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Measuring financial integration in Europe: a price-based approach for equity and bond markets

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Abstract

We compute three possible measures based on the sensitivity of domestic European stock (sovereign bond) markets to global, US or European shocks. 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 method, based on common factor portfolios, 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 investigate the degree of co-movement. This technical report collects JRC contribution to the European Financial Stability and Integration Review (SWD(2016)146, Brussels 25 April 2016) in agreement with the Administrative Arrangement FISMA/2015/124/B2/ST/AAR.

1. Introduction

The traditional role of capital markets is that of channeling 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[1] 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.

We compute three possible 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

[1] Increased concentration of savings in institutional funds, i.e. mutual funds, pension funds, insurance companies, unit trusts and hedge funds.

markets that actually hit EU domestic markets and secondly domestic sensitivity to foreign shocks. The third method, based on common factor portfolios, 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 technical report collects JRC contribution to the European Financial Stability and Integration Review (EFSIR, SWD(2016)146, Brussels 25 April 2016) in agreement with the Administrative Arrangement FISMA/2015/124/B2/ST/AAR.

EFSIR provides a general view on how financial markets performed in 2015 and identifies indicators for monitoring trends in capital market and macroeconomic developments that are relevant to the key objectives in the Capital Markets Union Action Plan[2]. The Action Plan sets out a set of measures[3] to achieve a single market for capital in the European Union, with the aim of mobilising capital to foster economic growth and create jobs. CMU also aims at promoting financial stability by facilitating a more diversified set of funding channels, complementing the actions undertaken under the Banking Union[4] initiative.

The report is organised as follows. Section 2 presents the method based on correlation of stock market returns and Section 3 the method based on common factor portfolios. Section 4 concludes and the appendix details the data used.

[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

2. Proportion of variance and spillovers intensity in equity markets across EU28

2.1 The model

For all EU28 countries, we analyze to what extent the volatility of domestic equity returns is driven by US-originated shocks (used as a proxy for global factors) or by the volatility originated in the European market, 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 US and EU 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 reflect 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 the Appendix 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 US index returns $(R_{US,t})$ and European index returns $(R_{EU,t})$:

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

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

The orthogonalized residuals for US $(u_{US,t})$ and Europe $(u_{EU,t})$ 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.[5]

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

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

[5] 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).

where D_1, D_2 and D_3 are time dummies covering 1999-2006, 2007-2011 and 2012-2015 respectively.[6]

The residuals $(e_{c,t})$ of equation (2) follow an asymmetric GJR-GARCH(1,1)[7] process with $h_{c,t}$ being the conditional variance of the local shock.

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

$$\sigma_{c,t}^2 = h_{c,t} + (\beta_{c,2})^2 D_1\, \sigma_{US,t}^2 + (\beta_{c,3})^2 D_2\, \sigma_{US,t}^2 + (\beta_{c,4})^2 D_3\, \sigma_{US,t}^2 + (\beta_{c,5})^2 D_1\, \sigma_{EU,t}^2 + (\beta_{c,6})^2 D_2\, \sigma_{EU,t}^2 + (\beta_{c,7})^2 D_3\, \sigma_{EU,t}^2$$

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

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

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

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

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 generated shocks. As with the PV indicator, larger values of the SI imply larger degree of integration with the US or with the European markets.

2.2 Results

Chart 1 presents the proportion of US (European) equity shocks that hit domestic market returns for each time period under study.[8] 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 US and EU 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 DK, SE and UK the proportion of variance that could be explained by US-generated shocks is similar to that of the EA core

[6] For BG, HR, CY, LV, LT, SI 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.
[7] Glosten, L. R., R. Jagannathan, and D. E. Runkle, 1993.
[8] Results for the PV indicator at the country level are presented in Chart 5.

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.

Chart 1. Equity market integration based on the proportion of variance indicator (PV indicator). Average for the following countries: EA (Euro Area) core (AT, BE, FI, FR, DE, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (CZ, HR, HU, PL, RO).

