Estimations for the multivariate GARCH model are made in Matlab environment using a diagonal BEKK from the publicly available UCSD GARCH toolbox by Kevin Sheppard (http://www.kevinsheppard.com/UCSD_GARCH).

(29) For Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Slovenia starting dates are 27/10/2000, 14/06/2002, 03/09/2004, 07/01/2000, 07/01/2000 and 04/04/2003 due to data availability.

(30) Glosten, L. R., R. Jagannathan, and D. E. Runkle, 1993.

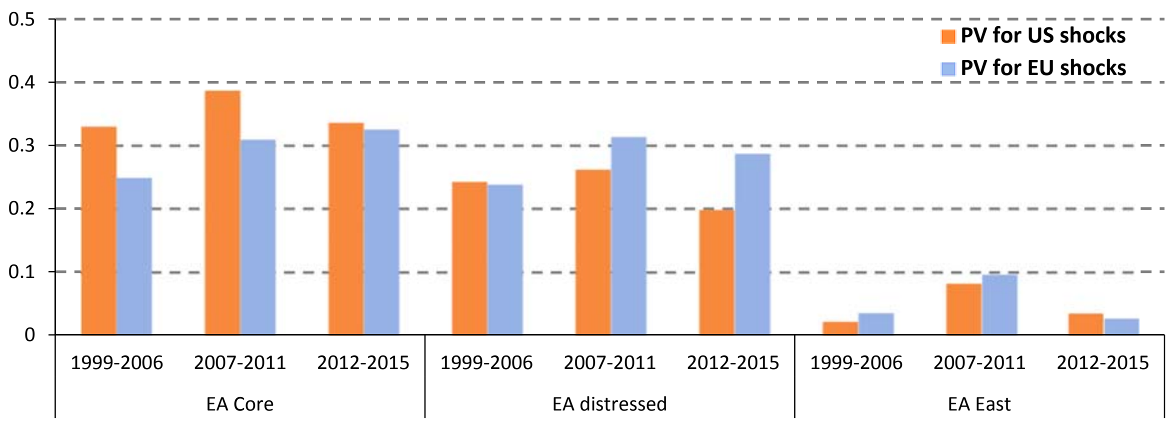
The proportion of variance (PV indicator) of the domestic shocks that could be explained by US shocks is then given by:

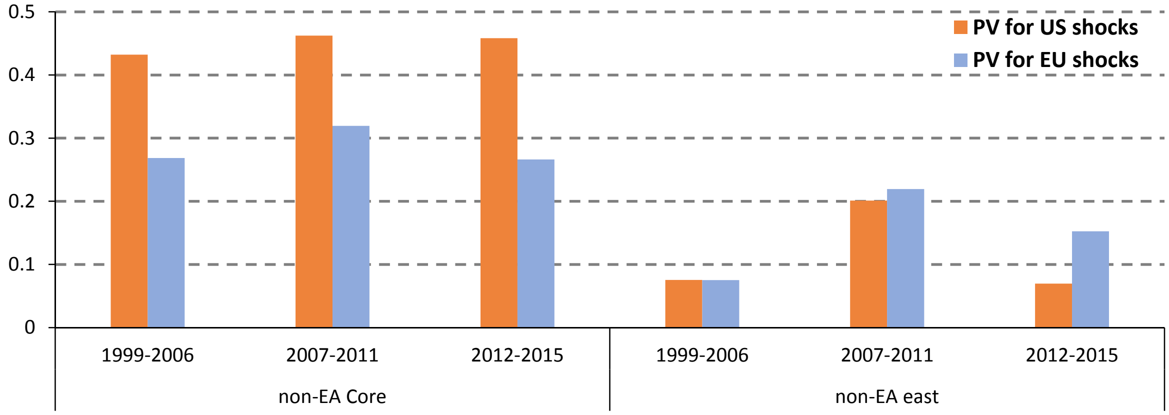
$$PV_{c,t}^{US} = \frac{(\beta_{c,2})^2 D_1\, \sigma_{US,t}^2 + (\beta_{c,3})^2 D_2\, \sigma_{US,t}^2 + (\beta_{c,4})^2 D_3\, \sigma_{US,t}^2}{\sigma_{c,t}^2}$$

Large values of the PV indicator signify more integrated financial markets. Coefficients $\beta_{c,2}$, $\beta_{c,3}$ and $\beta_{c,4}$ in equation (2) represent the spillover intensity (SI indicator) of US shocks to country c, while, coefficients $\beta_{c,5}$, $\beta_{c,6}$ and $\beta_{c,7}$ represent the spillover intensity of EU 0generated shocks. As with the PV indicator, larger values of the SI imply larger degree of integration with the European or with the US markets.

3.1.2 Results

Chart 1. Equity market integration based on the proportion of variance indicator (PV indicator). Average for each group of countries.





Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO).

Source: Bloomberg and JRC calculations.

Chart 1 presents the proportion of European (US) equity shocks that hit domestic market returns for each time period under study.[31, 32] Empirical evidence suggest that the equity returns in Western European countries (no matter the currency used) are driven to a large extent by global shocks (here proxied by EU and US shocks). As expected, distressed Euro area (EA) countries are more sensitive to shocks coming from the rest of Europe than from US. During the EU sovereign crisis over 35% of the euro-wide originated shocks were shifted into domestic volatility in distressed countries while they had little impact in Eastern countries, especially those of the euro area, mostly dominated by local influences. Interestingly for Denmark, Sweden and the United Kingdom the proportion of variance that could be explained by US-generated shocks is similar to that of the EA core countries (about 45%), while the EU influence is about 10 percentage points smaller in the latest years. Finally, for the extra-EU countries (see **Chart 2**) the rebound effect of EU shocks has been negligible as the link is one way from the US.

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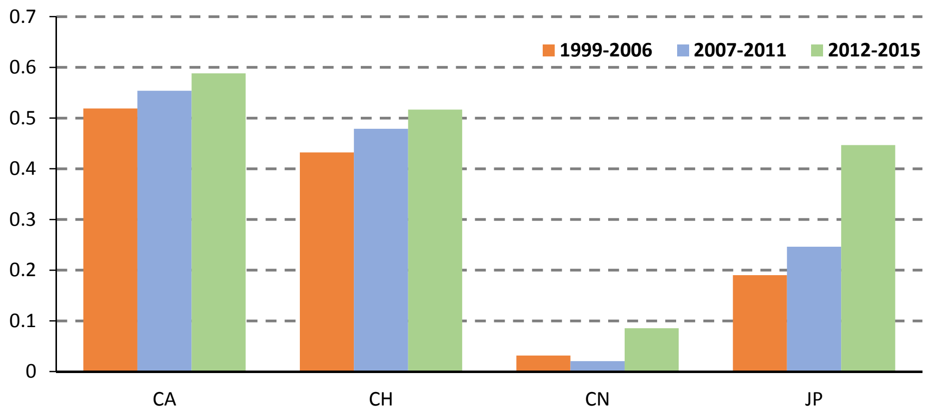
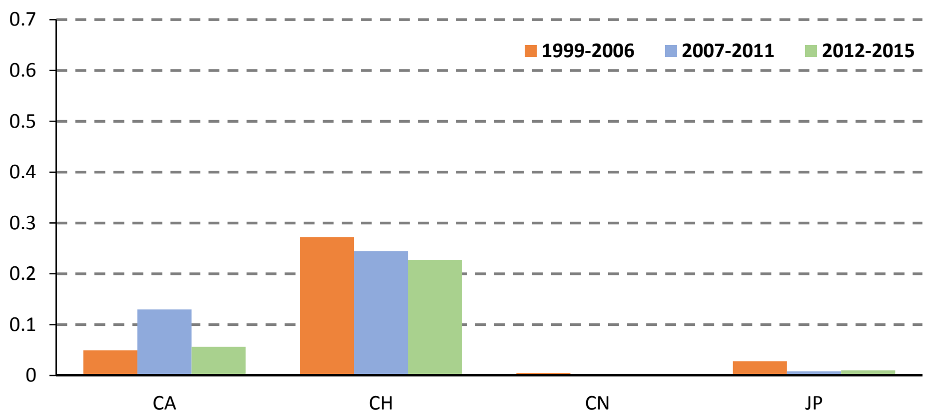
(31) Results for the PV indicator at the country level are presented in Chart 5. Chart A2.3 in Annex 2 provides alternative country breakdowns.
(32) See Table 2.1 in Annex 2 for a list of the stock market indices for each country.

Chart 2. Equity market integration based on the proportion of variance indicator (PV indicator) for extra-EU countries (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).



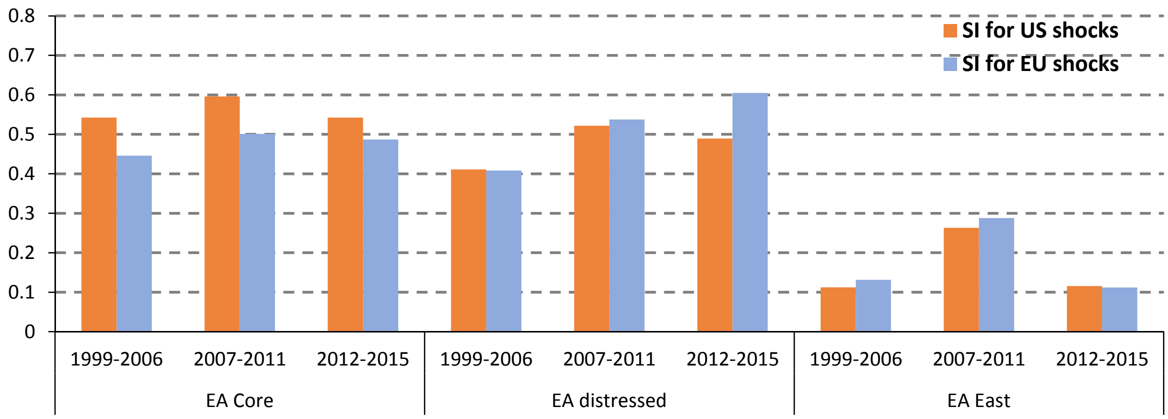


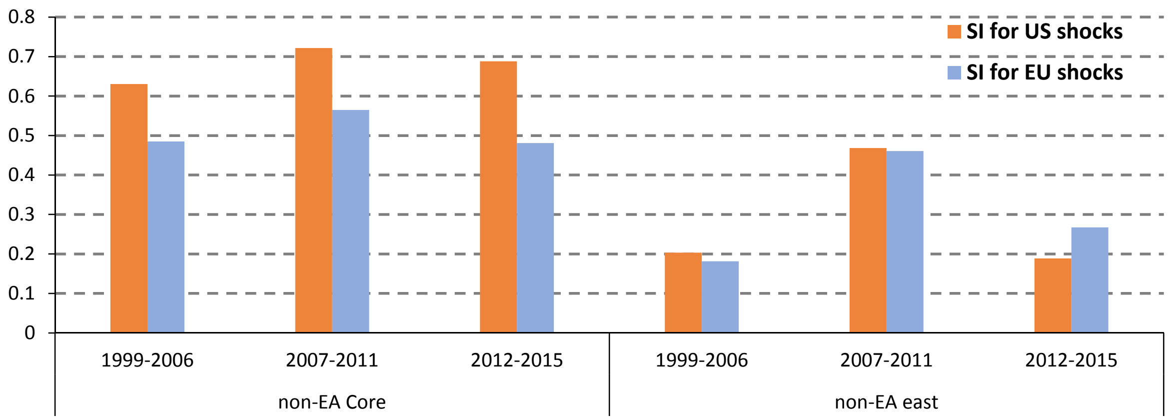
Source: Bloomberg and JRC calculations.

Chart 3 presents the results for the spillover indicator (SI)[33]. The EU core countries (both EA and non-EA countries) appear to be more sensitive to global than European originating news. The reverse is true for distressed Euro area countries where the betas steadily increase over time reaching almost 70% over the recent EU sovereign crisis. Again Eastern countries result to be sensitive to EU and US shocks only during the global financial crisis and much less afterwards. Finally, extra EU countries (see **Chart 4**) respond much less to EU generated shocks than to US originated ones. **Chart 5** and **Chart 6** present the results for the PV and SI indicator on a country basis for EU28.

(33) Results for the SI indicator at the country level are presented in Chart 6. Chart A2.4 in Annex 2 provides alternative country breakdowns.

Chart 3. Equity market integration based on the spillover intensity indicator (SI indicator). Average for each group.

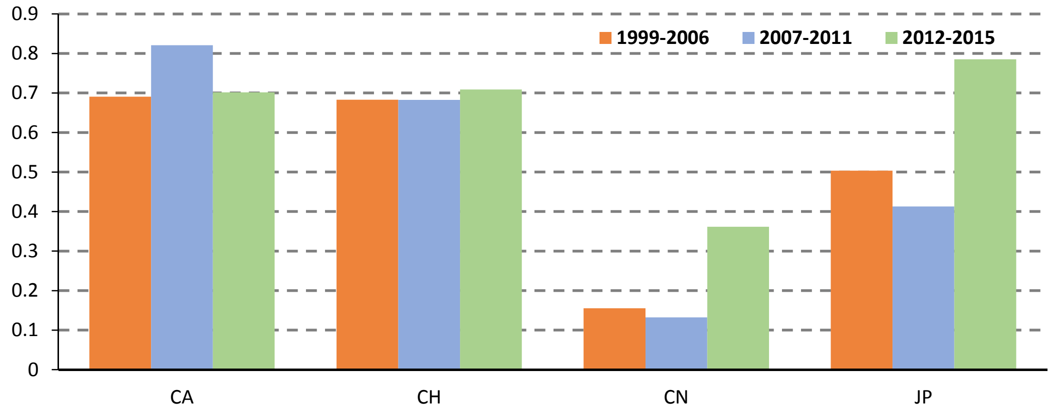


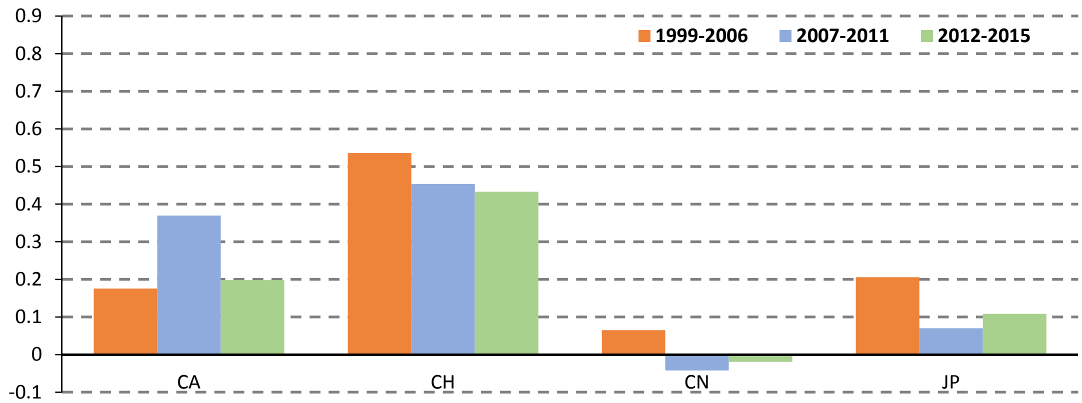


Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO).

Source: Bloomberg and JRC calculations.

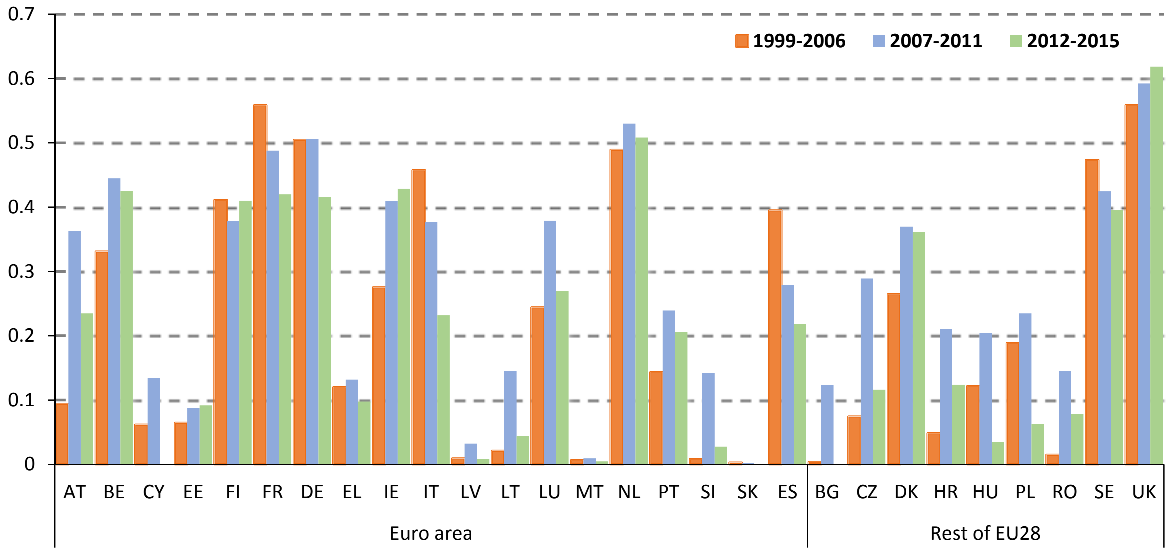
Chart 4. Equity market integration based on the spillover intensity indicator (SI indicator) for extra-EU countries (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

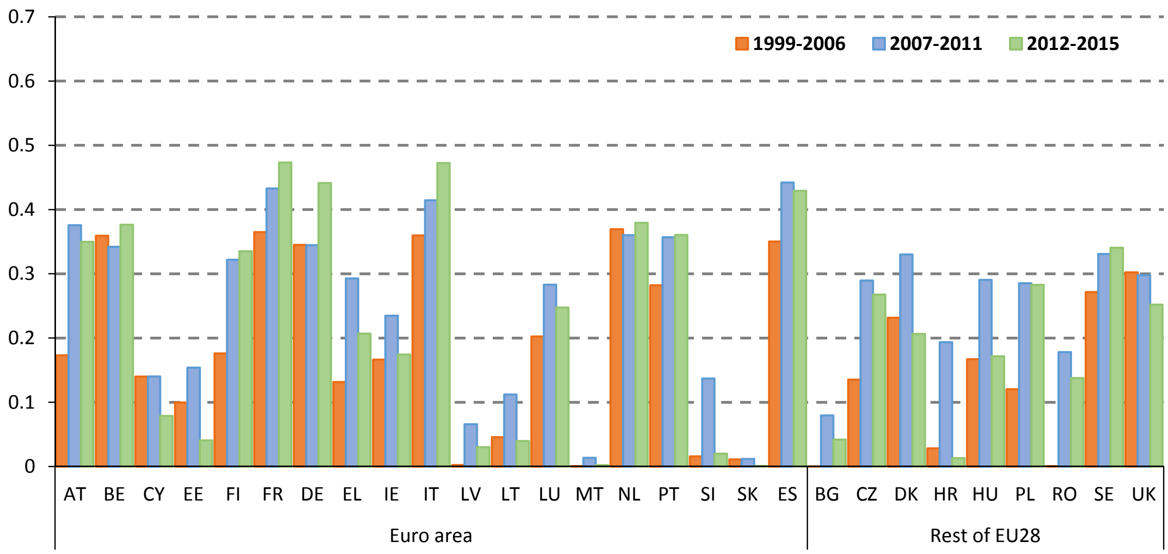




Source: Bloomberg and JRC calculations.

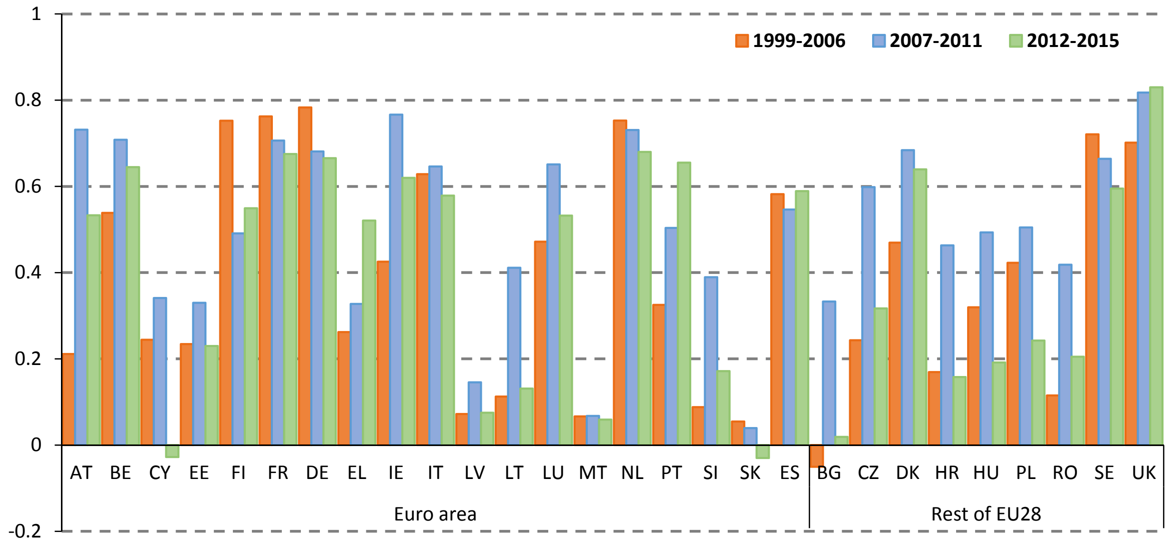
Chart 5. Equity market integration based on the proportion of variance indicator (PV indicator) for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

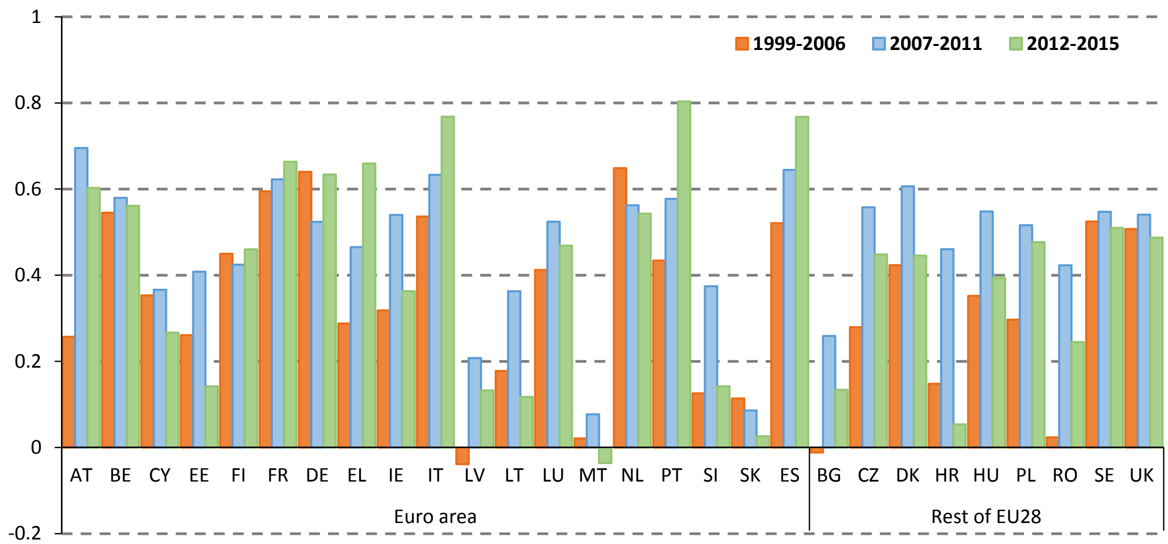




Source: Bloomberg and JRC calculations.