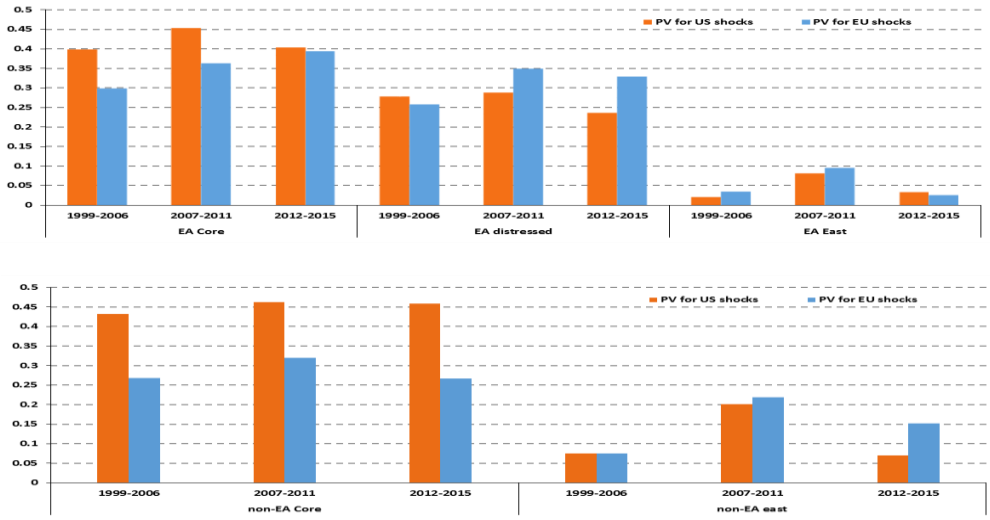


Chart 2. Equity market integration based on the proportion of variance indicator (PV indicator) for extra-EU countries (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

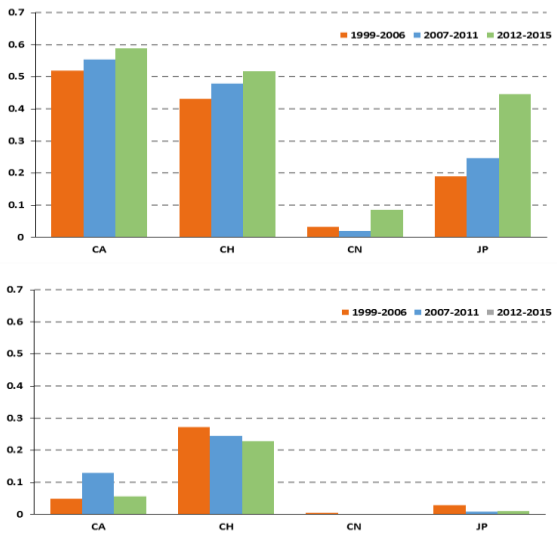
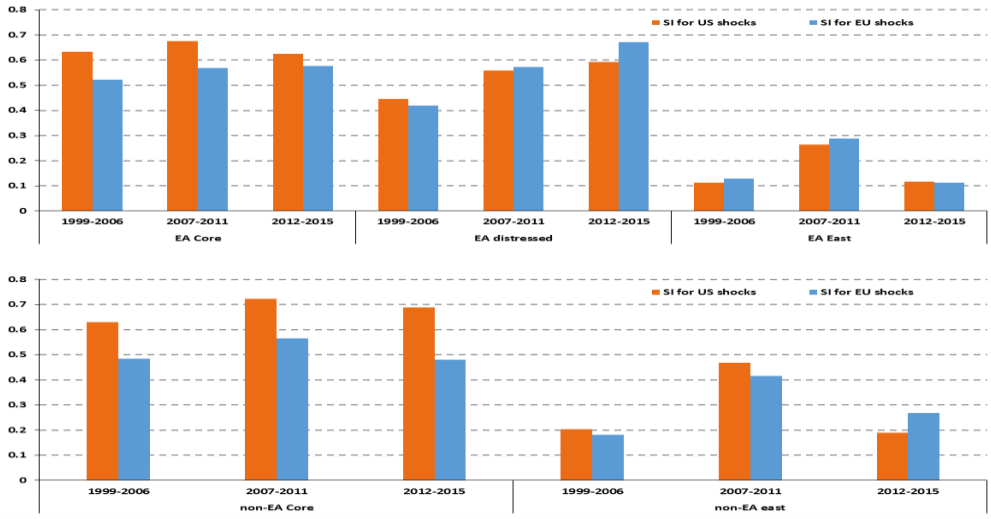


Chart 3 presents the results for the spillover indicator (SI).[9] The EU core countries (no matter the currency) appear to be more sensitive to global than European originating news. The reverse is true for distressed Euro area countries where the betas steadily increase over time reaching almost 70% over the recent EU sovereign crisis. Again Eastern countries results to be sensitive to US and EU 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 that to US originated ones.

Chart 3. Equity market integration based on the spillover intensity indicator (SI indicator). Average for the following countries: EA (Euro Area) core (AT, BE, FI, FR, DE, NL); EA distressed (EL, IE, IT, PT, ES); EA East (EE, LV, LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (CZ, HR, HU, PL, RO).



[9] Results for the SV indicator at the country level are presented in Chart 6.

Chart 4. Equity market integration based on the spillover intensity 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).

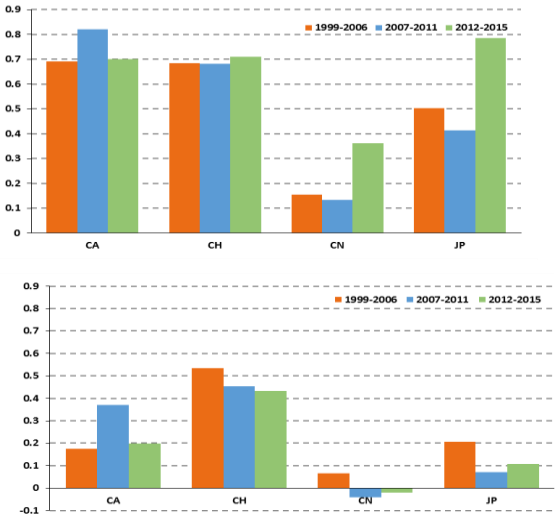


Chart 5. Equity market integration based on the proportion of variance indicator for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).