Chart 6. Equity market integration based on the spillover intensity indicator (SI indicator) for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).





Source: Bloomberg and JRC calculations.

Various robustness checks have been performed by using alternative indices as benchmarks. Results are presented in Chart A2.5 to Chart A2.8 in Annex 2. As expected, conclusions remain essentially unchanged. Small differences observed could be attributed to the fact that the composition of each index varies and as a result they exhibit different volatility levels.

3.2. EU28 equity and bond market integration based on common factor portfolios

3.2.1 The model

Common factor portfolio approach models common patterns in financial markets as response to a set of latent variables obtained from returns on a portfolio of global stocks and sovereign bonds. To what extent these global factors are able to account for the variability in domestic returns is interpreted as an indicator of equity (bond) market integration. An indicator close to zero would point to a country dominated by idiosyncratic (local or regional) influences, while an indicator close to one would be read as indicating perfect integration.

Annex 2 lists the stock exchange price indices used for the EU28 countries, Switzerland, China, USA, Canada and Japan. We selected the indices representing the largest proportion of trade in each stock exchange. For bonds we consider the yields of the generic benchmark sovereign bond with maturity of 10 years[34]. Daily trading data have been gathered from 1 January 1999 to 4 December 2015 (source Bloomberg). In a year, we observe for each country on average 261 trading days. When, for a given year and country, more than 130 missing data are found we drop that country from the analysis of that year (roughly speaking this means requiring trading data for at least 6 months). We also drop trading days corresponding to national or regional holidays. Following Pukthuanthong and Roll (2009) and the ECB 2014-2015 analysis, returns for USA and Canada have been reported with one day lag. As New York and Toronto's stock exchange open when in Europe is mid-afternoon and close in the evening, the trading date τ in the USA and Canada are associated to the trading date $\tau+1$ in Europe. Japan and China, instead, are reported without shift as they open at night and close in the morning of day τ.

For each year *t* and each country *C*, we estimate the following equation (see Pukthuanthong and Roll, 2009, and the ECB, 2014-15):

$$R_{\tau}^{t,C} = \alpha^{t,C} + \beta_{1,\tau}^{t,C}\theta_{1,\tau}^{t,-C} + \beta_{2,\tau}^{t,C}\theta_{2,\tau}^{t,-C} + \beta_{3,\tau}^{t,C}\theta_{3,\tau}^{t,-C} + e_{\tau}^{t,C} \tag{3}$$

Where τ indicates the trading day in year t, $R_{\tau}^{t,C}$ is the return on country C stock index computed for day τ in year t, and $\theta_{i,\tau}^{t,-C}$, for i=1,2,3 are the first three common factor portfolios obtained using principal component analysis (PCA) on all available observations of year *t* once excluded country C from the PCA[35]. We will test the results of dropping the assumption of 3 factors. The return *R* for the trading date τ has been computed as follows[36]:

$R_{\tau} = \log(P_{\tau}) - \log(P_{\tau-1})$ for equities

$R_{\tau} = P_{\tau} - P_{\tau-1}$ for bonds

[34] Luxemburg, Malta, Estonia, Croatia, Cyprus and Latvia have been excluded from the analysis due to missing data.
[35] I.T. Jolliffe, 2002. All computations have been performed in a Matlab environment.
[36] Returns have not been corrected for asset return parity.

For each year *t* and country *C* we compute the adjusted R^2 of regression (3), which represents the degree of integration of country C with respect to the market, characterized by the global factors. The cross sectional median of the adjusted R^2 will be a measure, for year *t*, of global market integration. Higher values of the adjR^2 will therefore indicate more integrated markets[37].

In order to run the PCA to identify global latent factors, returns are normalized with z-score to account for different variances which could influence the results[38]. In accordance with ECB (2014, 2015) we run the PCA on the year (*t*), extract the eigenvectors corresponding to the first 3 eigenvalues ordered in terms of decreasing proportion of explained variance, and multiply these eigenvectors[39] for the corresponding normalized data in (*t+1*), to have a sort of "out of sample" Principal Component[40]. This has several consequences, tested in section 3.3. We lose the first year of observations as eigenvectors found in 1999 are used to calculate global factors only in 2000. We also lose the eigenvectors of the last available year (the most recent observation) which could be interesting for explaining latest trends[41]. An additional consequence for the bond data is the reduction in the number of countries available for the full analysis: Denmark, Ireland, Netherland, Slovenia, and the Slovak Republic have to be partially eliminated as available data are discontinuous.

3.2.2 Results

We estimate the common factor portfolios for the time period 2000-2015 in all EU28 countries adding also Switzerland, China, Japan, USA and Canada to account for international factors potentially influencing EU markets. The average (median) adjusted R^2 across groups of countries is exposed in **Chart 7** for the equity market and **Chart 8** for the sovereign bond market.

Results in the equity markets show an increasing trend in the explanatory power of global factors for Western EU28 countries (**Chart 7**, groups *EA core*, *EA distressed* and *non-EA core*). This is especially true in the last two years of the analysis, 2014-15, when the explanatory power of global factors increases for all the countries sampled. **Chart 7** also highlights different patterns according to the group of countries taken into account. Euro area distressed countries present lower integration for all the period analysed with the largest gaps appearing

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(37) Abusing the technical aspect we use R^2 and adjR^2 as interchangeable in this document. In all cases what has been computed is the adjR^2.

(38) This corresponds to using the correlation matrix when running the PCA. Notice that Pukthuanthong and Roll (2009) use instead the covariance matrix for the calculation of PCA factors, while the ECB 2014 and 2015 does not specify the methodology used.

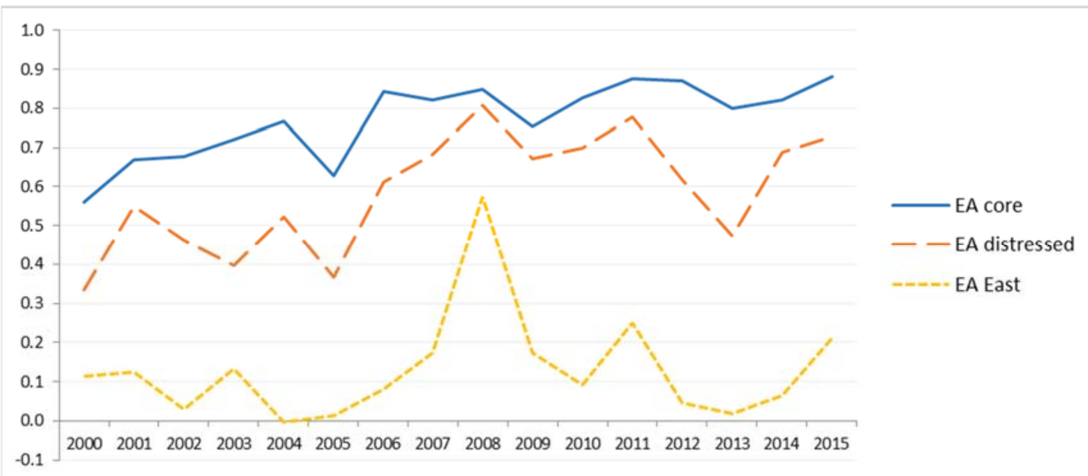
(39) Weights, in the words of ECB 2015.

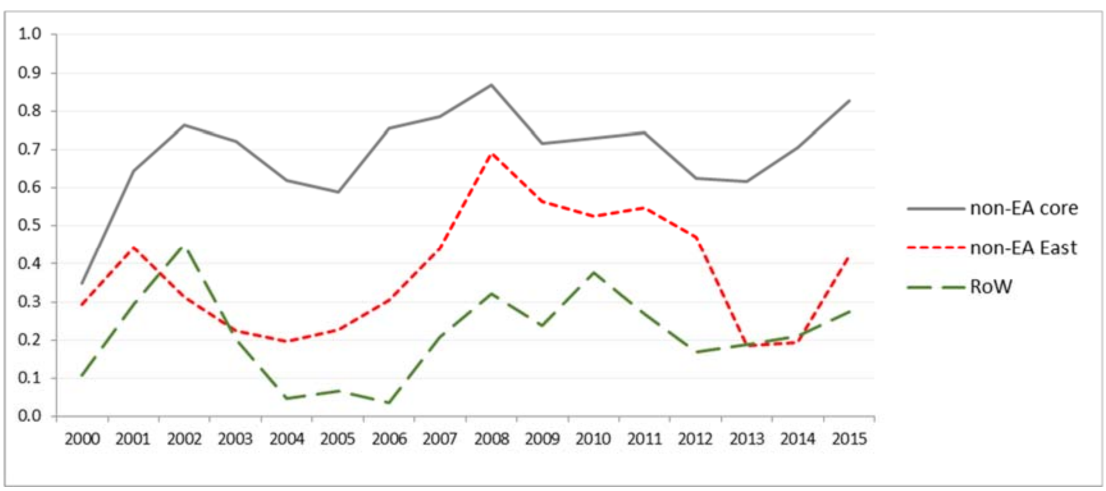
(40) Scores, in the words of ECB 2015.

(41) Given that the purpose of the exercise is not that of forecasting future values of a variable but rather making best use of the available information, we find little theoretical justification for the "out of sample" Principal Component that also implies the drop in the orthogonality property of eigenvectors. Besides we find hard to justify the use of loadings calculated in t-1, when in t these has been a structural change in the data (the example of 2008 is emblematic). If the lagging weights aim to capture the past then the most correct framework should be that of dynamic PCA (see for example Peña and Yohai, 2015).

in 2002-2004 (due to Ireland and Greece) and in 2013 triggered by the Greek sovereign crisis. *Non-EA core* countries (United Kingdom, Sweden, and Denmark) show patterns similar to *EA core* with higher sensitivity to idiosyncratic effects after 2009. Local or regional influences dominate for Eastern countries, where, with the exception of 2008, global factors have little explanatory power. Czech Republic, Hungary, and Poland are somehow an exception as their adjusted R^2 is close to that of distressed Euro area group (details in the **Chart 9**). Global factors have particularly low explanatory power for Slovak Republic and Latvia in the group of *EA East*, and for Romania in the group of *non-EA East*. With the exception of Switzerland, rest of the world countries are not very sensitive to global factors, which in this case mainly capture European core markets dynamics.

Chart 7. Equity market integration based on common factor portfolios (1 denotes complete integration, 0 absence of integration)

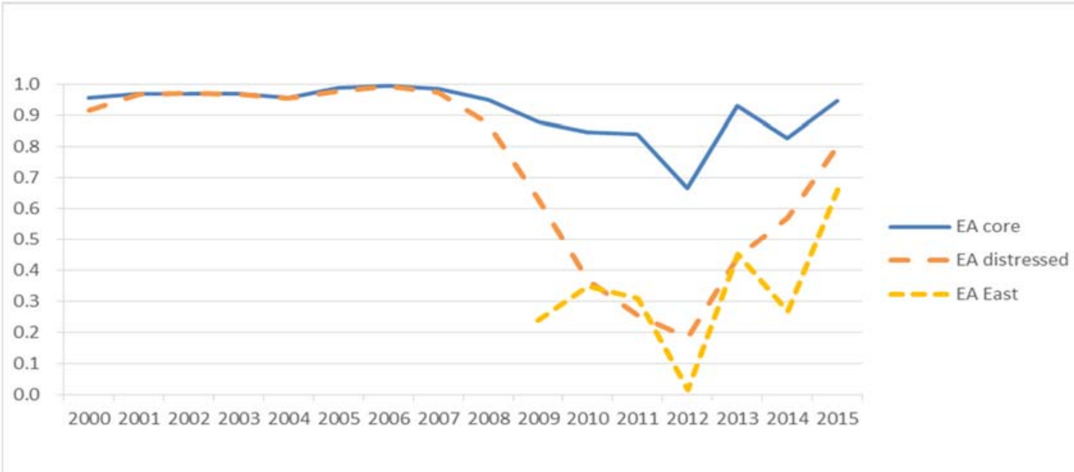


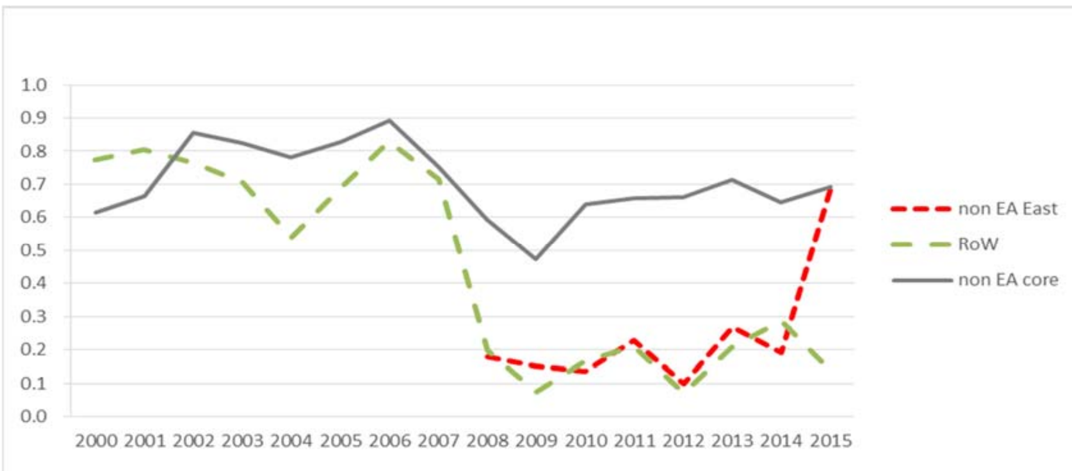


Note: median of adjusted R^2 for the following countries: EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). MT and CY are excluded from the graph.

Source: Bloomberg and JRC calculations.

Chart 8. Bond market integration based on common factor portfolios (1 denotes complete integration, 0 absence of integration)





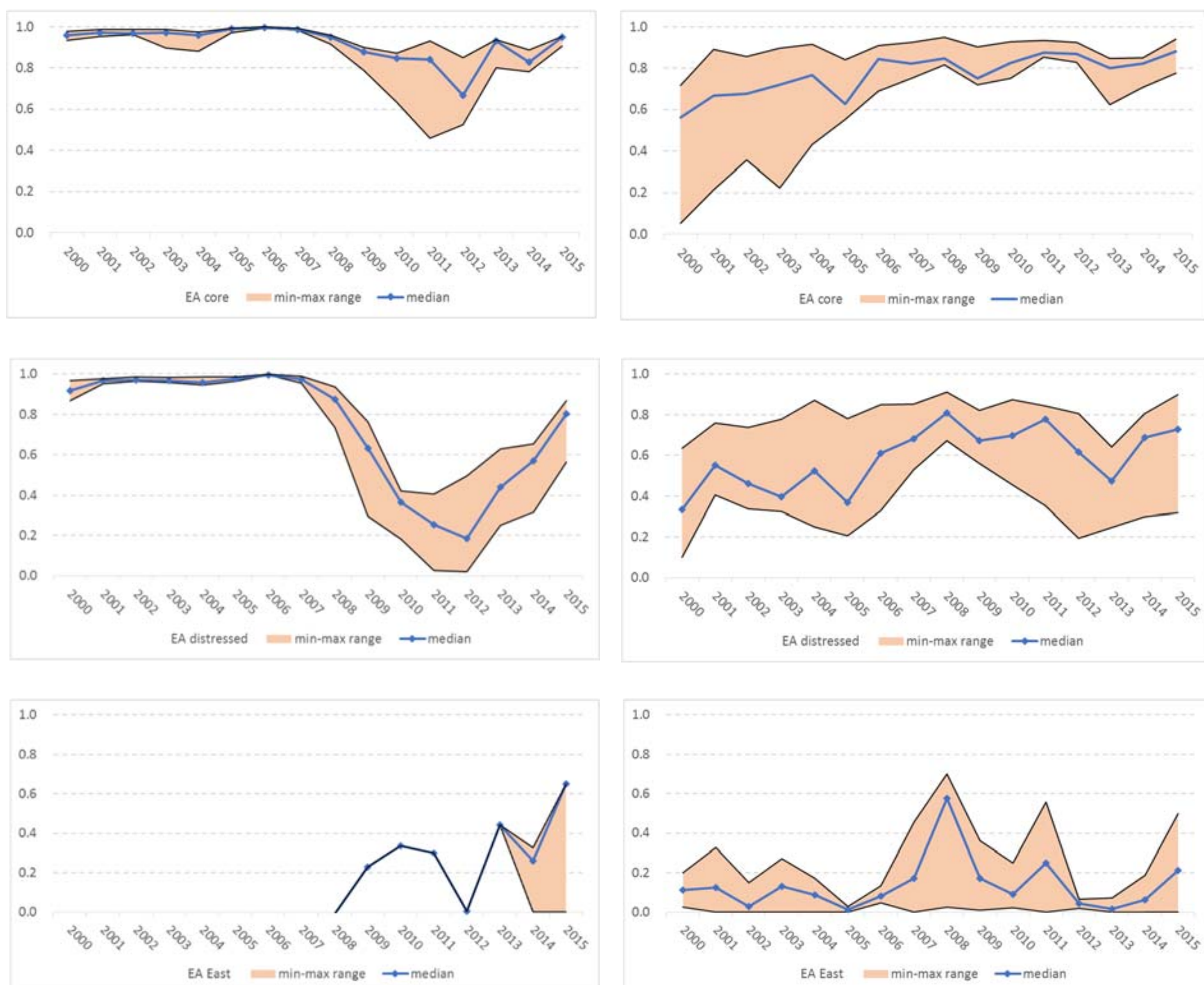
Note: median of adjusted R^2 for the following countries: EA (Euro Area) core (AT, BE, FI, FR, DE, NL); EA distressed (EL, IE, IT, PT, ES); EA East (LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). MT and CY are excluded from the graph.

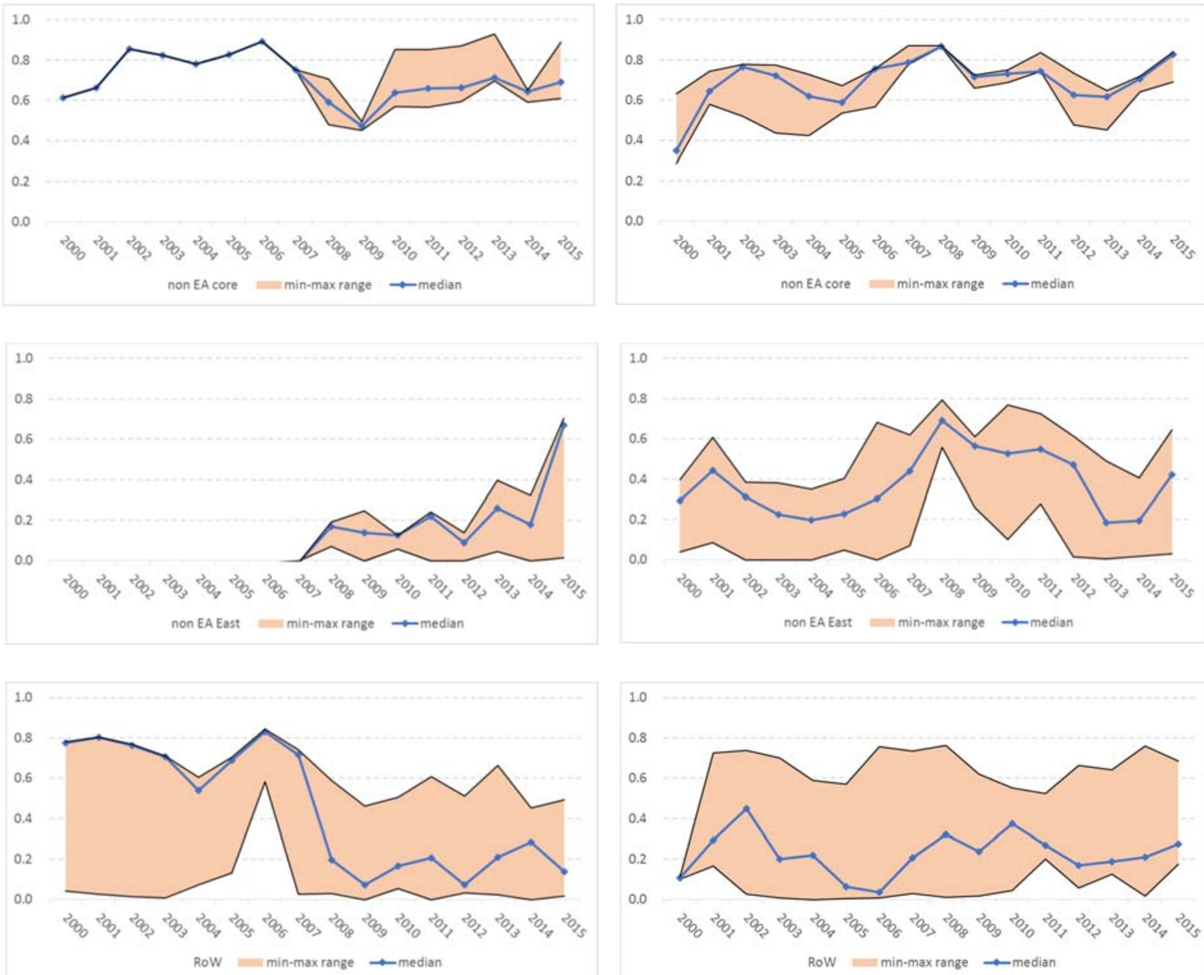
Source: Bloomberg and JRC calculations.