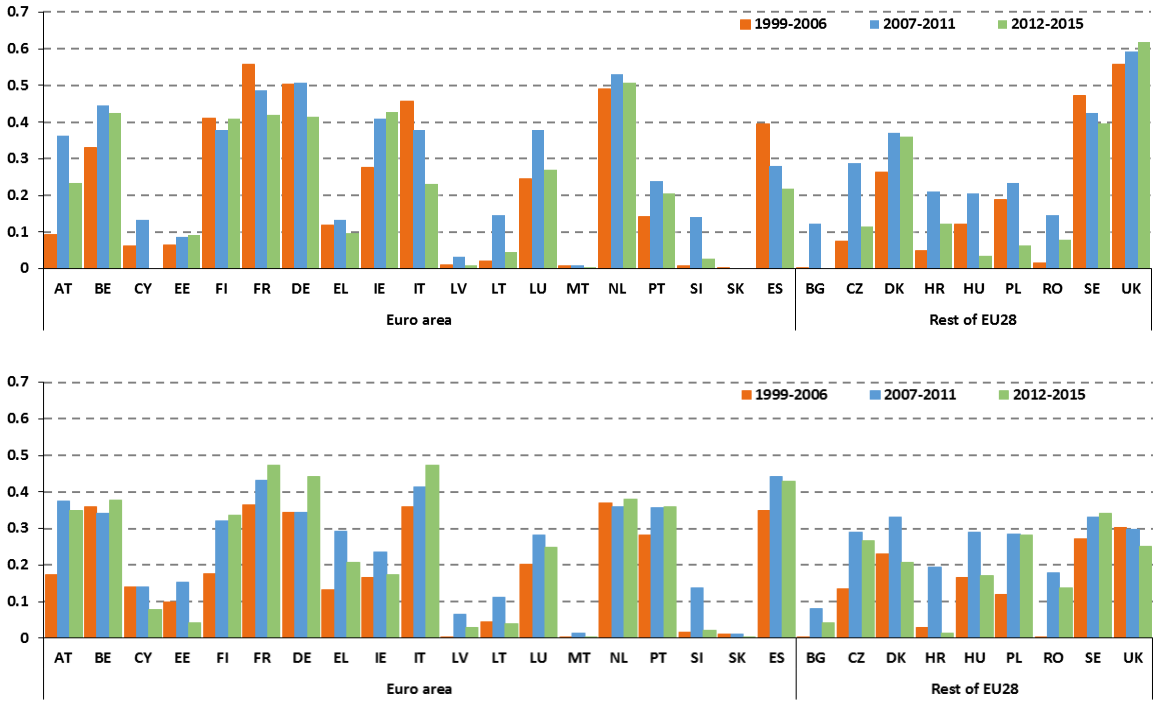
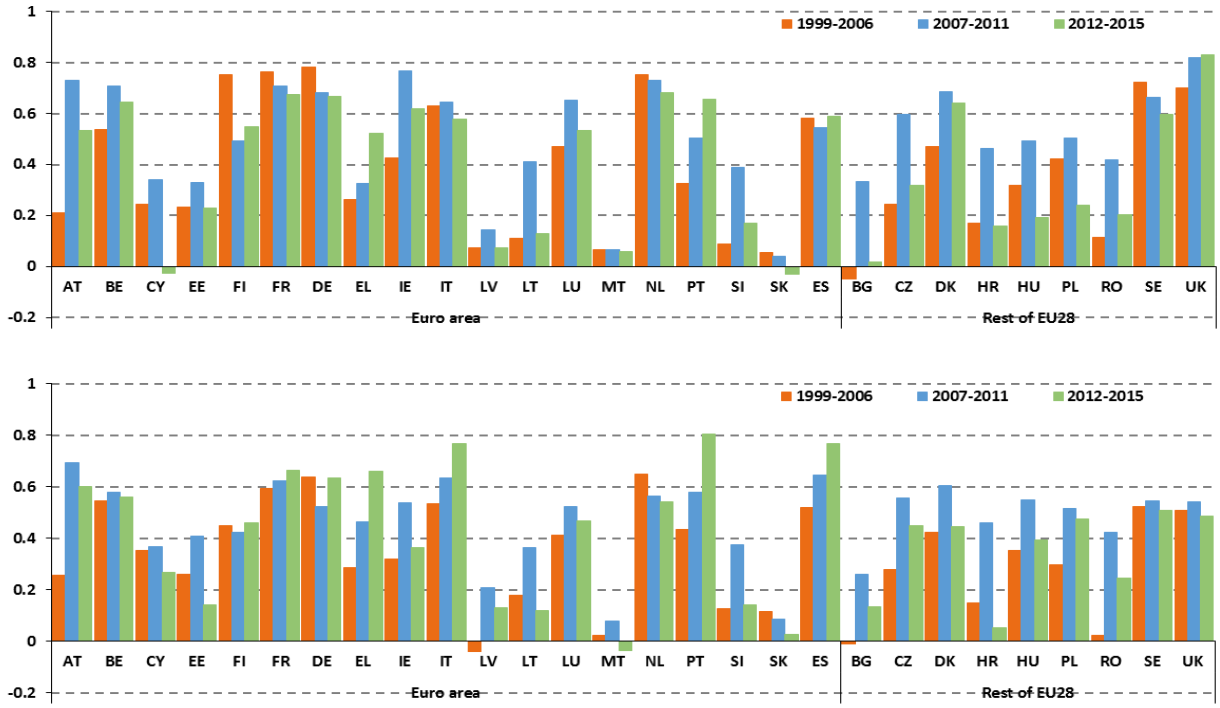


Chart 6. Equity market integration based on the spillover intensity indicator for EU28 (upper graph: the case of U.S. originated equity price shocks, lower graph: the case of European originated equity price shocks).