From 2000 to 2008 sovereign bond markets in the Euro area are well explained by common factor portfolios (**Chart 8**). For the *EA-distressed* countries, a major downward deviation occurs from 2008 to 2012, when the idiosyncratic reaction to the sovereign crisis in Greece, Portugal and Italy produces a drop in the median adjusted R^2 from 0.9 to 0.2 as local and "country group" factors take central stage. From 2012, that trend is reversed and global factors have an increased explanatory power over the *EA-distressed* countries. *EA-East* countries show rather volatile patterns. However, missing data prevent us from driving any solid conclusion. Common factors are able to explain 0.5 to 0.9 of the evolution *non-EA core* countries bond market. A major decrease in the explanatory power of common factors is observed between 2006 and 2009 and stabilizes around 0.7 afterwards. Idiosyncratic factors clearly prevail for *non-EA eastern* countries until 2014, with an adjusted R^2 being 6 to 8 times lower than the *non-EA core* group. This pattern seems to reverse in 2015 where the adjusted R^2 upsurges. From 2008 and analogously to the equity market, the sovereign bond market for Rest of the World countries is not sensitive to EU global factors, scoring far below in terms of adjusted R^2. **Chart 9** presents the detailed results. Charts A2.9 and A2.10 in Annex 2 provide detailed country breakdowns.

Chart 9. Equity and sovereign bond market integration based on common factor portfolios (1 denotes complete integration, 0 absence of integration). Dispersion of results.

Sovereign bonds | Equities





Note: Adjusted R^2 for the following countries: EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). For bond market LU, MT, HR, CY, LV and EE are missing; other countries are not available for all the time period analysed. For the equity market MT and CY are excluded from the graph. The shaded area represents the min-max range.

Source: Bloomberg and JRC calculations.

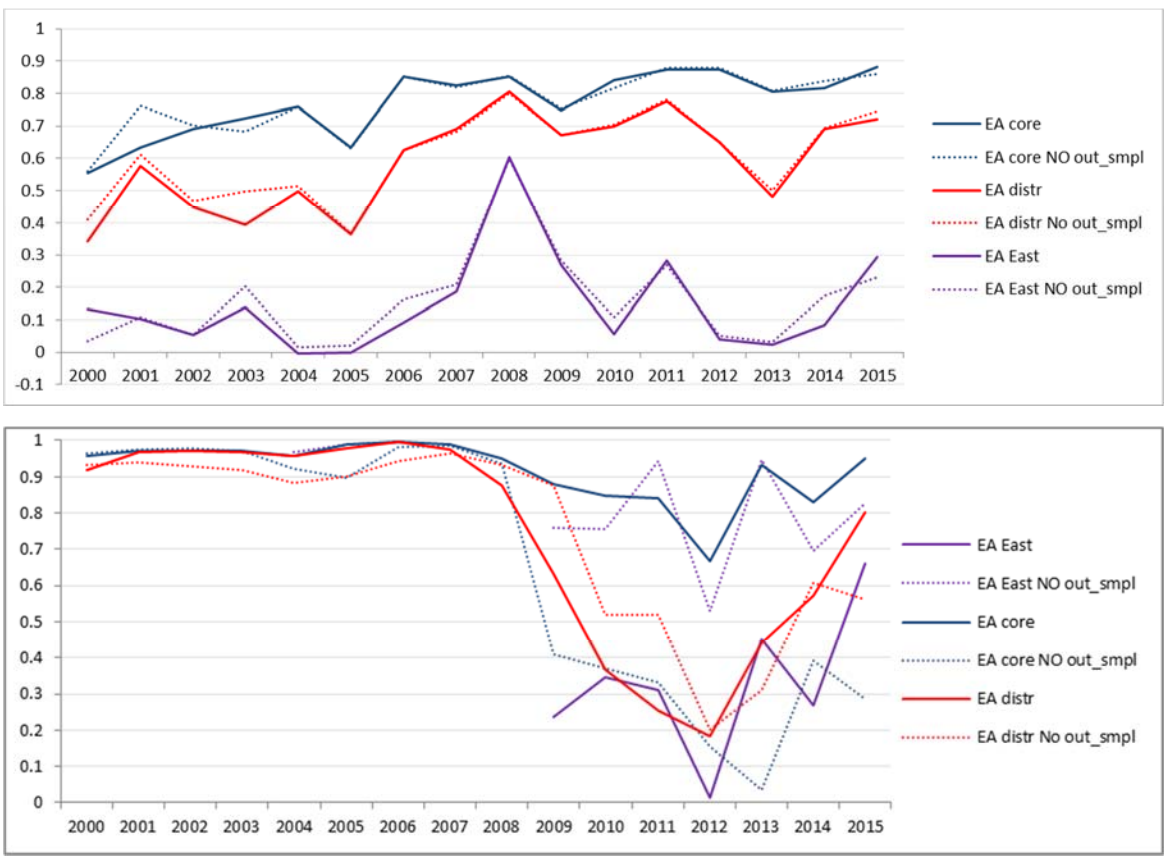
3.2.3 Robustness checks: in-sample PCA, number of retained factors, communalities and clustering

Two robustness checks have been carried out to verify the performance of common factor portfolio model for the bond and equity market. The first is related to the use of "out of sample" PCA. In order to make the best use of the available information the eigenvectors in time *(t)* are multiplied by the corresponding normalized data in *(t)* instead of *(t+1)*.

As displayed in **Chart 10** results for equity markets are moderately affected from the "out of sample" assumption. For equities, the methodology used by Pukthuanthong and Roll (2009) and BCE (2014-15) produces a slight underestimation of the convergence that would be higher without the out-of-sample assumption. The largest differences are visible for the group of *EA East*, while the 2001 spike for the *Euro Area core* is due to Austria, Belgium and Finland. For *EA distressed*, the gap is produced by the inclusion of IT, visible only the year after with the "out of sample" assumption.

The bond market analysis is heavily affected by the "out of sample" assumption. Huge discrepancies for all country groups are observed, as expected, especially after 2008. The gaps depend on two elements: data availability and unpredictability. With the "out of sample" assumption many countries for which we have irregular data, have to be dropped from the analysis, this is the case for example of Lithuania and Ireland. The other, and most important reason, is indeed related to the out-of-sample assumption. After 2008, with very volatile and unpredictable markets, re-mapping data on time *(t)* on the axis defined by what happened in *(t-1)*[42] produced huge differences in the R^2 of equation (3). This is evident from **Chart 10** (bottom part). Contrary to the equity market, the out-of-sample assumption does not produce a clear under- or over-estimation of integration but makes clear the crucially of this assumption at least for markets and periods of high turbulences.

Chart 10. Equity and Bond market integration based on common factor portfolios for EU countries, comparison of different assumptions on PCA.



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(42) This is the geometric interpretation of the out-of-sample assumption.

Note: Median of adjusted R^2 for different sets of countries with and without the "out of sample" PCA. EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US).

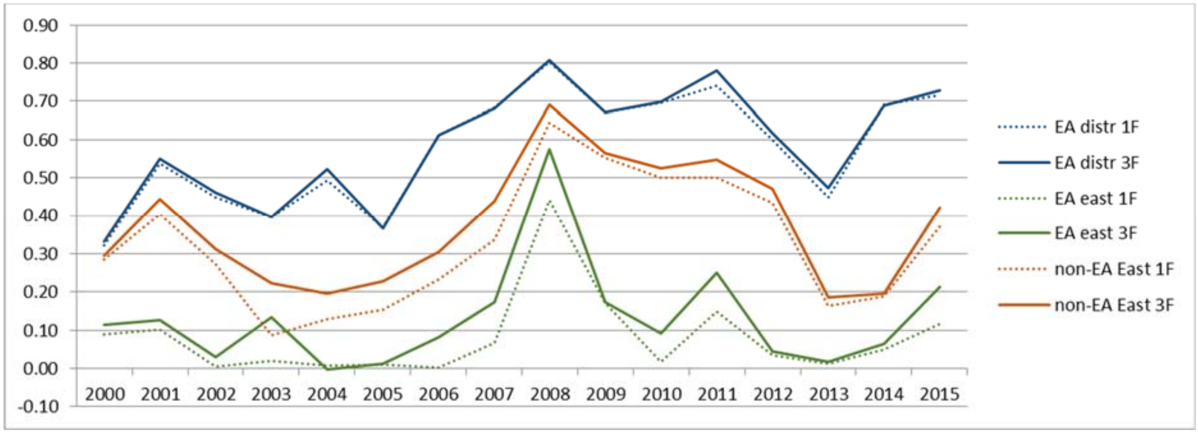
Source: Bloomberg and JRC calculations.

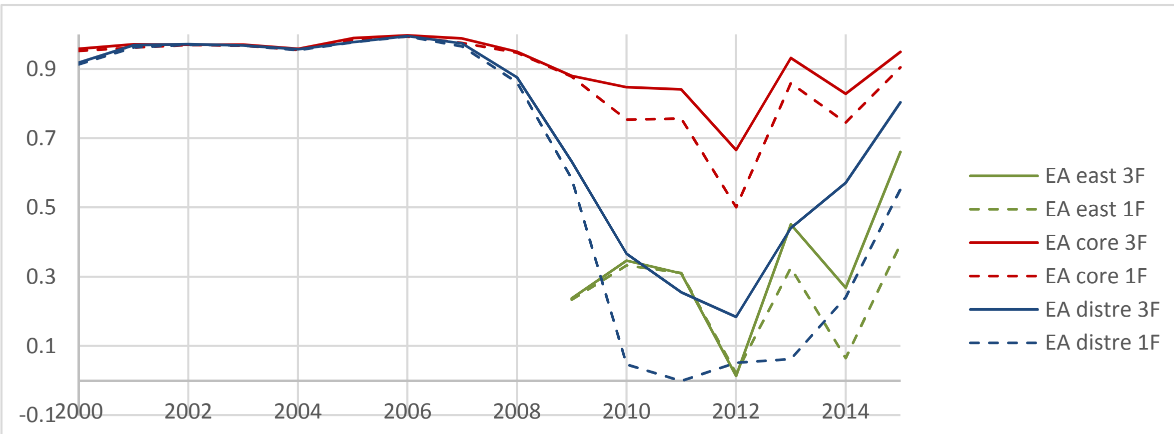
A second robustness check regards the number of PCA factors to retain and use as global factors in the country estimations. Concerns, in fact, could arise when one global factors in the analysis is country specific, suppose for example that country A is only sensible to factor 2 (but not to factor 1) and country B only to factor 1 (but not to factor 2). In this case we would still have high R^2 both for A and B without actual integration because A and B would respond to disparate global shocks.

The yearly inspection of the three global factors obtained with the PCA highlights that the first factor (which usually takes about 40% to 60% of the total variance of the equity market data for equity market and 35% to 90% for bond market) basically capture common EU dynamics: most of the EU countries are heavily loaded in this factor and with the same sign with the exceptions of Poland and Hungary from Bond market. The remaining two factors capture a much smaller part of data variability (usually less than 10% each). For equity market they represent either the behaviour of US and Canada or some idiosyncrasies of Eastern countries (especially the Baltics) or Greece, which could indeed be a problem for the estimated model. China is usually loaded by a factor which is not considered in the regression and Japan, moving sometimes with US and sometimes with China has little influence in the global factors. For bond market, after 2008, the second factor tends to separate core countries (Netherland, Denmark, Czech Republic, Germany, Sweden, France) from the main EA distressed countries (Portugal, Italy, Greece, Spain) while the third factor tends to separate eastern from western European countries. We believe that a model measuring integration should not use factors essentially representing group or country idiosyncrasies. Exactly those idiosyncrasies, while increasing model fit, would actually represent the absence of integration confusing the results and possibly driving policy conclusions.

To analyse the extent of this issue in our dataset, we estimate each county's returns on the first PCA factor which clearly represents the Euro-centric global pattern. If any, anomalous results should involve countries usually loaded by factors higher than the first, basically Eastern and distressed Euro area countries. While for the latter no difference is found (**Chart 11**) in the equity market, for the former the difference is more sizable, especially in 2003, due to Hungary, Czech Republic, Estonia and Lithuania driving down the performance by 10 points. For bond market, the difference is much higher especially for the distressed countries from 2008 and the *EA East* countries from 2013.

Chart 11. Comparison of results: equity (above) and bond (below) market integration based on common factor portfolios estimated from 1 or 3 factors for the following group of countries: *EA distressed*, *EA East*, *non-EA East*.





Note: Median of adjusted R^2 for different sets of countries and different number of factors: EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US).

Source: Bloomberg and JRC calculations.

We propose an alternative and simpler way to have a first snapshot of country integration within the framework of a PCA. The squares of factor loadings, the communalities, calculated for the first factor and plotted for the available time span, can be seen as a measure of how each country *behaves* with respect to the EU common driver (representing the integration within EU) [43]. **Chart 12** is an example for distressed Euro area countries. Roughly speaking, it gives an indication on how much a country "scores" in terms of integration as compared to *EU28*, *EA Core* and non *EA Core countries*. The data capture the difficulties of Ireland well before the 2008 crisis, the distancing of Greece and Portugal from the rest of Europe after

[43] The Communality is, in general, a cumulative measure of the variance explained by the first n factors. We display the results from 2005, the first year of a complete EU28 dataset.

2008 (especially in 2012 with the Greek turmoil) and the process of recovery (or lack of it for Greece) as well as the Spanish difficulties to obtain financing in the markets in the years 2011-12 and the recovery after the financial assistance from the European Stability Mechanism in 2012.

Chart 12. Equity market: communalities on the first factor of the PCA for EA distressed countries and comparison with *EU28*.

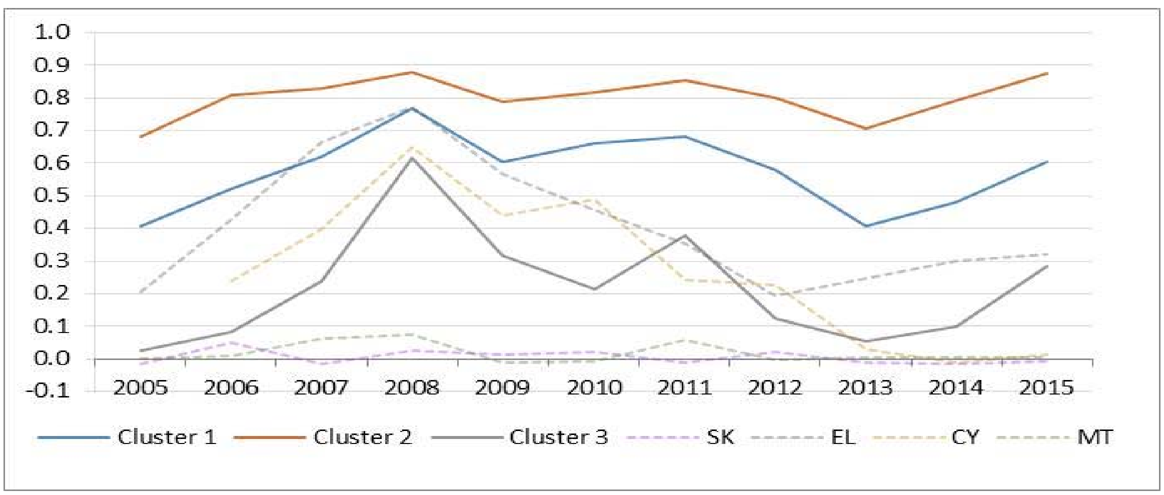
Note: *EA Core* (AT, BE, FI, FR, DE, LU, NL) and *nonEA_Core* (SE, DK, UK) countries

Source: Bloomberg and JRC calculations.

The last test performed is on the aggregation of countries. Cluster analysis on the adjusted R^2 helps to group countries according to statistical similarities in data patterns across years[44]. For equity market, hierarchical clustering confirms the outlier status of the Slovak Republic, Malta and Cyprus and to some extent of Greece, from the 2008 crisis (**Chart 13**). Clustering clearly shows 3 separated clusters the first grouping mainly EU28 core countries (Austria, Belgium, Finland, France, Germany, Netherland, Italy, Spain, Sweden and United Kingdom), the second grouping (Luxemburg, Greece, Ireland, Portugal, Denmark, Czech Republic, Hungary, Poland) and the third combining all the remaining. Group means (based on Euclidean distance) show well separated clusters with common patterns: an increasing trend towards integration until 2008 crisis. A recovery in 2010-11 (much less pronounced for the third cluster) followed from a decreasing trend after the Greek sovereign crisis a catch-up phase in the latest years.

For bond market, before 2008, as seen in **Chart 14**, the adjusted R^2 are particularly high for most of the countries (the UK is slightly below the rest of EU countries). After 2008 cluster analysis supplies a richer picture with respect to equity market. While Austria, Belgium, Denmark, Finland, France, Germany, and Netherland cluster together on the top part of the graph, Spain and Italy but especially Greece and Portugal display decreasing trends. United Kingdom and Sweden single out for a stable trend and Eastern countries (Czech Republic, Hungary, Poland, Slovak Republic) for idiosyncratic factors.

Chart 13. Equity market: Cluster analysis on the adjusted R^2.



Cluster 1: AT, BE, FI, FR, DE, NL, IT, ES, SE and UK; Cluster 2: LU, EL, IE, PT, DK, CZ, HU, PL; Cluster 3: EE, LT, LV, SK, SI, BG, HR. Slovakia (SK), Greece (EL), Cyprus (CY) and Malta (MT) are singled out as outliers.

Source: Bloomberg and JRC calculations.

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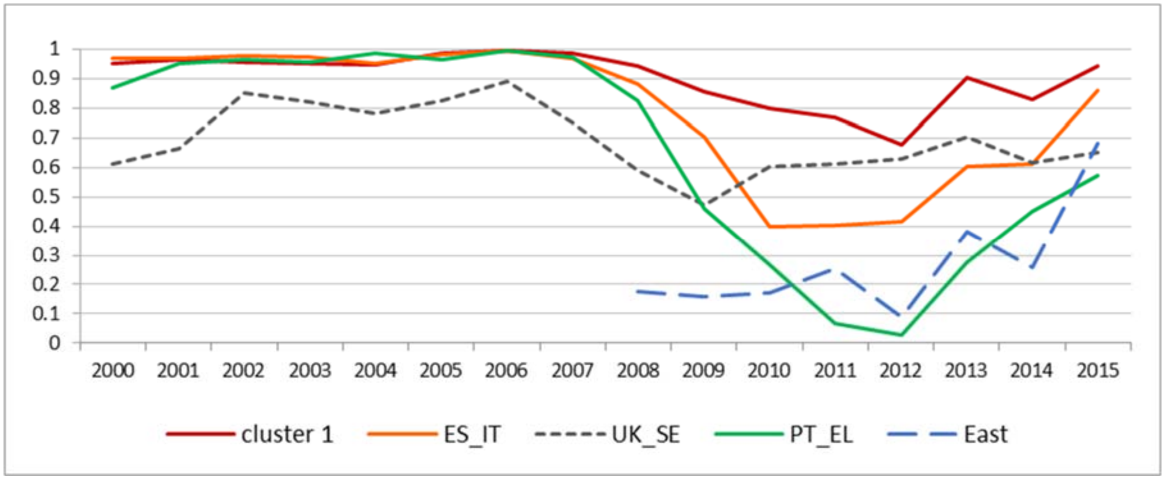
(44) 2005 is the first year for a complete dataset, so results are displayed from that date.

Chart 14. Bond market: Cluster analysis on the adjusted R2.



Cluster 1: AT, BE, DK, FI, FR, DE, and NL; East: CZ, HU, PL, SK; SE and EL have data starting from 2008.

Source: Bloomberg and JRC calculations.

3.2.4 Further analysis

It has been observed that, in periods of high common volatility, correlations tend to be higher.[45] In this case a measure of financial market integration based on (Pearson) correlation calculated from daily/weekly/monthly data will tend to be biased by volatility.[46] In particular volatility rises during crises and leads to an artificial over-estimation of average correlation - hence of integration (Forbes and Rigobon, 2002). Another and more relevant issue of standard correlation is that if financial markets are hit by a common shock, the correlation among countries might be higher even without integration (Obstfeld and Taylor, 2003), or in other terms one cannot distinguish between common shocks and real integration when using correlation. The literature considers PCA-derived factors much less sensitive to price volatility than correlation (Volosovych, 2011[47]) however a rigorous analysis is still pending.[48]

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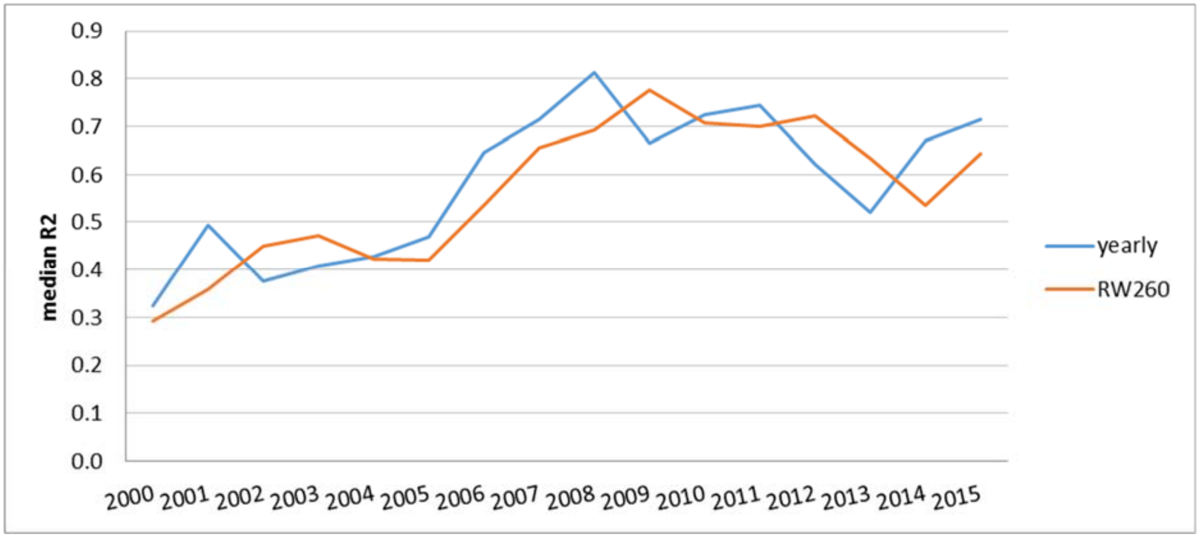
(45) Positive link between correlation and volatility can be found in King, Sentana and Washawani (1994), Longin and Solnik (1995), Ramchand and Susmel (1998), Morana and Beltratti (2008).
(46) Volatility implies non constant variance of market returns, i.e. heteroscedasticity. The literature distinguishes between conditional and unconditional heteroscedasticity. The first happens when volatility cannot be predicted in advance (i.e. future periods of high/low volatility cannot be identified ex ante, see Forbes and Rigobon, 2002 for a review of the relevant literature). The second occurs when volatility can be predicted with anticipation such as with seasonal variation or the periodical publication of firms' balance sheets (see Billio et al., 2015 for a discussion).
(47) Volosovych 2011 offers a quite extensive literature review on financial markets integration.
(48) Billio et al, 2015 find no substantial differences in their results when correcting the correlation matrix used to derive both the R^2 and the first PC for the correlation between measured correlation among stock returns and returns' volatility.