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

3.1 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 stock and sovereign bond markets worldwide. 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 integration.

The Appendix lists the stock exchange price indices used for the EU28 countries and Switzerland, China, USA, Canada and Japan. We selected those 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[10]. Daily trading data have been gathered from January 1, 1999 to December 4, 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):

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

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 PCA on all available observations of year *t* once excluded country C from the principal Component Analysis (henceforth PCA[11]). We will test the results of dropping the assumption of 3 factors in section 3.3. The return *R* for the trading date τ has been computed as follows[12]:

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

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

[10] Data are totally missing for LU, MT, and EE; HR, CY, LV have been excluded from the analysis due to missing data.
[11] I.T. Jolliffe, 2002. All computations have been performed in a Matlab environment.
[12] 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[13].

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[14]. 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[15] for the corresponding normalized data in (*t+1*), to have a sort of "out of sample" Principal Component[16]. 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[17]. An additional consequence for the bond data is the reduction in the number of countries available for the full analysis: DK, IE, NL, SI, and SK have to be partially eliminated as available data are discontinuous.

3.2 Results

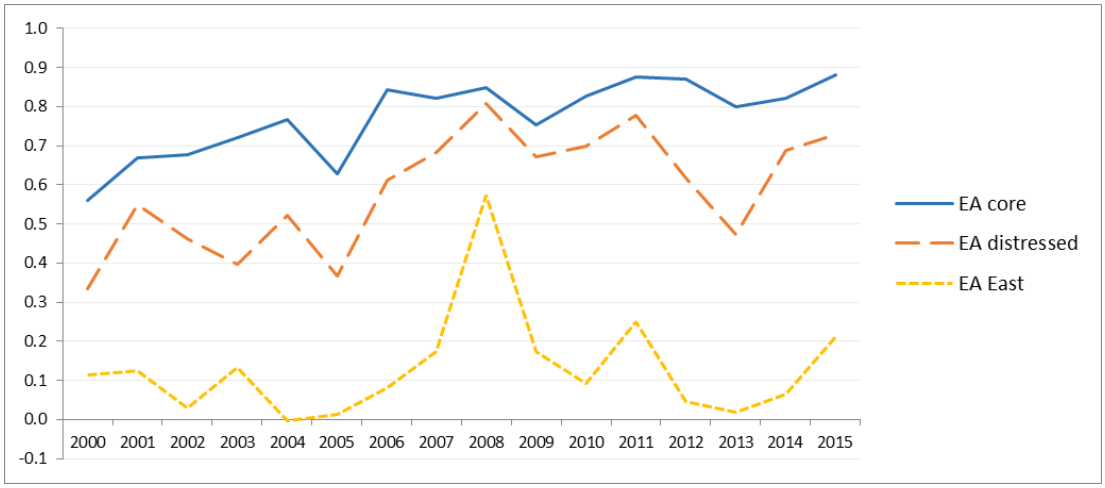
We estimate the common factor portfolios for the time period 2000-2015 and all EU28 countries adding also Switzerland, China, Japan, USA and Canada to account for international factors potentially influencing EU markets. The average (median) adjusted R^2 across groups of countries is exposed in Chart 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 in 2002-2004 (due to Ireland and Greece) and in 2013 triggered by the Greek sovereign crisis. *Non-EA core* countries (UK, SE, and DK) 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

[13] 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 $adjR^2$.
[14] This corresponds to using the correlation matrix when running the PCA. Notice that Pukthuanthong and Roll (2009) use instead the covariance matric for the calculation of PCA factors, while the ECB 2014 and 2015 does not specify the methodology used.
[15] Weights, in the words of ECB 2015.
[16] Scores, in the words of ECB 2015.
[17] 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).

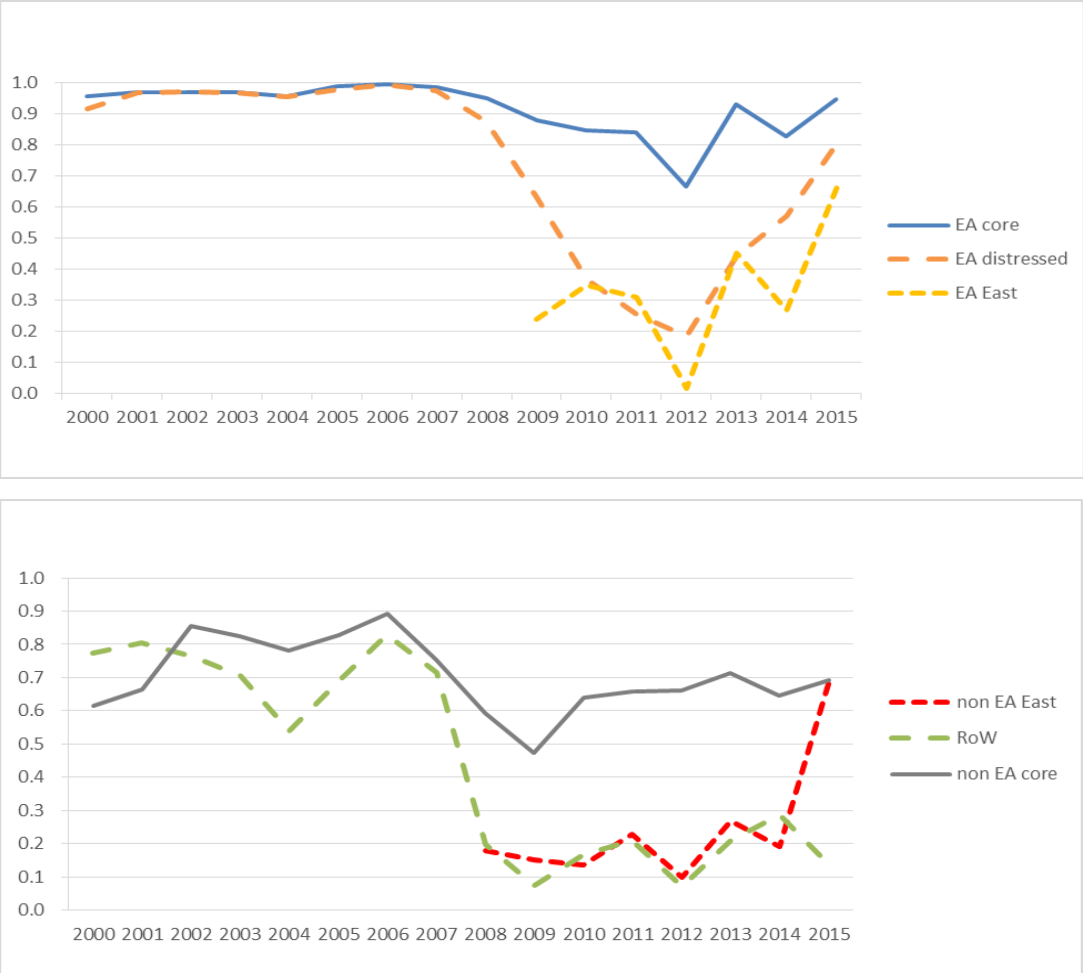
2008, global factors have little explanatory power. Czech Republic, Hungary, and Poland are somehow an exception as their adjusted R^2 is close to that of distressed Euro area group (details in the Chart 9). Global factors have particularly low explanatory power for Slovak Republic and Latvia in the 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 mainly capture European core markets dynamics.

Chart 7. Equity market integration based on common factor portfolios



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.