A device to smooth volatility is to take a moving average approach and work with rolling windows. The strategy is to partition the entire data set into $N = T - m + 1$ subsamples. The first rolling window contains observations for period 1 through m, the second rolling window contains observations for period 2 through $m + 1$, and so on. Equation (2) is then estimated for each of the rolling windows (Billio et al, 2015, Christiansen, 2014) and results averaged across-countries. A comparison of the two estimations is in **Chart 15**.

Chart 15. Comparison between rolling window (length: 260 trading days) and yearly estimation (Pukthuanthong and Roll method, 3 factors).



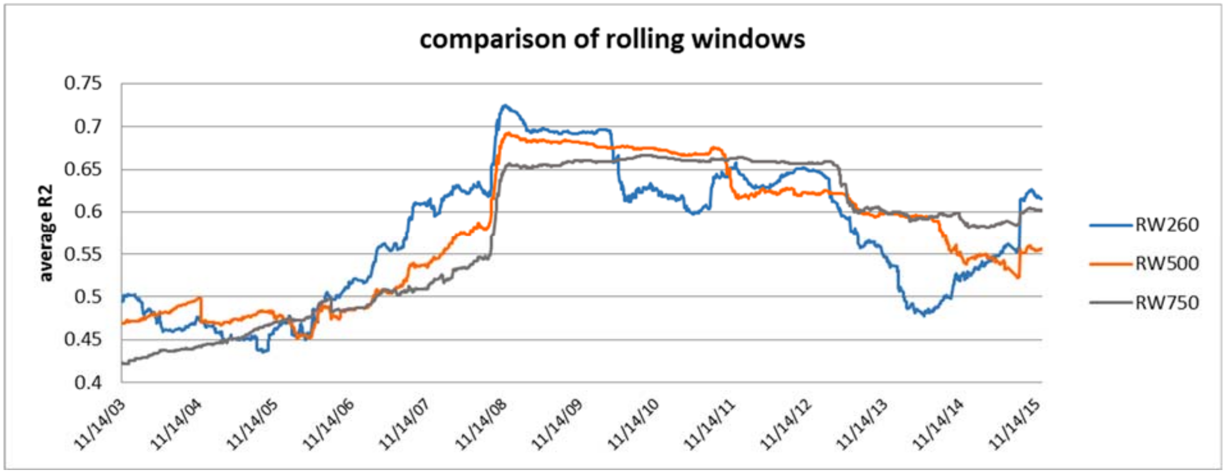
Note: Equity market. Median of adjusted R^2 for 22 EU countries (AT, BE, FI, FR, DE, LU, NL, EL, IE, IT, PT, ES, EE, SK, SE, DK, UK, CZ, HU, PL, RO, MT); the rolling window estimation for a given year is the median of all adjusted R^2 corresponding to all rolling window estimations of that year.

Source data: Nardo, Ndacyayisenga, Papanagiotou, Rossi, (2016).

An additional issue for these models is the size of the window. The literature is again heterogeneous: e.g. Volosovych (2011, 2013[49]), with monthly bond data estimates a sequence of rolling windows each of 156 months (13 years), Billio et al. (2012[50]) and Zheng et al. (2012) with monthly equity data use 60 and 36 months respectively, while Berger and Pukthuanthong (2012[51]) and Yang et al. (2015) with daily equity data use 500 and 504 trading days (about 2 years) respectively. To which extent the length of the interval matters for the robustness of the results is an open question. Notice that in the macroeconomic literature m should approximately include one economic cycle. However financial cycles are much longer than economic cycle (16 versus 1-8 years, see Borio, 2012) so data availability could be an issue. Moreover, it is not clear the meaning of using large m when working with daily stock market data. Practically a Kaiser-Meyer-Olkin index of sampling adequacy can be used and the recommended minimum value is 0.5 (Yang et al. 2015).

(49) Volosovych: analysis for 11 countries from 1875 to 2009.
(50) Billio et al. : analysis for 14 countries from April 1985 to December 2014.
(51) Berger and Pukthuanthong: analysis for 82 countries from 1984 to 2010.

Chart 16. Rolling window estimation (Pukthuanthong and Roll method, 3 factors): different window lengths (260, 500, 750 trading days)



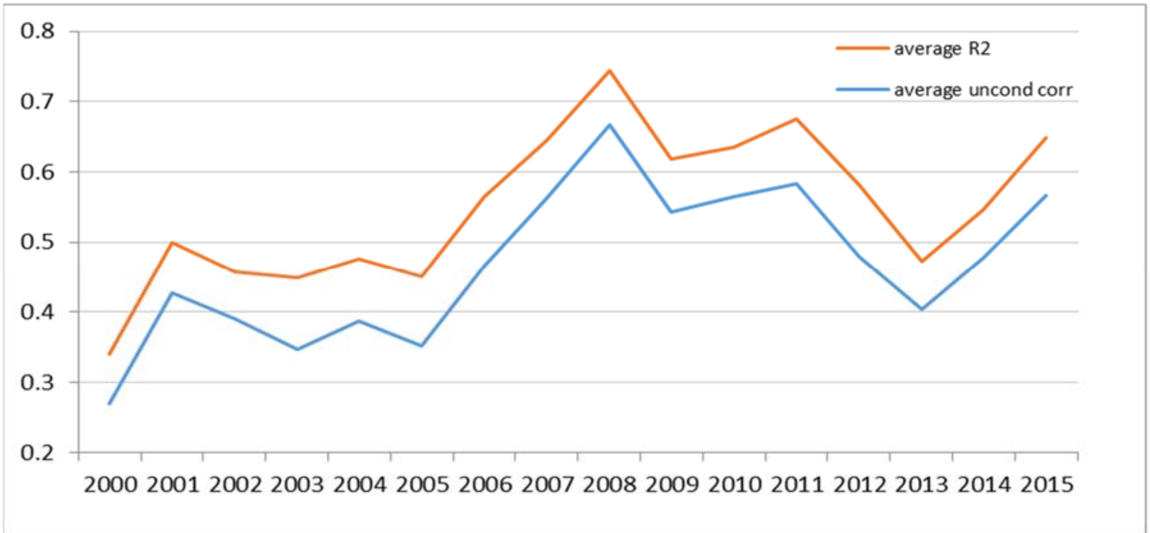
Note: Equity market. Average adjusted R^2 for 22 EU countries (AT, BE, FI, FR, DE, LU, NL, EL, IE, IT, PT, ES, EE, SK, SE, DK, UK, CZ, HU, PL, RO, MT). Source data: Nardo, Ndacyayisenga, Papanagiotou, Rossi, (2016).

Chart 16 compares different window lengths when performing the Pukthuanthong and Roll estimation (3 factors) on a set of 22 EU countries. In particular we consider three windows of 260, 500 and 750 trading days (in all cases the KMO index is well above 0.5). As expected a larger the window length implies a smoother adjusted R^2 curve but also the smaller ability to differentiate events (e.g. sub-prime and sovereign crisis periods).[52] This is why Zheng et al. (2012) switch from 36 months to 12 months moving window claiming that *if the window size is too large, large shocks are overridden by all other signals* (page 3).

The use of factor models has traditionally been presented as a theoretically sounder methodology as compared to the simple average of unconditional (Pearson) correlations. Pukthuanthong and Roll (2009) show that the R^2 is to be preferred to the simple correlation coefficient which tends to underestimate integration.[53] **Charts 17** and **18** indeed show that, for a set of EU stock market indices, average unconditional correlation underestimate integration if compared with the average R^2 obtained both with yearly estimates (**Chart 17**) and with rolling window estimation (**Chart 18**[54]).

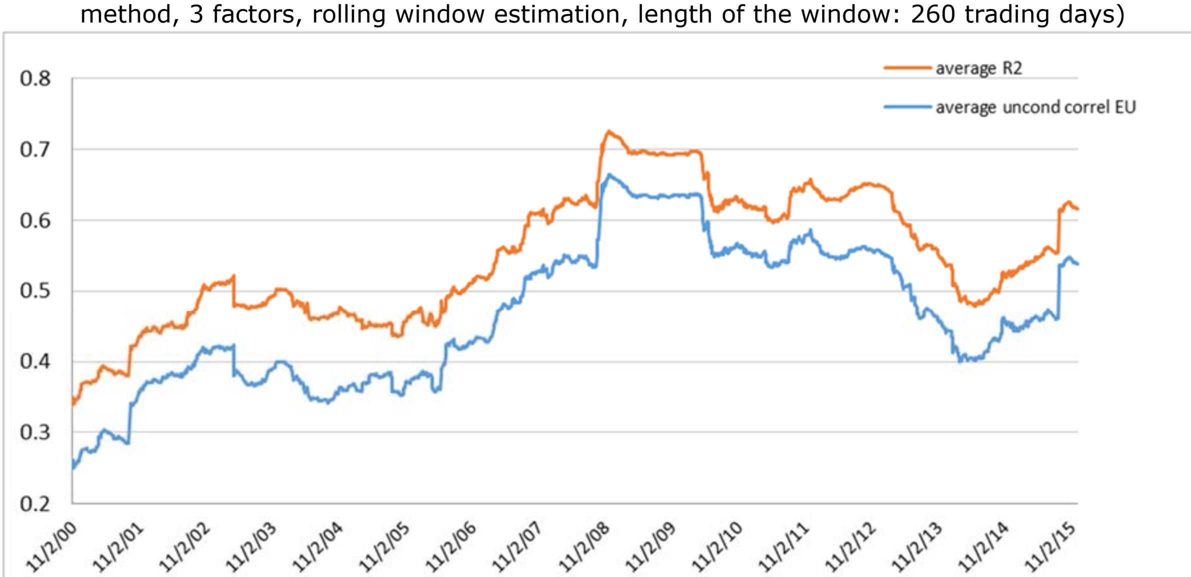
Chart 17. Comparison between unconditional correlation and average R^2 (Pukthuanthong and Roll method, 3 factors)

(52) Alternative way to characterize breakpoints is suggested by Berger et al. 2011 and is obtained by regressing the adjusted R^2 of equation (2) on a time trend and dummies indicating breakpoints.
(53) See also Billio, et al., 2015 for a comparison of various methods.
(54) Here we use 260 trading days but results are robust to larger windows of 500 and 750 days.



Note: Equity market. Average unconditional correlation and average adjusted R^2 for 22 EU countries (AT, BE, FI, FR, DE, LU, NL, EL, IE, IT, PT, ES, EE, SK, SE, DK, UK, CZ, HU, PL, RO, MT). Source data: Nardo, Ndacyayisenga, Papanagiotou, Rossi, (2016).

Chart 18. Comparison between unconditional correlation and average R2 (Pukthuanthong and Roll method, 3 factors, rolling window estimation, length of the window: 260 trading days)



Note: Equity market. Average unconditional correlation and average adjusted R^2 for 22 EU countries (AT, BE, FI, FR, DE, LU, NL, EL, IE, IT, PT, ES, EE, SK, SE, DK, UK, CZ, HU, PL, RO, MT). Source data: Nardo, Ndacyayisenga, Papanagiotou, Rossi, (2016).

4 Drivers of integration in common factor portfolios model

In this chapter, we investigate of possible drivers of financial integration among the EU countries. Several factors affect the degree of globalization/integration through time. Lane and Milesi-Ferretti (2008) show that financial integration depends on the developed stage of the domestic markets, on the overall economic development and on trade. Büttner and Hayo (2011) analyse the determinants of stock market integration among EU countries. They show that market capitalization, foreign exchange risk and interest rate spreads and business cycle synchronization are the most important ones. Volosovych (2011) shows that both policy related variables (i.e., inflation, government deficit, and the fixed exchange-rate regime during Bretton Woods) as well as the global market environment could explain the evolution process of financial integration. Christiansen (2014) examines the time variation in the integration of EU government bond markets and finds that being an EMU member state, an old member state and the sovereign's credit rating influence the integration process. We take stock of this literature and analyse the drivers of integration starting from a specific measure: that derived in Pukthuanthong and Roll, 2009, and based on common factor portfolios model applied to equity markets.

The remaining of this section is organized as follows. Section 4.1 presents the data for the drivers, section 4.2 presents the econometric methodology. In section 4.3, we present the empirical results. Finally, section 4.4 concludes.

4.1 Data Description

We consider a dataset of yearly *R*-squared value for 22 EU28 countries (AT, BE, CZ, DK, EE, FI, FR, DE, EL, HU, IE, IT, LU, MT, NL, PL, PT, RO, SK, ES, SE, UK) from 1999 to 2015. These data come from the estimation of the model presented in Section 3.2 on the stock exchange market.

In order to investigate the integration among the EU countries and through time, we consider a set of variables that are related to the country's macro-economic or business profile characteristics. We downloaded the following data from the World Bank:

(i) *Proxies for the overall country's trading profile* include: (a) Trade openness (denoted by *Trade_GDP*) is defined as the sum of exports and imports of goods and services measured as a share of the gross domestic product. This variable is often used in the literature as a globalization driver (e.g. Volosovych, 2011; Lane and Milesi-Ferretti, 2008). (b) The ratio of the sum of merchandise exports and imports divided by the value of GDP (*Merchandisetrade_GDP*). (c) Foreign direct investment net outflows of investment from the reporting economy to the rest of the world divided by GDP (denoted by *FDI_Outflows_GDP*). (d) Foreign direct investment net inflows in the reporting economy from foreign investors divided by GDP (denoted by *FDI_Inflows_GDP*).

(ii) *Proxies for government's policies* include: (a) Inflation is used as a proxy of the overall laxity of government policy (see Volosovych (2011)) The inflation variable

(*Inflation*) is measured by the annual growth rate of the GDP implicit deflator and shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. (b) Government deficit to GDP (*Deficit_GDP*), defined as cash surplus or deficit, is revenue (including grants) minus expense, minus net acquisition of nonfinancial asset.

(iii) *Proxy for the development of the domestic financial market*: Market capitalization of listed domestic companies as a percentage of GDP (denoted by *MarketCap_GDP*).

(iv) *Economic development* is measured by GDP variables (i.e., GDP and GDP per capita).

(v) *Governance indicators from the World Bank*[55] are also considered because a country with a better governance quality is expected to attract more foreign investors, and thus exhibit a higher degree of integration.

(a) Control of Corruption (*CorruptionControl*) captures perceptions of the extent to which public power is exercised for private gain. It includes both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

(b) Government Effectiveness (*GovernmentEffect*) captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

(c) Political Stability and Absence of Violence/Terrorism (*PoliticalStability*) measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.

(d) Rule of Law (*RuleofLaw*) captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

(e) Regulatory Quality (*RegulatoryQuality*) captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

(f) Voice and Accountability (*VoiceandAccountability*) captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

(55) The World Bank also provides the "ease of doing business" indicators. However, as the data start in 2005 those indicators are not taken into account.

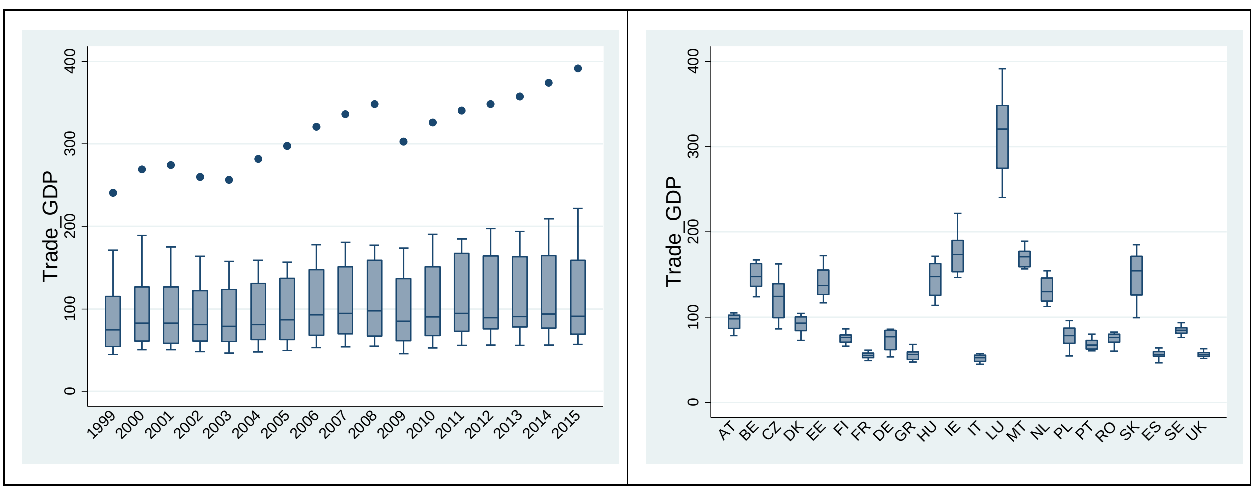
(vi) *Investing and economic indicator:* the sovereign long term rating (*Rating*) of a specific country. Ratings are downloaded from the Moody's rating agency. All rating classes are transformed into a numerical scale varying from one to 21, with 21 describing the best rating category.

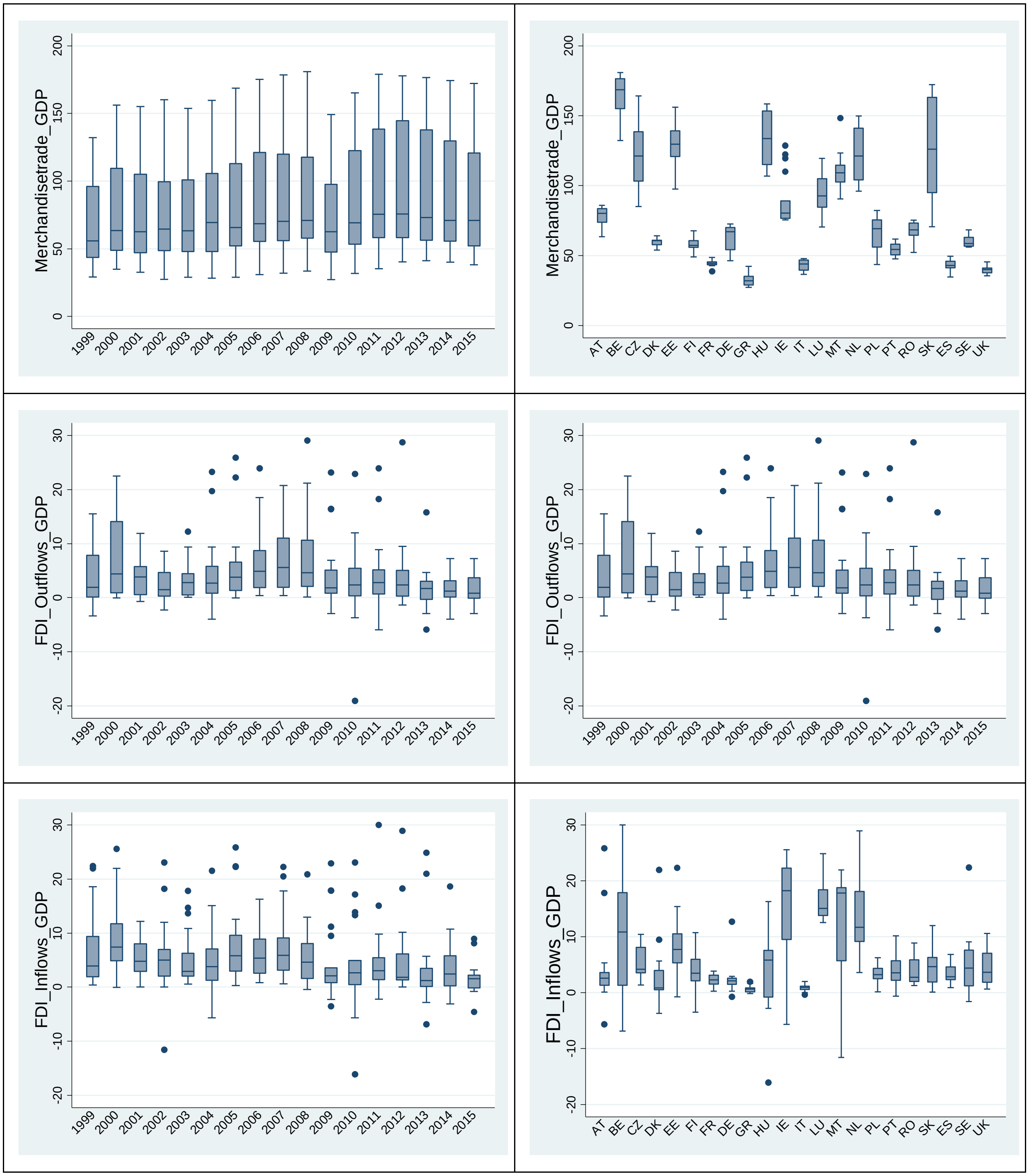
Our panel of data is unbalanced, i.e. there are some missing values as we do not have complete information for the variables (i)-(vi) considered.

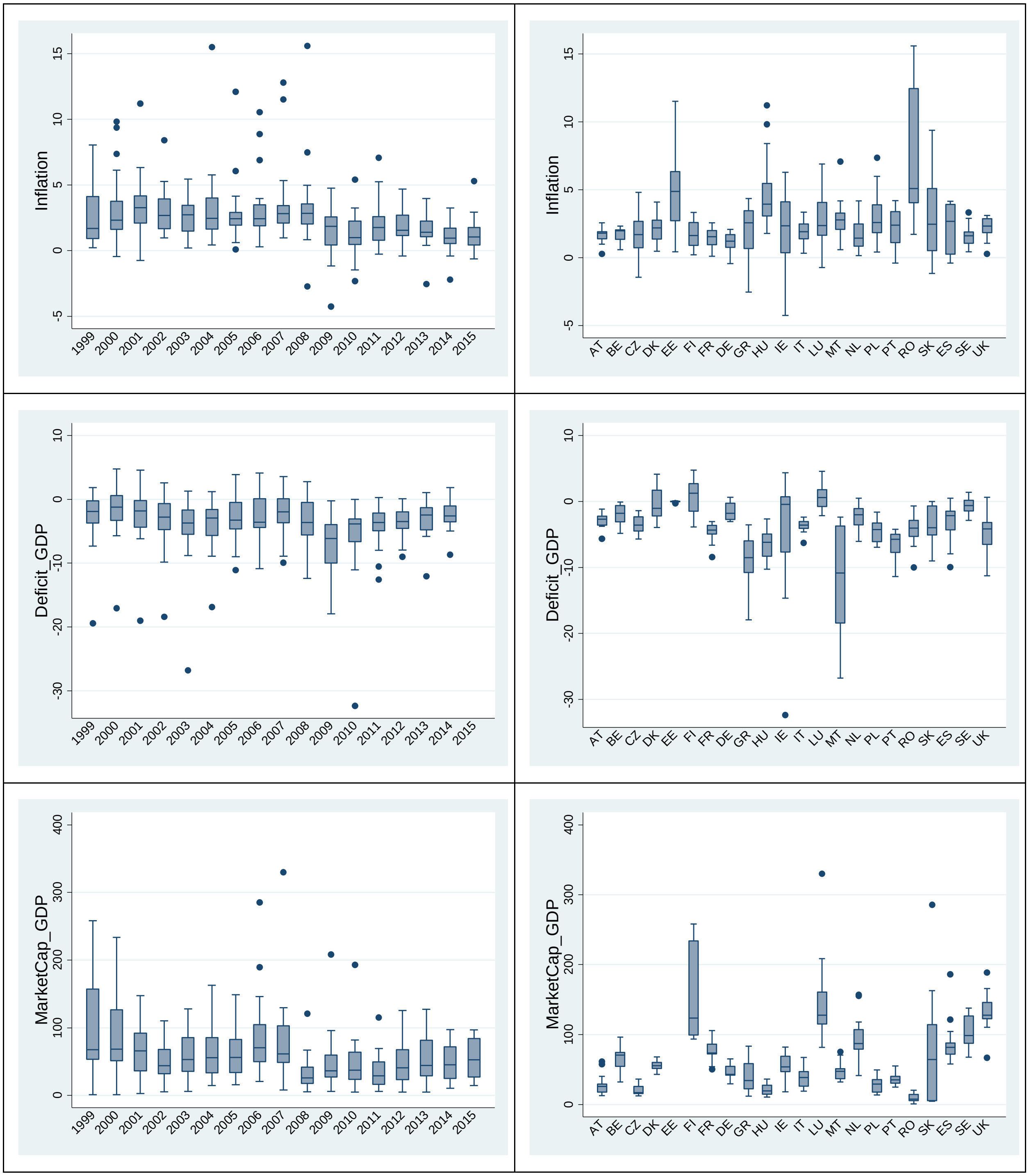
Figures 1 to 3 plot the distribution over time (left part of the graph) and across countries (rights part of the graph) of the variables considered in our analysis. Each boxplot shows the interquartile variation (IQR, i.e., the difference between the 75th and 25th percentile).

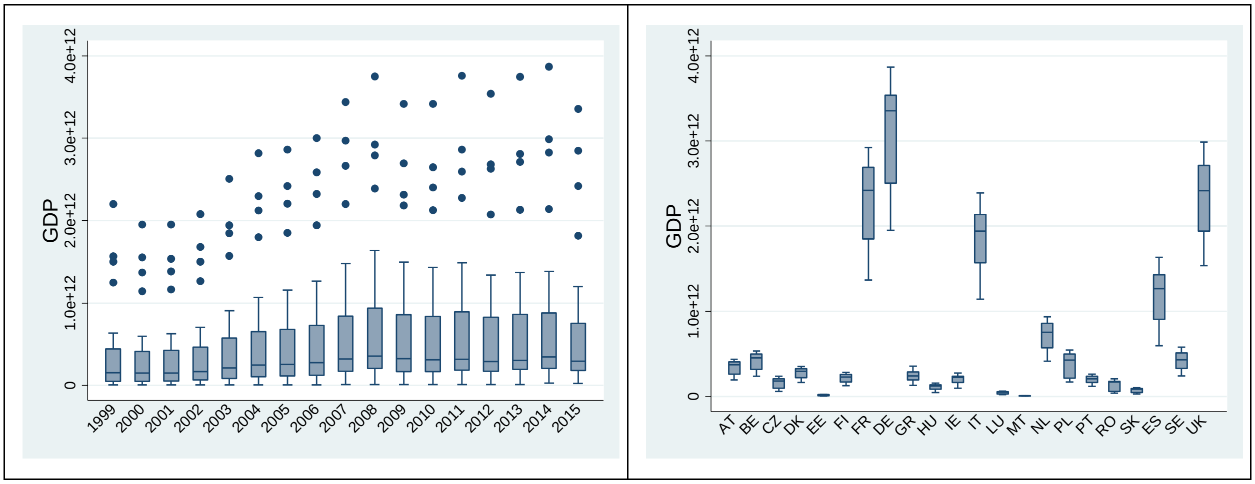
In **Figures 1** and **2,** we present the distributions for the macro-economic variables (i)-(iv) introduced above. The left panels show the cross-sectional distribution at each year. The right panels show the distribution of the variable in each country. We observe that the interquartile variation is stable over time for the *Trade_GDP*, *Merchandisetrade_GDP* and *Deficit_GDP.* On the opposite, the market capitalization shows a strong variation in the cross-sectional data. Moreover, we observe that the variables related to the GDP are characterized by a cyclic effect. For example, the distribution of these variables moves down corresponding to the global financial crises in 2009. *Trade_GDP*, *Merchandisetrade_GDP*, *MarketCap_GDP* and GDP have a strong positively skewness. Across countries, for most of the variables the degree of variability is large. On the opposite, the governance indicators appear to be more stable over time (see **Figure 2**, right panels). The indicator about political stability is the only one that is affected by changes over time. Across countries governance indicators vary a lot. Finally, following the recent sovereign crisis, the median for the rating dropped over the recent years. In particular, the IQR of rating is larger in from 2012 than in the past years (see **Figure 3**).

Figure 1. Box plots of variables describing a country's macro-economic variables (variation over time in left graph and variation across countries in right graph)




Merchandisetrade_GDP
FDI_Outflows_GDP
FDI_Inflows_GDP
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
AT BE CZ DK EE FI FR DE GR HU IE IT LU MT NL PL PT RO SK ES SE UK

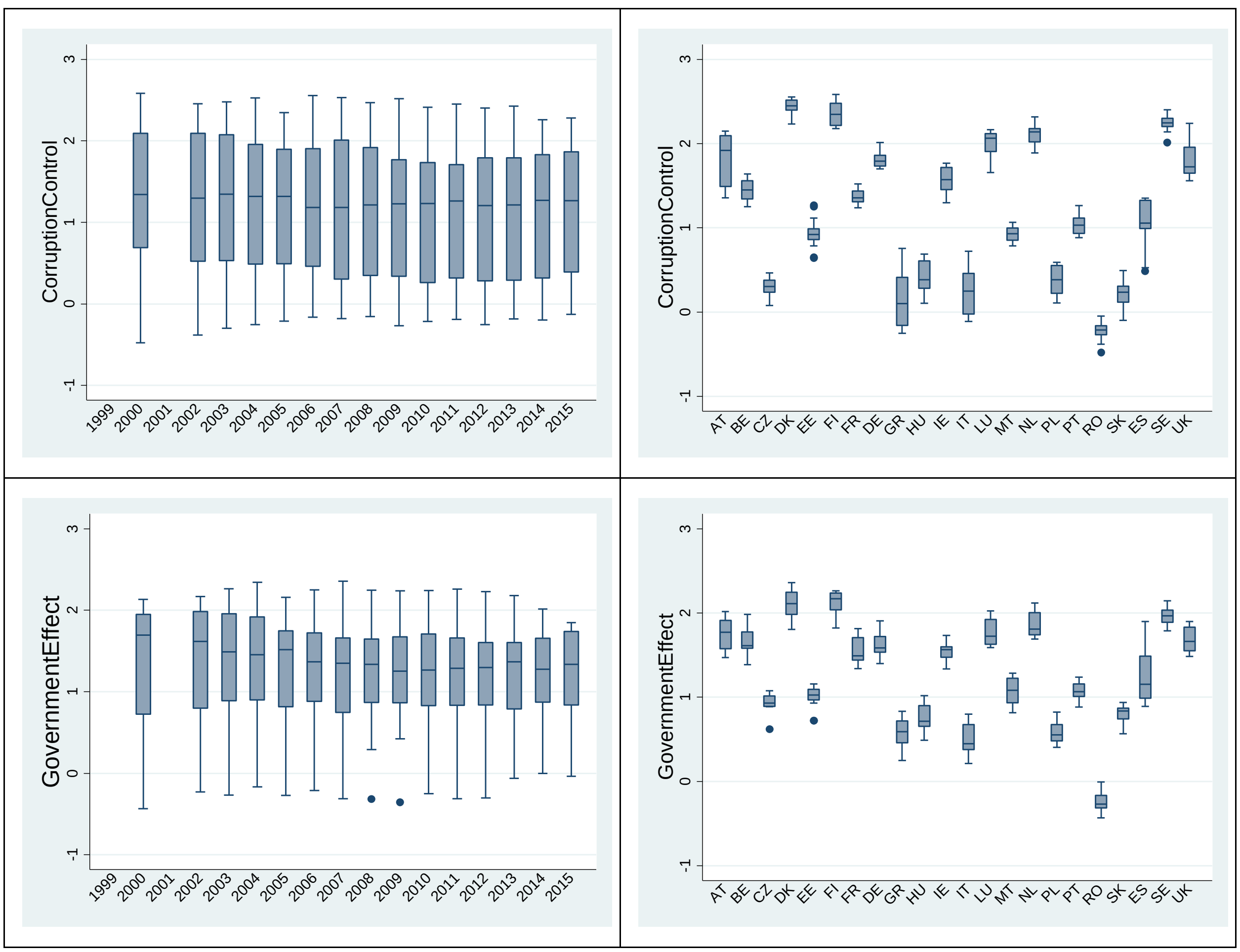

Inflation
Deficit_GDP
MarketCap_GDP
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
AT BE CZ DK EE FI FR DE GR HU IE IT LU MT NL PL PT RO SK ES SE UK

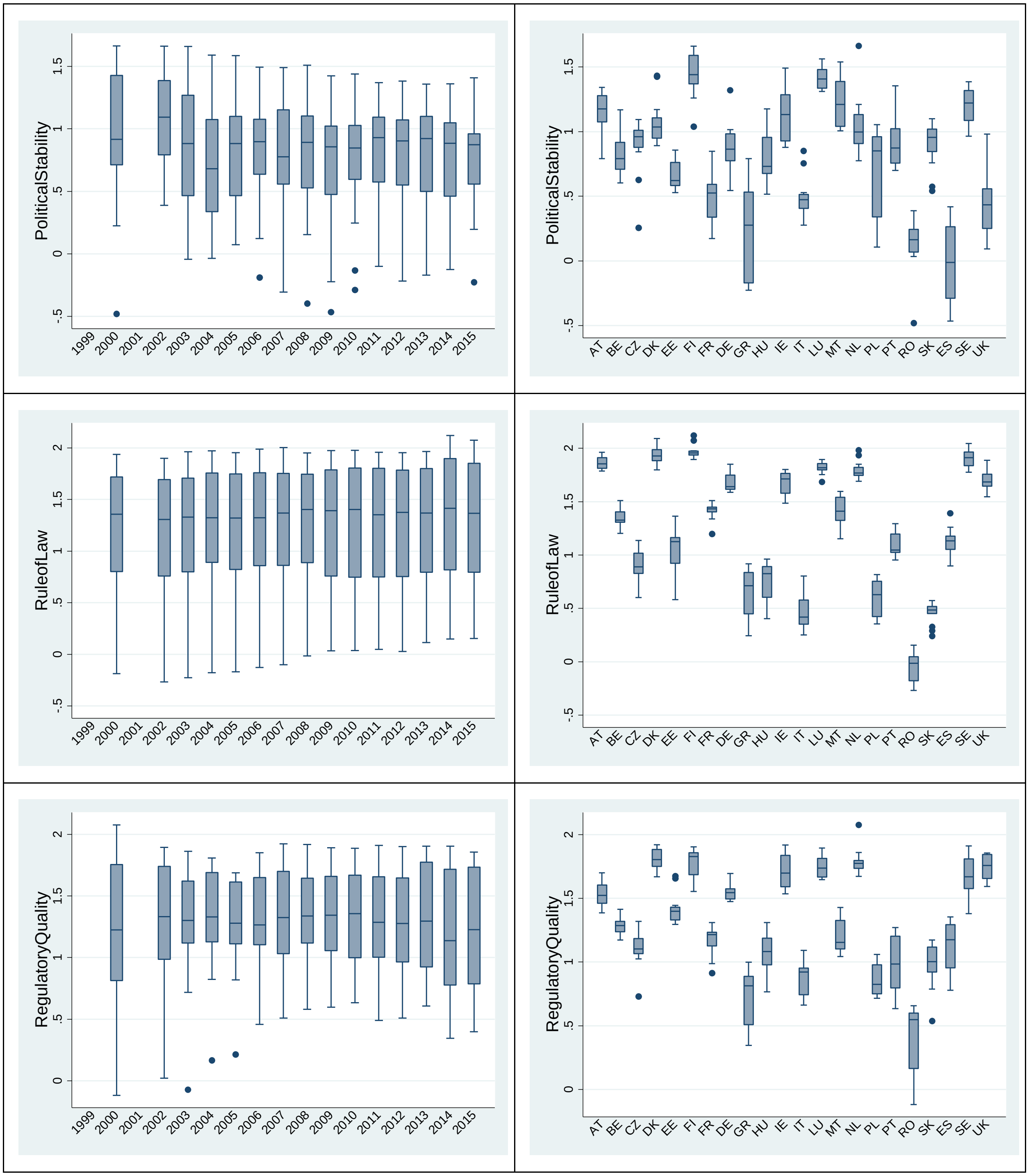


Notes: in the Box-plots the central mark corresponds to the median, the edges of the box are the 25th and 75th percentiles, and the dots point to outliers. Outliers have been adjusted for FDI_Inflows_GDP, FDI_Inflows_GDP and Inflation

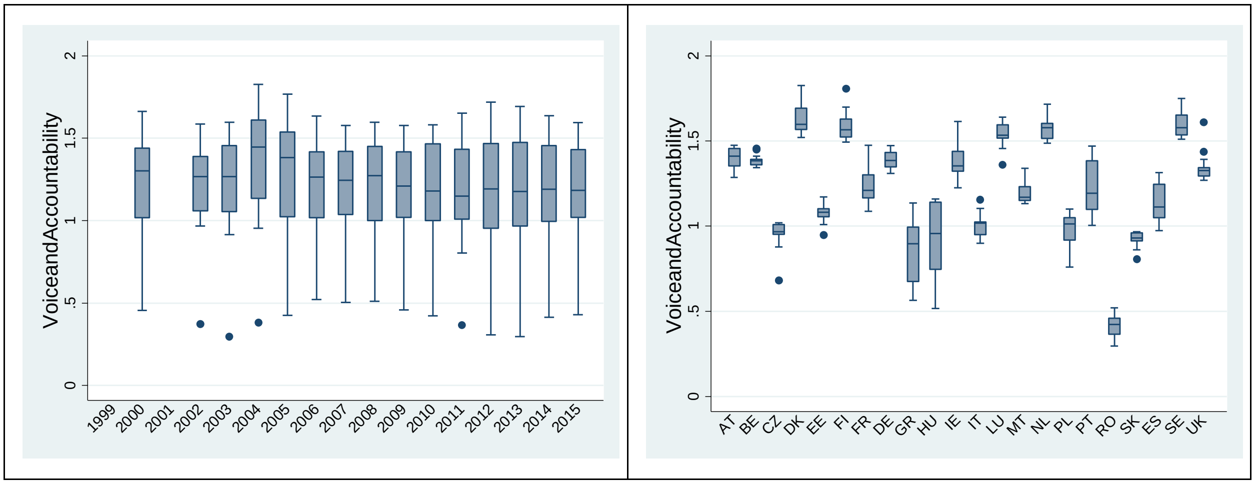
Source: World Bank and JRC calculations.

Figure 2. Box plots for the governance indicators (variation over time in left graph and variation across countries in right graph)





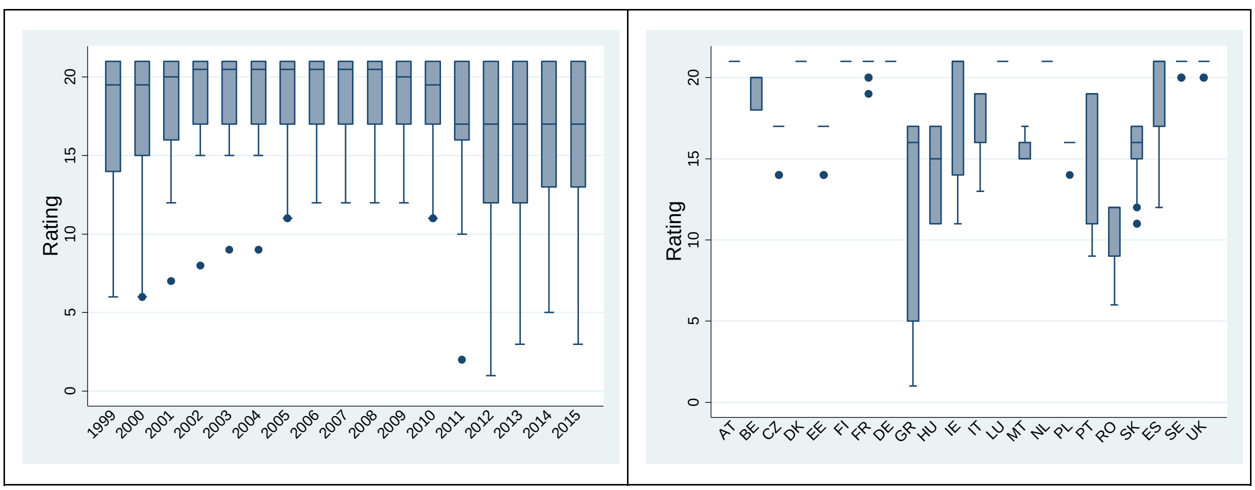
PoliticalStability
RuleofLaw
RegulatoryQuality
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
AT BE CZ DK EE FI FR DE GR HU IE IT LU MT NL PL PT RO SK ES SE UK



Notes: in the Box-plots the central mark corresponds to the median, the edges of the box are the 25th and 75th percentiles, and the dots point to outliers.

Source: World Bank and JRC calculations.

Figure 3. Box plots for the sovereign rating (variation over time in left graph and variation across countries in right graph)



Notes: in the Box-plots the central mark corresponds to the median, the edges of the box are the 25th and 75th percentiles, and the dots point to outliers.

Source: Moody's and JRC calculations.

4.2 Econometric Methodology

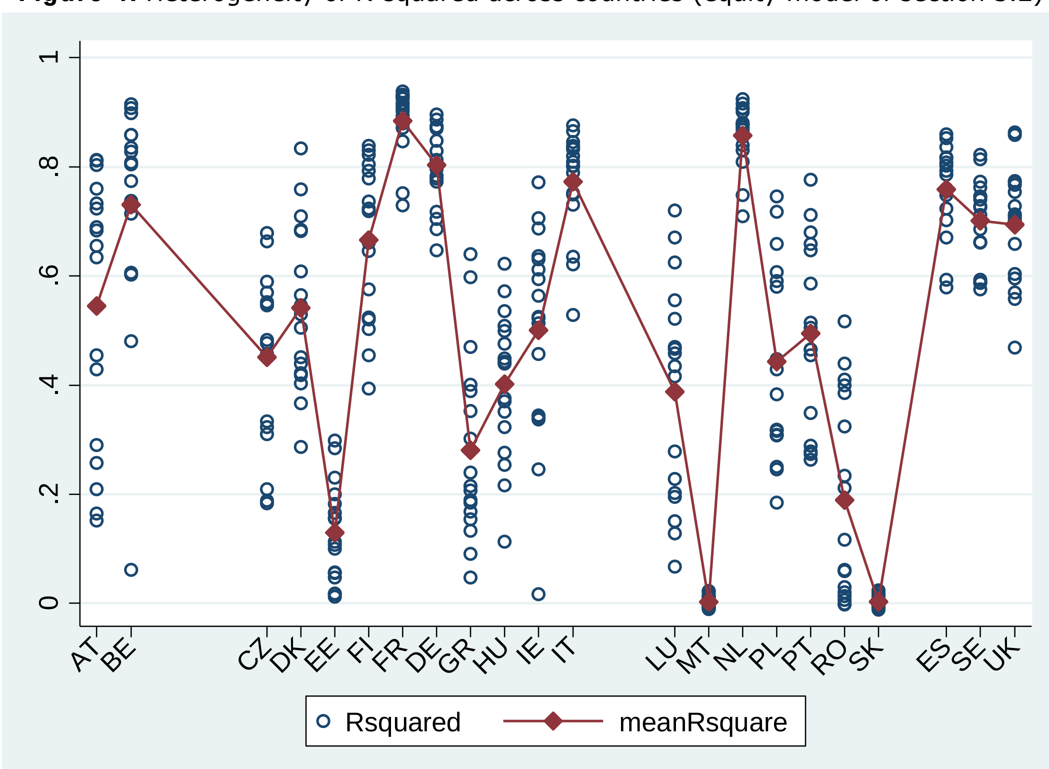
In order to study the relation between the integration level, measured by the R-squared of Pukthuanthong and Roll (2009) equity model presented in section 3.2, and the variables described in the previous section, we estimate the following panel model:

$$Rsquared_{i,t} = X'_{t-1}\beta + u_{i,t}, \tag{4}$$

where the variable $Rsquared_{i,t}$ comes from section 3.2, the lagged vector X'_{t-1} contains the lagged values of the explanatory variables detailed above and $u_{i,t}$ is the residual term. The index $i = 1, \dots, \mathrm{N}$ denotes the country while the index $t = 1, \dots, T$ denotes time. Lagged dependent variables allow us to avoid any contemporaneous feedbacks among the independent and the explanatory variables.

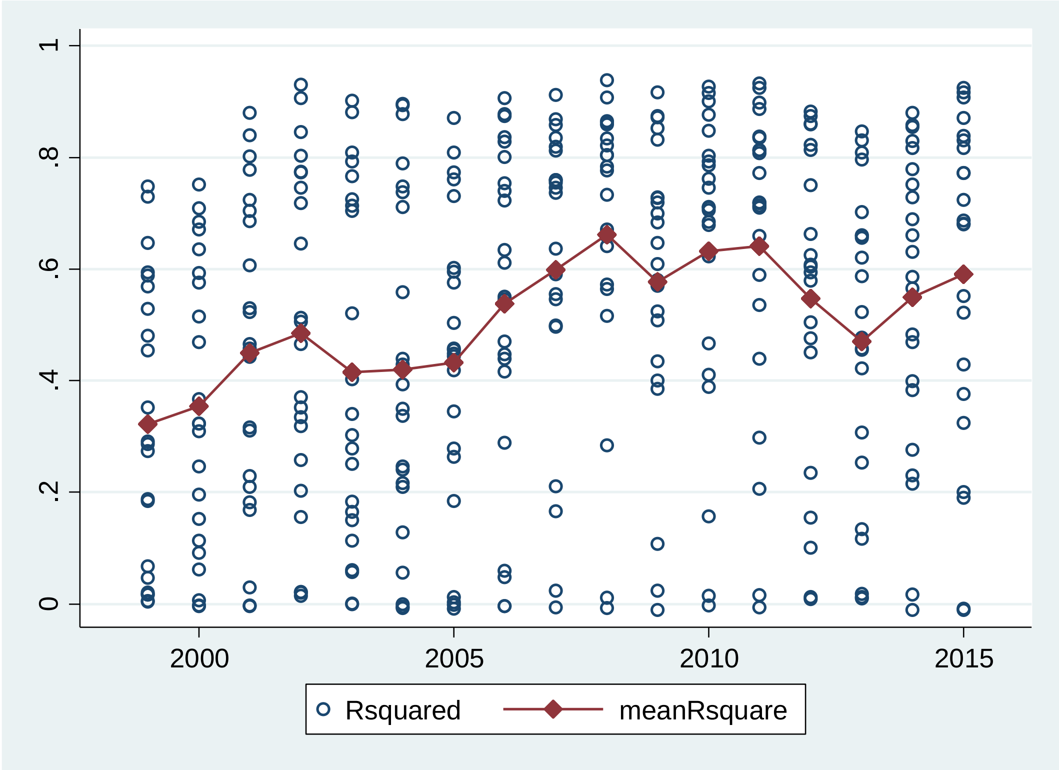
Figure 4 and **Figure 5** show the heterogeneity of the average R-squared across country and over years, respectively. This heterogeneity advice the estimation of a panel regression with country fixed effects and time effect. Various versions of the model are also considered as robustness checks.

Figure 4. Heterogeneity of R-squared across countries (equity model of section 3.2)



Source: JRC calculations.

Figure 5. Heterogeneity of R-squared across years (equity model of section 3.2)



Source: World Bank and JRC calculations.

4.3 Empirical Results

First, we investigate the relationship between the *R-squared*, the *GPD* (levels in natural logarithms), the market capitalization and the country's rating. Model 1, corresponding to equation (4), is our benchmark model. We run a panel least square regression with country fixed effects and time effects (**Table 1** shows the estimation results). We also estimate several versions of Model 1 considering for example only EMU member and/or the recent sovereign crisis[56] without altering the results obtained.

Table 1. Panel regression estimation results using fixed effects and time effects

	(1)	(2)
VARIABLES	Benchmark model	Model
L.lnGDP	0.211*	0.349***
	(0.107)	(0.113)
L.MarketCap_GDP	0.000755***	0.000705***
	(0.000260)	(0.000171)
L.Rating	-0.00193	-0.00439
	(0.00865)	(0.00503)
L.Trade_GDP		0.00127
		(0.000846)
L.Inflation		0.00731***
		(0.00169)
L.Deficit_GDP		-0.00656***
		(0.00161)
L.PoliticalStability		0.0587
		(0.0567)
Constant	-5.171*	-8.953***
	(2.670)	(2.858)
Observations	298	257
R-squared	0.553	0.622
Rho	0.695	0.882

(56) The results for these models are available on request. However, using a dummy variable for EMU member state caused multi-collinearity problems with country fixed effect because our sample consists mainly of EMU countries. Thus, the estimates are imprecise. Finally, introducing a dummy variable for the recent sovereign crisis does not add information to our results.

Number of unit_id	21	21
Country FE	YES	YES
Year FE	YES	YES

(*) Robust standard errors in parentheses

(*) *** p<0.01, ** p<0.05, * p<0.1

Source: World Bank, Moody's and JRC calculations.

In **Table 1**, benchmark model, the coefficients for *lnGDP* and *MarketCap_GDP* are both positive and statistically significant. Thus, countries with large GDP or a more developed financial market exhibit a larger degree of financial integration. The *Rating* variable is, instead, not statistically significant. Time variables, although not presented here, are statistically significant indicating the necessity to control for time effects. The regression's overall R-squared is 55% pointing to a good fit of the estimated model. Nevertheless, according to the interclass coefficient (*Rho*) almost 70% of the variance is due to differences across countries, pointing to the need to add country fixed effects.

We perform additional analysis on several extensions of the benchmark model. In order to analyse the statistical significance of each of the variables taken individually, we add one variable at a time to the benchmark model. Estimates (not presented here) show that the variables having statistically significant impact on the degree of financial integration are *Trade_GDP*, *Inflation*, *Deficit_GDP* and *PoliticalStability*. On the opposite, *Merchandisetrade_GDP*, *FDI_Inflows_GDP*, *FDI_Outflows_GDP*, *CorruptionControl*, *GovernmentEffect*, *RuleofLaw*, *RegulatoryQuality VoiceandAccountability* are not found statistically significant.

The full model (model 2) is then estimated by adding to the benchmark all the significant variables coming from the above exercise. Estimation results are presented in **Table 1** column (2). Similarly to the benchmark model, the coefficients for the GDP and market capitalization variables are both significant with a positive impact on the degree of integration. The country's credit rating does not appear to have any impact on integration, according to our estimates. For the macro-economic variables, a country high deficit (in proportion to the GDP) negatively affects integration. The opposite holds for inflation as the coefficient is significant with a positive sign. Trade openness and political stability are not found to be statistical significant. The overall R-squared is raised 62%.

Robustness checks

As first robustness check, we estimate the benchmark model excluding the time fixed effect (model 3), to capture the distortion that the absence of time effects is producing on the regression. The F-test ensures that model 3 fits to the data. Table 2 presents estimations for several models. Model 3 is the benchmark model without time effects; model 4 is the full model (model 2) without time effects; The GDP and the market capitalization remain significant for both models. For the full model, political stability and trade openness remain not significant, while, the rest of the variables have an impact on the degree of integration.

A natural choice arising when estimating panel regressions is to decide whether to include either fixed or random effects. We first estimate both the benchmark and the complete model with random effects. Model 5 is the benchmark model with random effects only, while model 6 is the full model with random effects. Results in **Table 2** show that statistical significance for the coefficients remains unaltered for the benchmark model (model 5). For the full model (model 6) trade openness and the sovereign rating are now statistical significant, while the significance for political stability remains unaltered. The choice among models, however, should be based on Hausman test, where the null hypothesis is that the preferred model is random effects (see Hausman, 1978, Green, 2008). We perform the Hausman test comparing model (5) with model (1) and model (6) with model (2). In both cases, we reject the null hypothesis and we advocate for fixed effects estimations[57].

Table 2. Panel regression estimation results

	(3)	(4)	(5)	(6)
VARIABLES	Country-Fixed Effects	Country-Fixed Effects	R.E. Benchmark model	R.E. model
L.lnGDP	0.252***	0.270***	0.188***	0.218***
	(0.0415)	(0.0449)	(0.0235)	(0.0232)
L.MarketCap_GDP	0.000806***	0.00104***	0.000694**	0.000910***
	(0.000272)	(0.000305)	(0.000275)	(0.000239)
L.Rating	0.00292	0.00554	0.00418	0.00628**
	(0.00549)	(0.00357)	(0.00524)	(0.00303)
L.Trade_GDP		0.00103		0.00154***
		(0.000757)		(0.000446)
L.Inflation		0.00517**		0.00336*
		(0.00192)		(0.00172)
L.Deficit_GDP		-0.00821***		-0.00851***
		(0.00201)		(0.00185)
L.PoliticalStability		0.0287		0.0346
		(0.0484)		(0.0417)
Constant	-6.226***	-6.943***	-4.540***	-5.622***
	(1.099)	(1.181)	(0.593)	(0.643)
Observations	298	257	298	257

[57] The p-values for Hausman test are equal to 0.0081 for the benchmark model and 0.0007 for the full model.

R-squared	0.385	0.478		
Number of unit_id	21	21	21	21
Country FE	YES	YES	NO	NO
Year FE	NO	NO	NO	NO

(*) Robust standard errors in parentheses

(*) *** p<0.01, ** p<0.05, * p<0.1

Source: World Bank, Moody's and JRC calculations.

4.4 Conclusions

This section investigates on possible factors that might affect the counties' degree of integration. The degree of integration is measured by the R-squared obtained with Pukthuanthong and Roll (2009) equity model presented in section 3.2. Various variables are used as possible drivers. Our analysis shows that macro-economic variables reflecting the country's economic prospects, such as GDP, deficit and inflation indeed have an impact on the degree of integration. Instead, county credit ratings, trade openness and various measures of governance overall do not affect financial integration in the equity market. The development of the domestic financial market turned out to be an important driver of integration. Various robustness checks were also performed confirming the results.

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List of abbreviations and definitions

APT	Arbitrage Pricing Theory
CAPM	Capital Asset Pricing Model
GARCH	Generalized Autoregressive Conditionally Heteroskedastic
PCA	Principal Component Analysis
PV	Proportion of Variance
SI	Spillover Intensity

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Annexes

Annex 1 Studies on Measuring Financial Integration

Table A1.1. Studies on Measuring Financial Integration

Study	Data	Time period	Method	Conclusions
Abad et al., 2009	Weekly 10 year Government benchmark yields for 13 EU-euroarea (Datastream)	1999-2008	CAPM	•Incomplete integration • EMU and US government bond markets present a low degree of integration. It is domestic rather than international risk factors that mostly drive the evolution of government debt returns in EMU •The degree of integration with the US and German bond markets differs between euro and non-euro countries •Government bond returns of non-EMU countries are more influenced by world risk factors Government bond returns of EMU countries are more influenced by Eurozone risk factors
Abad et al., 2010	Government bonds (weekly)	1999-2008	CAPM	•Euro markets are less vulnerable to the influence of world risk factors but more vulnerable to EMU risk factors. •Only partially integrated •Eu15-non-euro area countries present higher vulnerability to external risk factors
Arshanapalli and Doukas, 1993	Stock markets of US, Japan, France, Germany, and UK.	1980-1990	Cointegration analysis	•For the post-crash period, the US stock market is found to have a considerable impact on the French, German and UK markets •Japan has no links with any market during the pre-and post-crash period.

Babetskii et al., 2007	Stock & Sectoral indices	1995-2006	beta-convergence, sigma-convergence	•Evidence of stock market integration between the Czech Republic, Hungary, Poland and the euro area
Baele, 2004	Stock index (weekly)	1980-2001	Spillover	•EU and U.S. shock spillover intensity increased substantially over the 1980s and 1990s •Most strongly in the second half of the 1980s and first half of the 1990s •Rise is more pronounced for EU spillovers •US is the dominating factor
Bartram, 2007	Stock index (daily)	1994-2003	Copula model	•Euro area: market dependence increased after the introduction of the euro only for large equity markets (France, Germany, Italy, the Netherlands and Spain) •UK and Sweden, but not other European countries outside the Euro area, exhibit an increase in equity market co-movement
Bekaert and Harvey, 1995	13 emerging country indices from IFC	1975-1992	Regime switching model	•Time-varying integration for a number of countries
Bekaert et al., 2002	11 time series representing the following groups of variables: stock data (returns, dividends), liquidity, capital flows to the market, structure and comovements of returns, local economic environment for 20 emerging markets	1980-1996	They consider a series of financial and macroeconomic variables related to integration and look for endogenous break points.	•Strong evidence of structural breaks •Integration is associated with an equity market that is significantly larger and more liquid than before and stock returns that are more volatile and more correlated with world market returns than before. •Integration is associated with a lower cost of capital, an improved credit rating, a real exchange rate appreciation, and increased real economic growth

Bekaert et al., 2011	69 countries: •monthly equity industry portfolio data (Datastream) •firm-level data (Standard & Poors' Emerging Market Data Base)	1980-2005	Segmentation analysis using valuation ratios	•Emerging countries tend to have a higher and more volatile segmentation measure. •Factors like barriers to foreign capital, political risk profile and market development are important segmentation determinants
Bekaert et al., 2013	Monthly earning yields firm level data for 33 European countries	1990-2007	Bilateral segmentation analysis	EU membership, but not the common increased financial and economic integration between European countries.
Berben and Jansen, 2005	Stock & Bond indices (weekly)	1980-2003	STC-GARCH	•Stock market integration is a more gradual process than bond market integration •For government bond markets, EMU has affected the timing of the integration advances rather than the size of them •Little discernible effect on stock market integration
Berger and Pukthuanthong, 2011	Stock returns index (daily)	1984-2010	Factor models (1 factor)	•Develop a measure of market fragility for 82 countries (including all EU-28) and estimate increasing likelihood of systemic risk
Berger, Pukthuanthong and Yang, 2012	Stock returns index (daily)	1989-2006 (sample depending on the country)	Factor Models (1 factors)	•Little evidence of frontier market integration and lack of consistent integration dynamics.

Bessler and Yang, 2003	Daily stock index for Australia, Japan, Hong Kong, United Kingdom, Germany, France, Switzerland, United States, and Canada	1997-1999	Cointegration analysis	•US is the only market that has a consistently strong impact on price movements in other major stock markets in the longer-run
Billio et al., 2015	Stock returns index (monthly) for 14 countries	1985-2014	Various methods (Correlation, conditional correlation, factor models, GARCH, time varying parameters)	•Comparison of methods to assess integration •Standard unconditional correlation and PCA provide similar patterns •Volatility and heteroscedasticity corrected measures produce high volatility patterns. •Dynamic of unconditional correlation capture well the integration patterns
Billio and Pelizzon, 2003	Stock index (weekly)	1988-2001	Volatility spillover	•Volatility spillovers from both the world index and the German market have increased after EMU for most European stock markets
Bley, 2009	Stock index (daily), industry sectors	1998-2006	Cointegration/Impulse response analysis	•Euro markets became more integrated between 1998 and 2003 •Time-varying nature of the financial market integration process •Evidence that behavior is changing and stock markets within the Euro zone are starting to drift apart
Boubakri and Guillaumin, 2011	exchange rates (monthly)	2001-2009	ICAMP, MGARCH, Kalman	•Financial integration (i) is not perfect but is increasing and (ii) is linked to currency stability. •The growing financial integration in 2007–2009 seems to be rather the result of the shock propagated by the global crisis
Büttner and Hayo, 2011	Stock index (daily)	1999-2007	DCC-MGARCH	•Significant trend toward more integration enhanced by the size of relative and absolute market capitalisation

				•hindered by foreign exchange risk between old member states and the euro area •Interest rate spreads and business cycle synchronisation are also significant factors in explaining equity market integration
Cappiello, 2006	Stock and Bond indices (daily)	1994-2005	Factor model/Co-movements	•Largest new member states (Czech Republic, Hungary, Poland) exhibit strong comovements between themselves and with the euro area •Smaller countries, only Estonia and to a less extent Cyprus show increased integration both with the euro zone and the block of large economies •Bond markets: increase in integration only for the Czech Republic versus Germany and Poland
Carrieri et al., 2007	emerging markets	1997-2000	ICAMP, integration index	•The degree of integration significantly varies across countries None of the countries is fully segmented
Carrieri et al., 2013	•6 developed markets 2 Segments for the emerging markets: investables and non-investables	1989-2008	ICAMP, integration index	•Developed markets are fully integrated Emerging markets not fully integrated with the world market
Christiansen, 2007	Government bond indices: •US •EMU-member countries (Belgium, France, Germany, Italy, Netherlands, Spain)	1988-2002	Volatility spillovers intensities	•For EMU countries (plus Denmark) regional effects are most important, followed by local effects. Global effects are almost negligible. For non-EMU countries own country effects are stronger, European effects smaller and US effects larger.

	non-EMU member countries (Denmark, Sweden, UK)			
Christiansen, 2014	Sovereign Bond yields (monthly) for 17 EU countries	1994-2012	Factor models plus panel regression	•Analysis of variables influencing integration •Integration is stronger for EMU than for non-EMU countries. •For EMU: integration is weaker the lower is the credit rating.
Christiansen and Ranaldo, 2009	Stock total return index (daily)	2000-2007	Coexceedance methodology	Differences between: (a) negative and positive coexceedance (b) between old and new EU member states (c) before and after the EU enlargement in 2004 Closer connection of new EU stock markets to those in Western Europe
Dunis et al. (2013)	Stock index (daily)	1998-2006	beta-convergence, sigma-convergence	•Increasing degree of integration for Malta and Slovenia, Estonia appears segmented. •Cyprus and Slovakia exhibited a degree of integration after their accession into EU but this trend changes after they adopted the euro •Integration process accelerated after the accession in the EU •EMU does not seem to have the same positive impact on it
Forbes and Rigobon, 2002	Stock indices for 28 countries		Correlation coefficients	High level of co-movements in all periods

Fratzscher, 2001	Stock indices for 16 EMU, plus Denmark, Sweden, UK, and Australia, Canada, Japan, Norway, Switzerland	1986-2000	Trivariate GARCH model	European equity markets have become highly integrated only since 1996
Gjika and Horváth, 2013	Stock index (daily)	2001-2011	asymmetric DCC	•Central European stock markets are strongly correlated with Western Europe •Financial crisis increased the correlations
Graham et al., 2012	Stock indices for 22 emerging markets	2001-2010	Wavelet analysis	•The strength of co-movement varies by country. • Higher degree of co-movement for lower frequencies Co-movement at highest frequencies is weak.
Hardouvelis et al., 2006	Weekly, deutschmark denominated, dividend-adjusted, and continuously compounded stock returns based on Friday closing prices in the 11 EU countries	1992-1998	Conditional asset pricing model with time-varying degree of integration.	•Stock markets expected returns converged toward full integration, becoming increasingly determined by EU-wide market risk and less by local risk •UK shows no increase in stock market integration
Horvath and Petrovski, 2013	Stock index (daily)	2006-2011	Multivariate GARCH	•High degree of stock market integration •Croatia recently displayed a degree of integration toward Western Europe •No evidence that crisis altered the degree of integration
Kaza, 1992	Monthly and quarterly data on Morgan Stanley's	1974-1990		Results indicate the presence of a single common trend driving these countries' stock markets

	Capital International (U.S., Japan, England, Germany, and Canada)			
Kenourgios and Samitas, 2011	Stock indices in five Balkan stock markets, US, UK, Germany and Greece	2000-2009	AG-DCC multivariate GARCH	Increased dependence among Balkan and developed equity markets
Kim et al., 2005	Daily stock returns for 12 Eurozone, 3 EU-non euro, US and Japan	1989-2003	Bivariate EGARCH with time-varying conditional correlations, linear systems regressions	•Regime shift in stock market comovements within the EU and deeper stock market linkages with the introduction of the euro •Necessity for currency union for financial market integration
Kim et al., 2006	Daily bond and stock returns for FR, DE, IT,ES, UK and JP, Us	1994-2003	Bivariate EGARCH with time-varying conditional correlation investigate whether time-varying co-movements between daily government bond and stock returns over the past decade have been affected by the implementation of the EMU	•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 (even negative mean levels in most European countries) •Bond market return shocks have more influence than stock market shocks Monetary union has Granger caused the segmentation between bond and stock markets within Europe but not outside
Mittoo, 1992	Stock prices (domestic and Interlisted)	1978-1996	CAPM and APT	•Segmentation in 1977-1981 Integration in 1982-1986

Pasqual, 2003	Stock index	1965-1995	Co-integration	•Cointegration tests do not show evidence of changes in the degree of financial integration for the UK and Germany stock markets •Evidence of increasing financial integration is found for France
Pozzi and Wolswijk, 2012	Government bonds (daily)	1995-2009	CAPM	•Idiosyncratic factors almost eliminated by 2006 in Italy reappeared due to the financial crisis in 2007 •Country-specific exposures to the common international risk factor have converged across countries, with no setback during the crisis
Pukthuanthong and Roll, 2009	Stock returns index (daily) for 81 countries (all EU-28 and main developed and developing countries)	1973-2006	Factor Models (10 factors)	•Strong evidence of growing integration for most of the 81 countries analysed. •Integration is feaster for EU countries.
Pungulescu, 2013	Government bond rates (monthly) Stock index (weekly)	1999-2010	Set of indicators	•Integration is not complete in either the more advanced member states or the East-European •Patterns of convergence seen in 1990s reappear in the evolution of the new comers •Different segments of the markets integrate at different speeds •Neither before the setback brought about by the financial crisis, not at present the aims and the very reasons of financial market integration, perfect capital mobility and full international risk sharing have not been achieved in EU
Ratanapakorn and Sharma, 2002	World composite indices	1990-2000	Cointegration analysis	•no long-run relationship is observed among these indices during the pre-crisis period During the crisis period, one significant cointegrating vector is observed

Santis and Gerard, 2006	IMF CPIS portfolio holdings database	1997-2001	Portfolio analysis	•Equity and bond home biases declined significantly among European countries (Financial integration) •EMU eased the access to the equity market and enhanced regional financial integration
Savva and Aslanidis, 2010	Stock index (weekly)	2001-2007	DCC-GARCH	•Czech, Slovenian and Polish markets increased their correlation to the Euro-zone •This is not a broad-based phenomenon across Eastern Europe •The increase in correlations is mainly driven by EU-related developments
Skintzi and Refenes, 2006	Weekly bond data: •eight EMU countries •three EU-non EMU Norway	1991-2002	Volatility spillovers intensities	Regional spillover effects are larger as compared to global ones
Syriopoulos, 2007	Stock index (weekly)	1997-2003	Cointegration	•CE stock markets tend to display stronger linkages with their mature counterparts rather than with the other CE neighbors •Polish, Hungarian, and Czech stock markets appear more sensitive to shocks from the mature markets •Slovakian stock market is found to exhibit a more autonomous behavior •No dramatic post-EMU shock is detected in stock market dynamics
Volosovych, 2011	Sovereign Bond yields (monthly) for 15 industrialized countries	1875-2009	Factor models (1 principal component) and regression	•Examine the long-run pattern of integration and variables influencing it. •Globalization seems the reason of increasing integration in latest years; policy variables and

				country risk are also important in explaining the integration trends.
Volosovych, 2013	Sovereign Bond yields (monthly) for 15 industrialized countries	1875-2009	Factor models (1 principal component) and regression	•Refinement of the 2011 paper distinguishing between real and nominal returns series. Inflation matters when measuring integration. •Analysis of variables influencing integration
Wang and Moore, 2008	Stock index (daily)	1994-2006	DCC-GARCH	•Significant dynamic correlations with the Eurozone market during the financial crises and a higher level of linkage after crises •Entry to the EU seems to have strengthened the correlation •Financial markets development seems to be an important driving factor behind higher levels of co-movement in the Czech Republic and Hungary with the Eurozone.
Yang et al., 2003	Stock index (daily)	1996-2001	ECM	EMU has significantly strengthened stock market integration among its member countries, but lessened linkages with a non-member country (UK) in the same region

Table A1.2. Financial integration studies for EU28 countries: countries analysed

Authors	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE	UK
Abad et al. (2010)	*			*	*		*		*	*		*							*	*		*				*	*	*
Babetskii et al. (2007)			*														*				*				*			
Baele (2004)	*			*	*		*		*	*		*							*	*								*
Bartram (2007)	*			*	*		*	*	*	*		*				*			*	*		*				*	*	*
Bekaert et al. (2013)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Berben & Jansen (2005)	*			*	*					*		*							*								*	*
Berger, Pukthuanthong (2011)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Berger, Pukthuanthong, and Yang (2011)		*									*				*								*	*				
Billio & Pelizzon (2003)					*				*	*		*																*
Billio and others (2015)	*			*	*		*			*		*															*	*
Bley (2009)	*			*	*		*	*	*	*		*							*	*						*		*

Boubakri & Guillaumin (2011)	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Büttner & Hayo (2011)	*		*	*	*		*		*	*		*					*		*	*	*	*				*	*	*
Cappiello (2006)			*			*							*	*			*				*			*				
Christiansen (2014)	*		*	*	*		*	*	*	*		*					*		*	*	*	*				*	*	*
Christiansen & Ranaldo (2009)	*	*	*	*	*	*	*	*	*	*		*		*	*		*		*	*	*	*	*	*	*	*	*	*
Christiansen (2007)	*			*	*				*	*		*							*								*	*
Dunis et al. (2013)						*							*					*						*	*			
Fratzscher (2002)	*			*	*				*	*		*							*	*						*	*	*
Gjika & Horváth (2013)			*														*				*							
Hardouvelis et al. (2006)	*				*		*		*	*		*							*	*		*				*		*
Horvath & Petrovski (2013)			*								*						*				*							
Kim et al. (2005)	*			*	*		*	*	*	*		*				*			*	*		*				*	*	*
Kim et al. (2006)					*				*	*		*																*
Kim et al. (2006)	*		*		*		*			*		*					*		*		*							*
Pasqual (2003)					*					*																		*
Pozzi & Wolswijk (2012)	*				*					*		*							*									
Pukthuanthong&Roll (2009)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pungulescu (2013)	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Santis & Gerard (2006)	*			*			*		*	*		*							*	*		*				*	*	*
Savva & Aslanidis (2010)			*														*				*			*	*			
Skintzi & Refenes (2006)	*			*	*		*		*	*		*							*	*							*	*
Syriopoulos (2007)			*		*												*				*				*			
Volosovych (2011, 2013)	*			*	*				*	*		*							*	*						*	*	*
Wang & Moore (2008)			*														*				*							
Yang et al. (2003)	*				*		*		*	*		*							*	*		*				*		*
	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE	UK

Annex 2 Supplementary Material

Table A2.1. List of stock market indices

Country			Index
Euro area	Austria	AT	AUSTRIAN TRADED ATX INDX
	Belgium	BE	BEL 20 INDEX
	Cyprus	CY	GENERAL MARKET INDEX CSE
	Estonia	EE	OMX TALLINN OMXT
	Finland	FI	OMX HELSINKI INDEX
	France	FR	CAC 40 INDEX
	Germany	DE	DAX INDEX
	Greece	EL	Athex Composite Share Pr
	Ireland	IE	IRISH OVERALL INDEX
	Italy	IT	FTSE MIB INDEX
	Latvia	LV	OMX RIGA OMXR
	Lithuania	LT	OMX VILNIUS OMXV
	Luxemburg	LU	LUXEMBOURG LuxX INDEX
	Malta	MT	MALTA STOCK EXCHANGE IND
	Netherlands	NL	AEX-Index
	Portugal	PT	PSI 20 INDEX
	Slovenia	SI	Slovenian Blue Chip Idx
	Slovak Rep.	SK	SLOVAK SHARE INDEX
	Spain	ES	IBEX 35 INDEX
Rest of EU28	Bulgaria	BG	SOFIX INDEX
	Czech Rep.	CZ	PRAGUE STOCK EXCH INDEX
	Denmark	DK	OMX COPENHAGEN INDEX
	Croatia	HR	CROATIA ZAGREB CROBEX
	Hungary	HU	BUDAPEST STOCK EXCH INDX
	Poland	PL	WSE WIG INDEX
	Romania	RO	BUCHAREST BET INDEX
	Sweden	SE	OMX STOCKHOLM 30 INDEX
	United Kingdom	UK	FTSE 100 INDEX
RoW	Canada	CA	S&P/TSX COMPOSITE INDEX
	Switzerland	CH	SWISS MARKET INDEX
	China	CN	SZSE COMPONENT INDEX
	Japan	JP	TOPIX 500 INDEX
EU benchmark			STOXX Europe 600
US benchmark			S&P 500 INDEX

Source: Bloomberg.

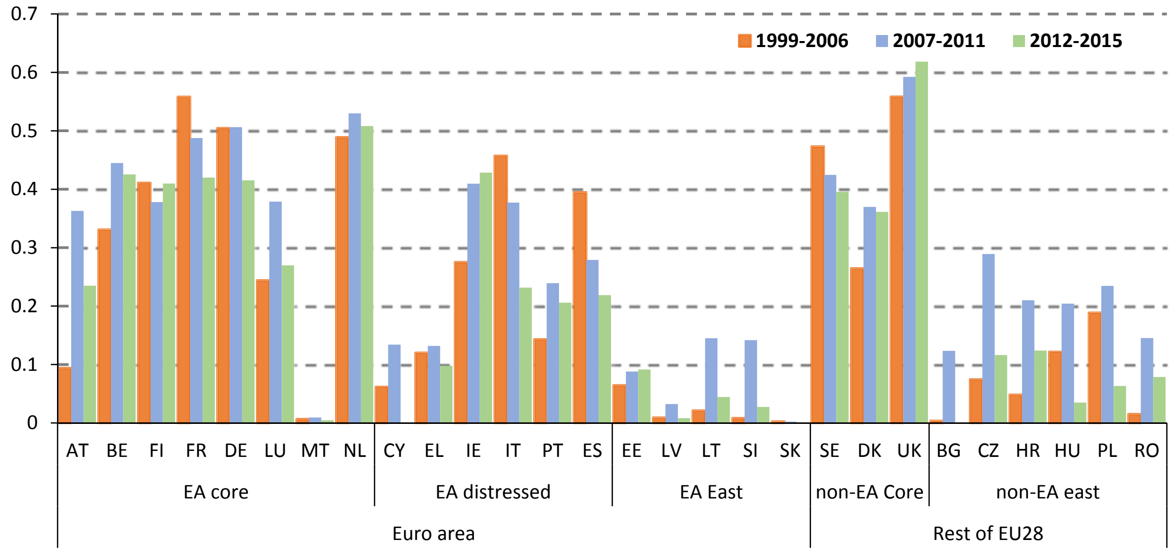
Table A2.2. Data availability for benchmark sovereign bonds with 10 years maturity: countries with sparse data (y=available; n=not available). For a given country and a given year, 'Y' appears in the table when more than 110 daily data are available and 'n' otherwise.

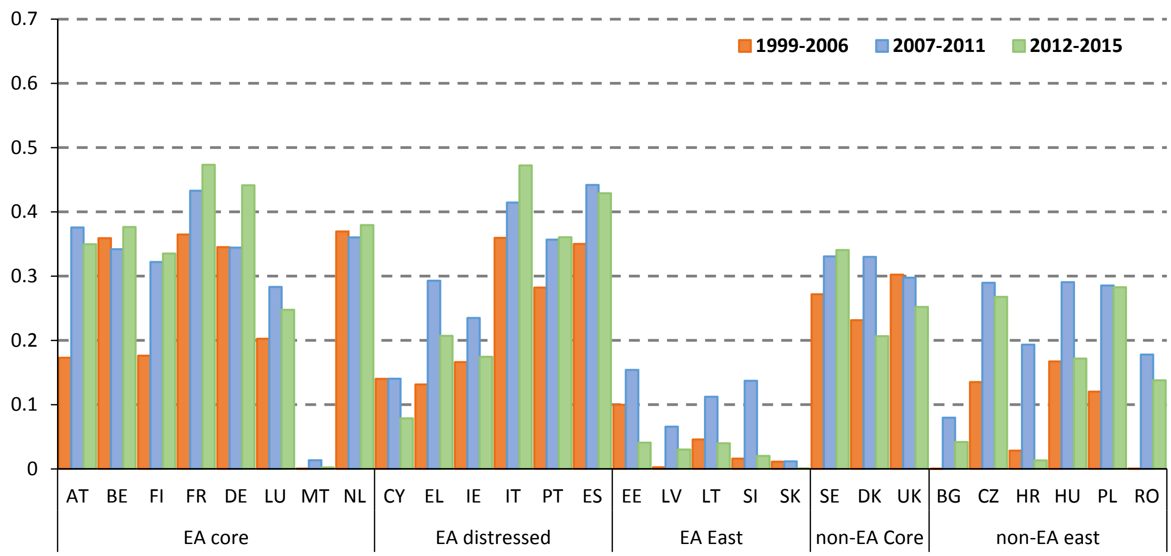
	BG	CZ	DK	IE	EL	IT	LT	HU	PL	RO	SI	SK	SE	CN	CH
1999	n	n	Y	n	n	n	n	n	n	n	n	n	n	n	n
2000	n	n	Y	Y	n	Y	n	n	Y	n	n	n	n	n	n
2001	n	n	Y	Y	n	Y	n	n	Y	n	n	n	n	n	n
2002	n	n	Y	Y	n	Y	n	n	n	n	n	n	n	n	n
2003	n	n	Y	Y	n	Y	n	n	Y	n	n	Y	n	n	n
2004	n	n	Y	Y	n	Y	n	n	Y	n	n	Y	n	n	n
2005	n	n	Y	Y	n	Y	n	n	Y	n	n	Y	n	n	n
2006	n	n	Y	Y	n	Y	n	n	Y	n	n	n	n	n	n
2007	n	Y	Y	n	Y	Y	n	Y	Y	n	n	n	Y	Y	Y
2008	n	Y	n	Y	Y	Y	n	Y	Y	n	n	Y	Y	Y	Y
2009	n	Y	Y	Y	Y	Y	n	Y	Y	n	n	Y	Y	Y	Y
2010	Y	Y	Y	Y	Y	Y	n	Y	Y	n	n	Y	Y	Y	Y
2011	Y	Y	Y	Y	Y	Y	n	Y	Y	n	Y	Y	Y	Y	Y
2012	Y	Y	Y	n	Y	Y	n	Y	Y	Y	n	Y	Y	Y	Y
2013	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2015	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: Six EU countries (EE, LU, MT, HR, CY, LV) are excluded from the analysis as daily data are ether very limited or absent while twelve countries have a complete dataset for the period 1999-2015 (BE, DE, ES, FR, NL, AT, PT, FI, UK, US, JP, CA) and are included. The remaining countries are included depending on data availability.

Source: Bloomberg and JRC calculations.

Chart A2.3. Equity market integration based on the proportion of variance indicator (PV indicator) for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

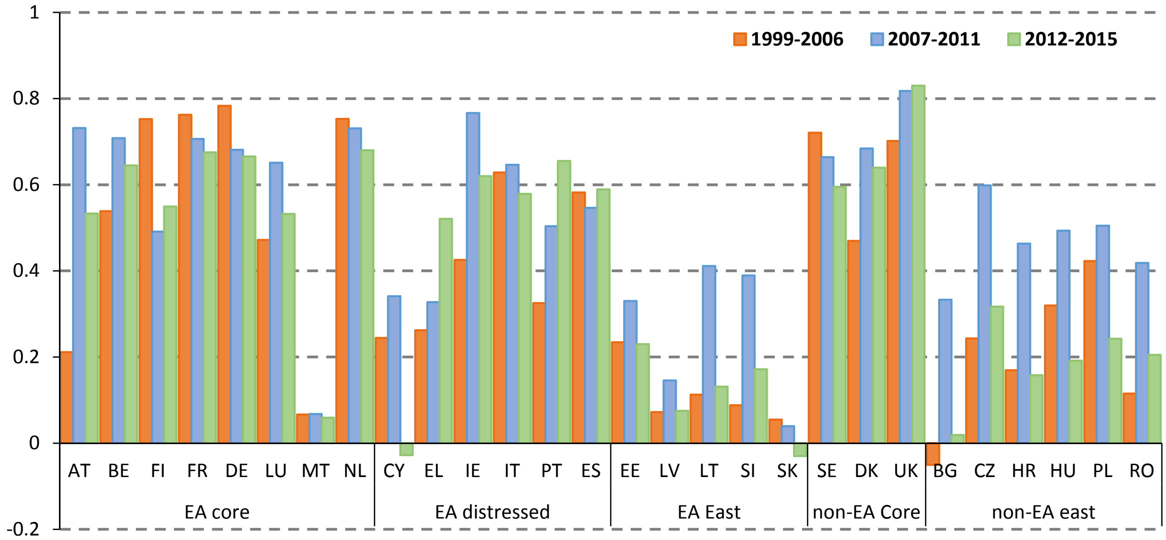


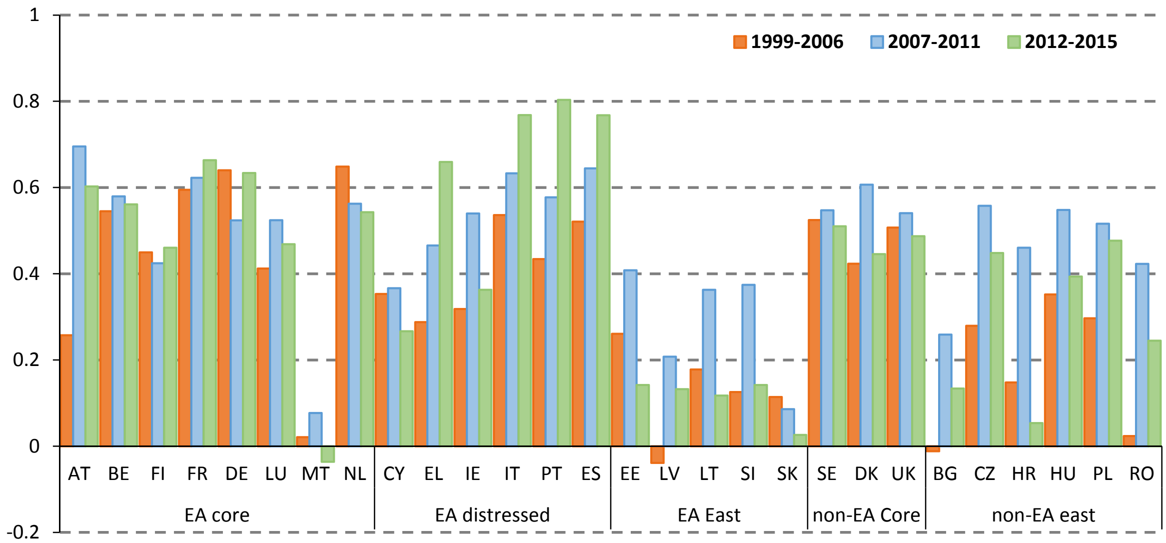


Note: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO).

Source: Bloomberg and JRC calculations.

Chart A2.4. Equity market integration based on the spillovers intensity indicator (SI indicator) for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

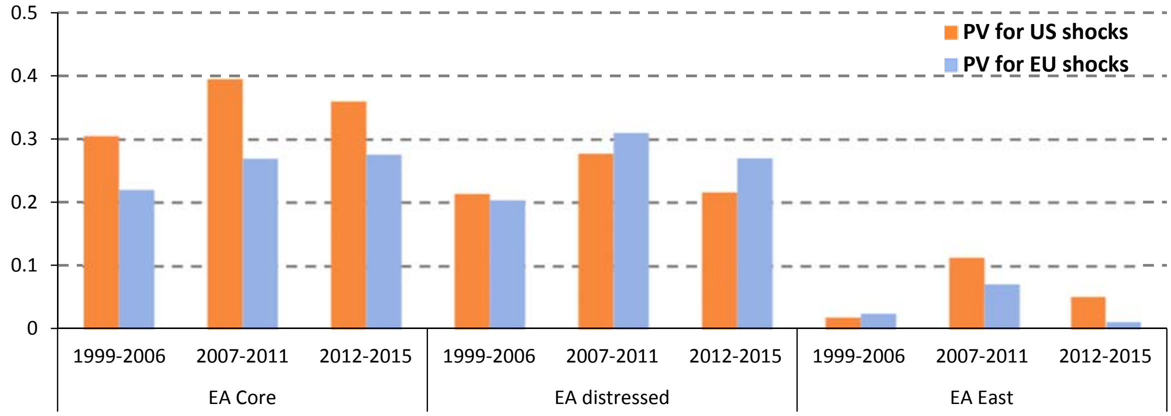


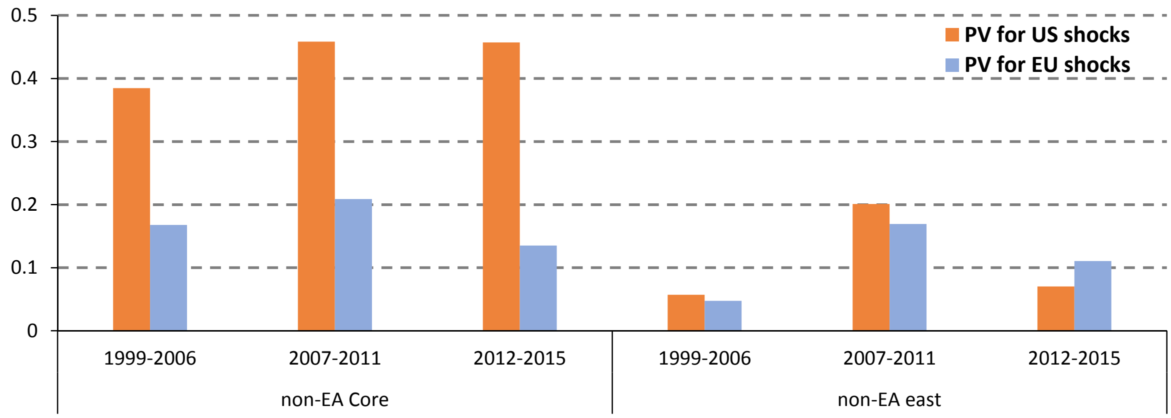


Note: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO).

Source: Bloomberg and JRC calculations.

Chart A2.5. Equity market integration based on the proportion of variance indicator (PV indicator). Average for each group of countries.

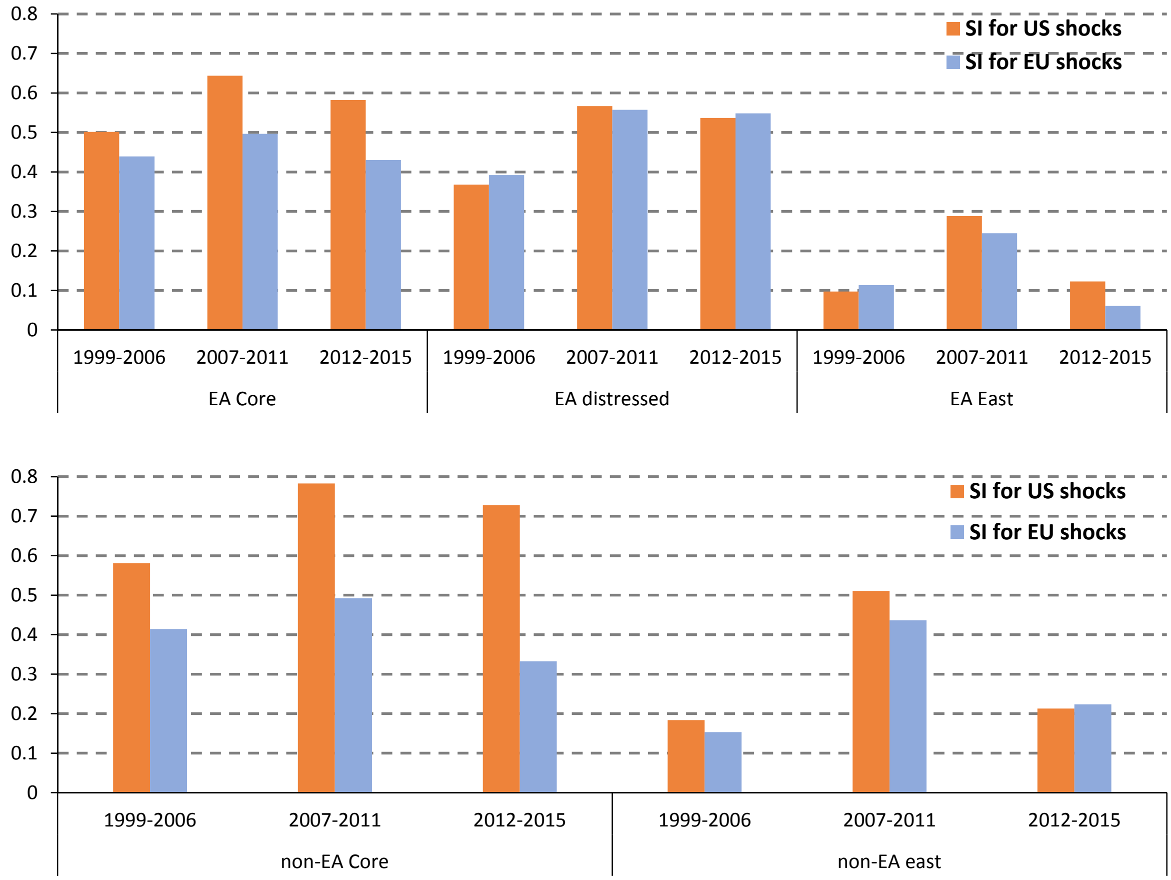




Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO). Benchmark indices: S&P500 and STOXX Euro 50.

Source: Bloomberg and JRC calculations.

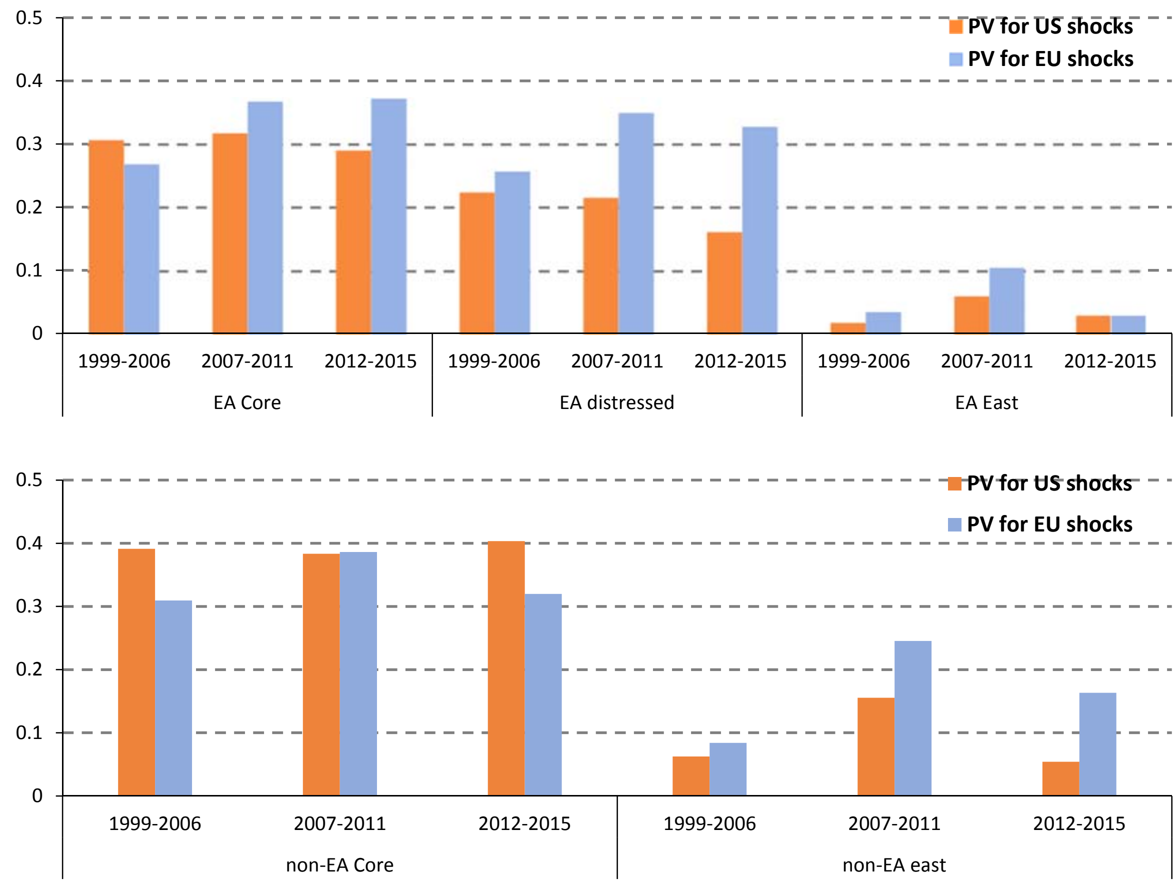
Chart A2.6. Equity market integration based on the spillovers intensity indicator (SI indicator). Average for each group



Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO). Benchmark indices: S&P500 and STOXX Euro 50.

Source: Bloomberg and JRC calculations.

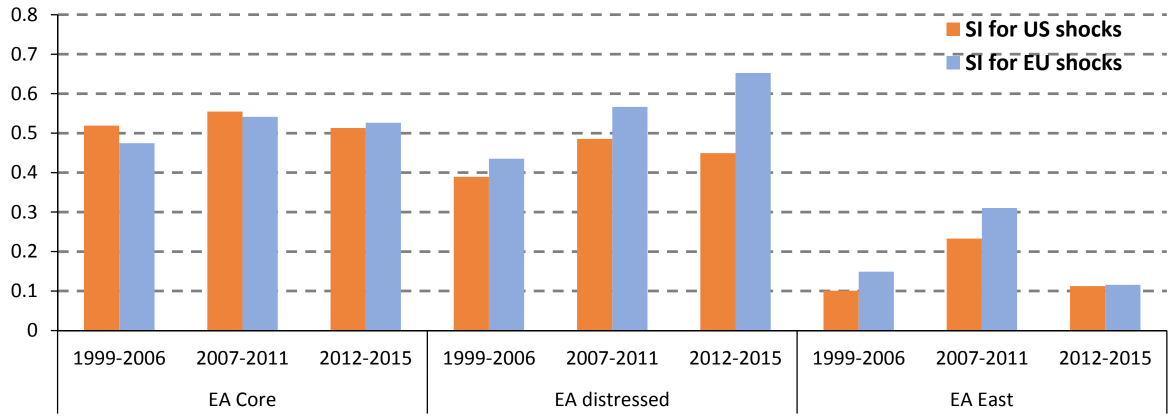
Chart A2.7. Equity market integration based on the proportion of variance indicator (PV indicator). Average for each group of countries.

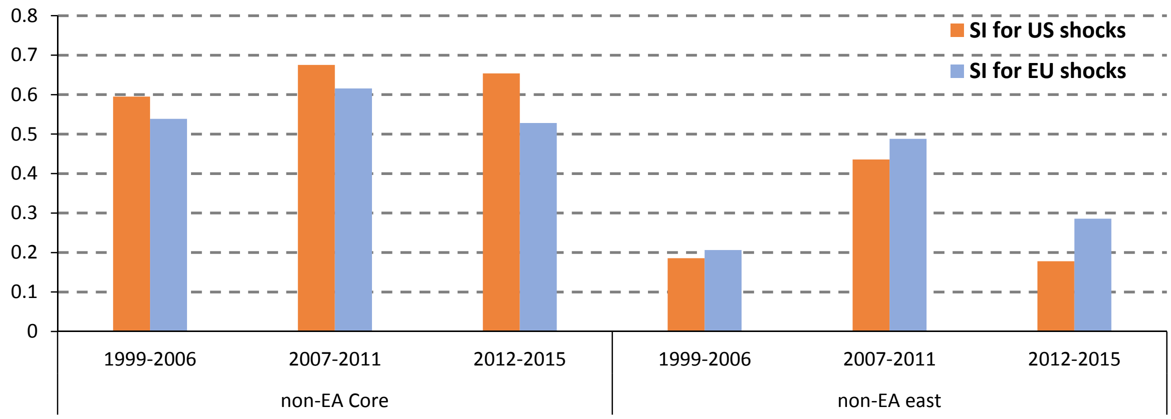


Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO). Benchmark indices: DJIA and STOXX Euro 600.

Source: Bloomberg and JRC calculations.

Chart A2.8. Equity market integration based on the spillovers intensity indicator (SI indicator). Average for each group

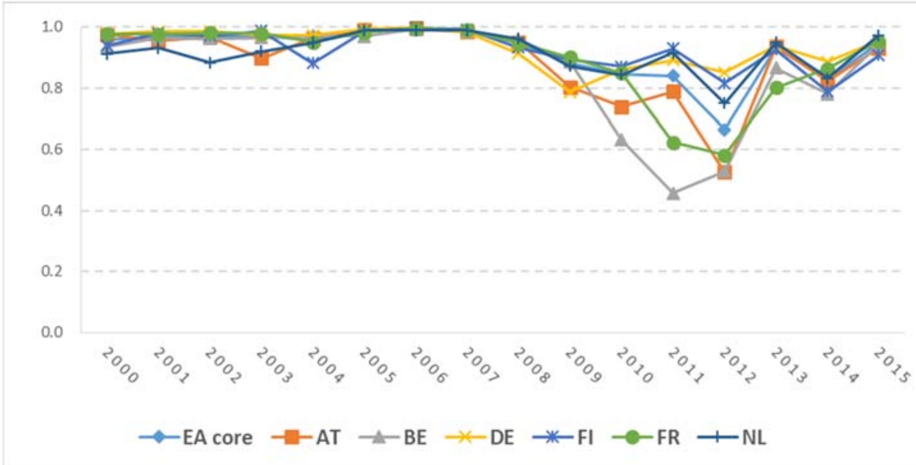


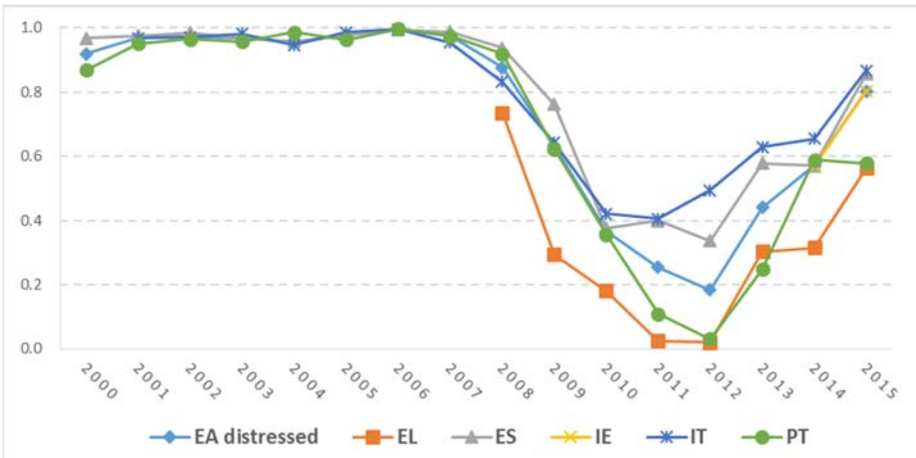


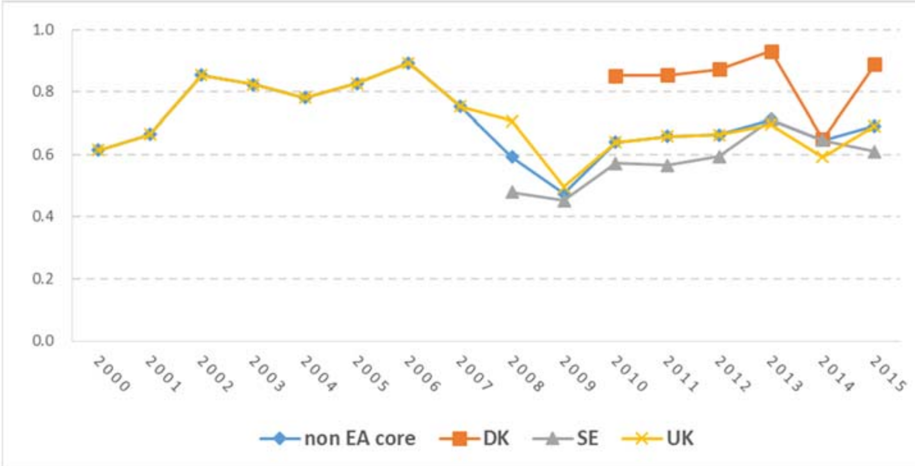
Notes: EA (Euro Area) core (AT, BE, FI, FR, DE, LU, MT, NL); EA distressed (CY, EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HR, HU, PL, RO). Benchmark indices: DJIA and STOXX Euro 600.

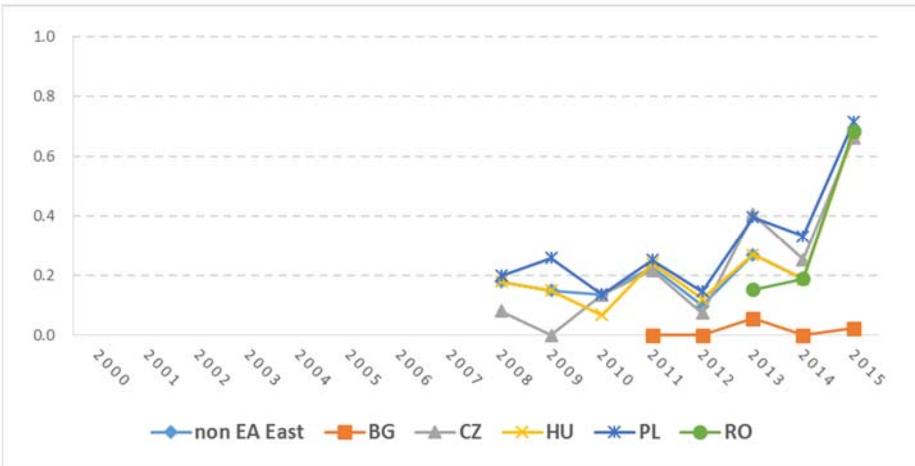
Source: Bloomberg and JRC calculations.

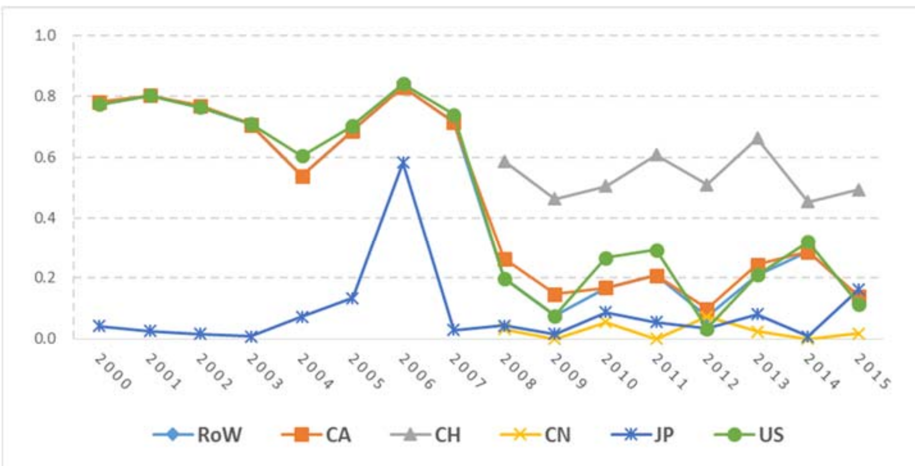
Chart A2.9. Sovereign bond market integration based on common factor portfolios by region (1 denotes integration, 0 absence of integration): country details.







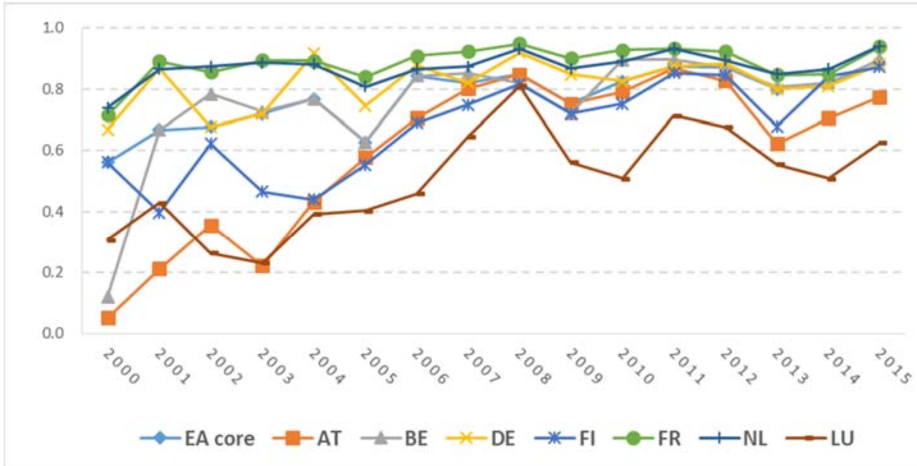


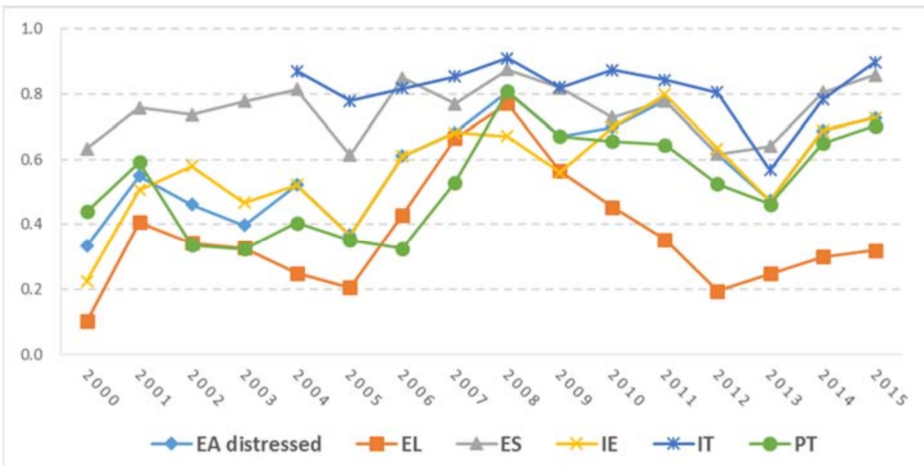


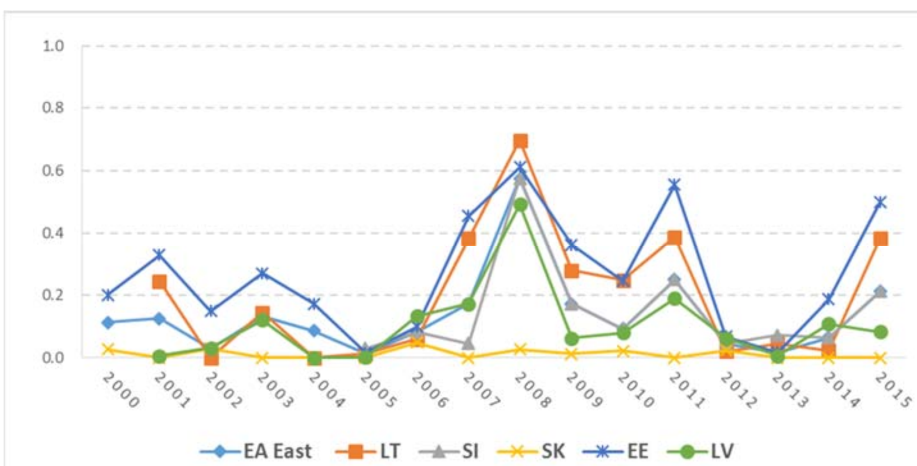
Note: adjusted R^2 for the following countries: EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). LU, MT, HR, CY, LV and EE are missing; other countries are not available for all the time period analysed.

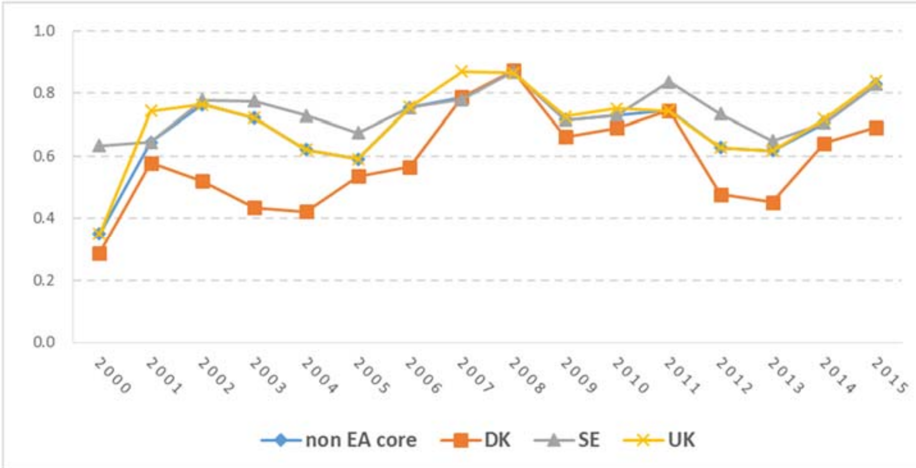
Source: Bloomberg and JRC calculations.

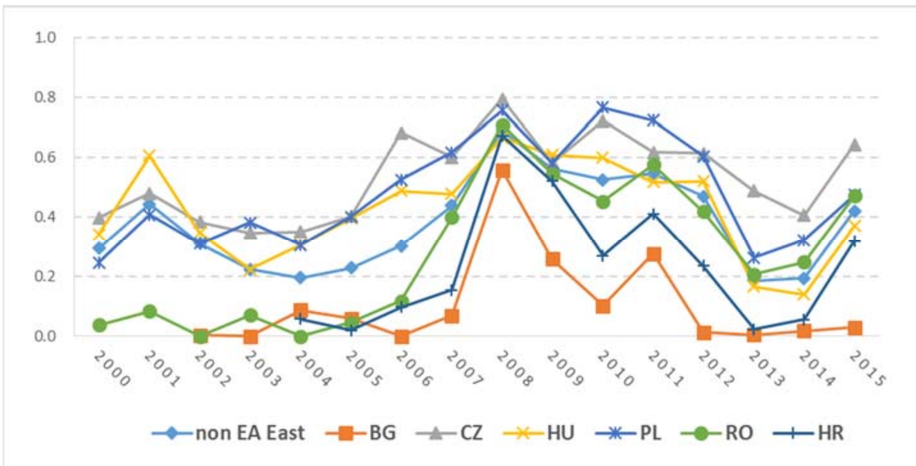
Chart A2.10. Equity market integration based on common factor portfolios by region (1 denotes integration, 0 absence of integration): country details.

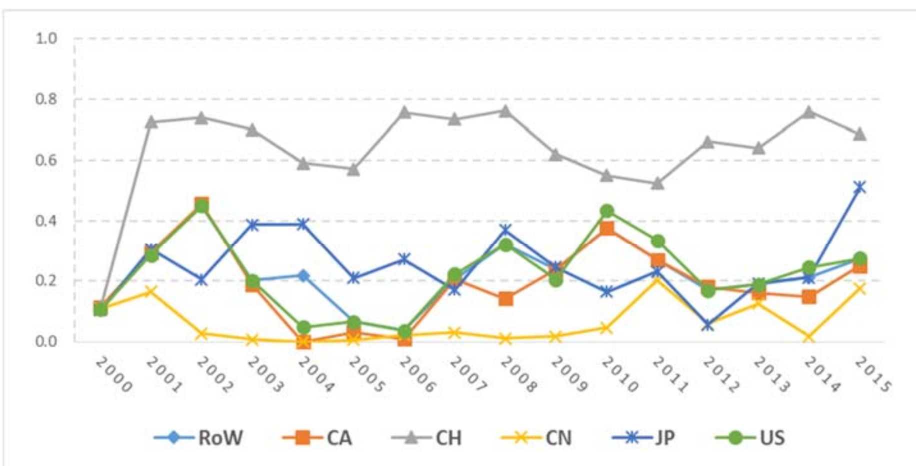












Note: adjusted R^2 for the following countries: EA (Euro area) core (AT, BE, FI, FR, DE, LU, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LT, LV, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, HR, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). MT and CY are excluded from the graph.

Source: Bloomberg and JRC calculations.

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