Chart 8. Bond market integration based on common factor portfolios



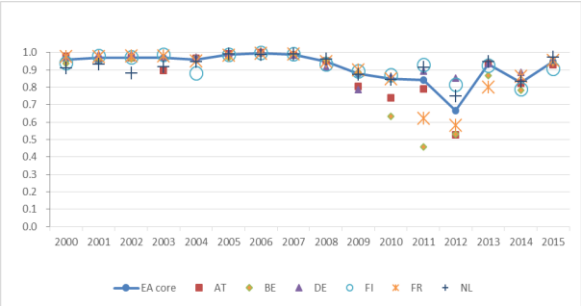
Note: median of adjusted R^2 for the following countries: EA (Euro Area) core (AT, BE, FI, FR, DE, NL); EA distressed (EL, IE, IT, PT, ES); EA East (LT, SK, SI); non-EA core (SE, DK, UK); non-EA east (BG, CZ, HU, PL, RO); RoW (CA, CH, CN, JP, US). MT and CY are excluded from the graph.

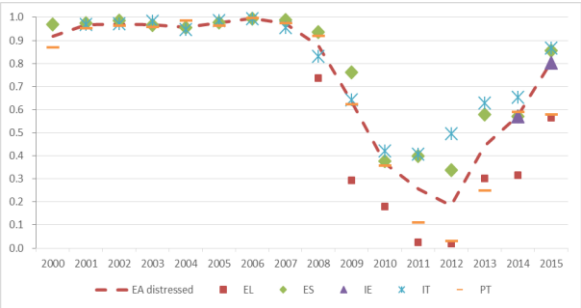
From 2000 to 2008 sovereign bond markets in Euro-area are well explained by common factor portfolios (Chart 8). For the *EA-distressed* countries, a major downward deviation occurs from 2008 to 2012, when the idiosyncratic reaction to the sovereign crisis in Greece, Portugal and Italy produces a drop 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

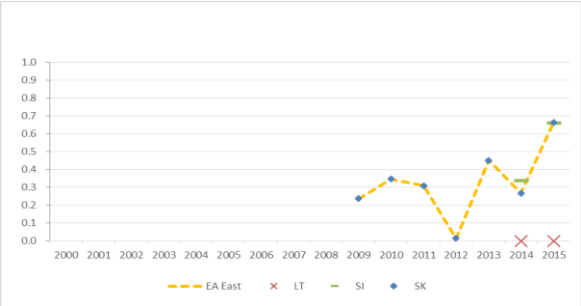
countries is not sensitive to EU global factors, scoring far below in terms of adjusted R^2. Chart 9 presents the detailed results.

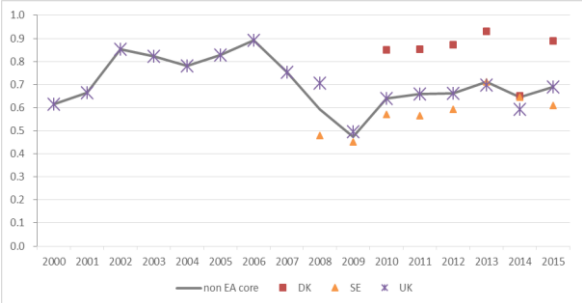
Chart 9. Equity and sovereign bond market integration based on common factor portfolios

Sovereign bonds

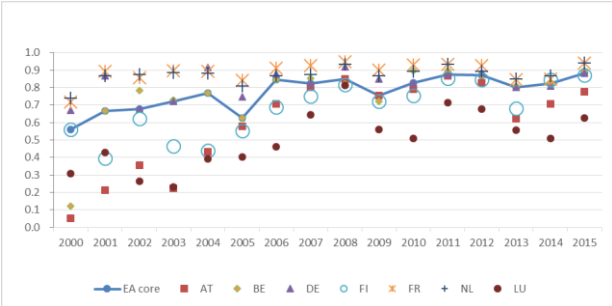


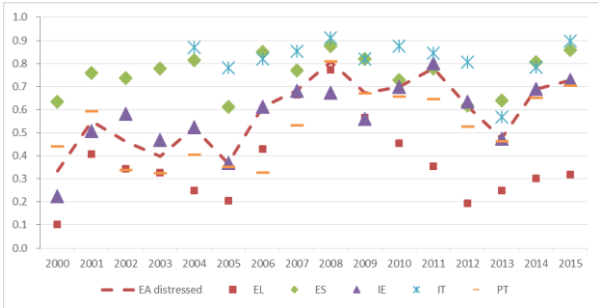


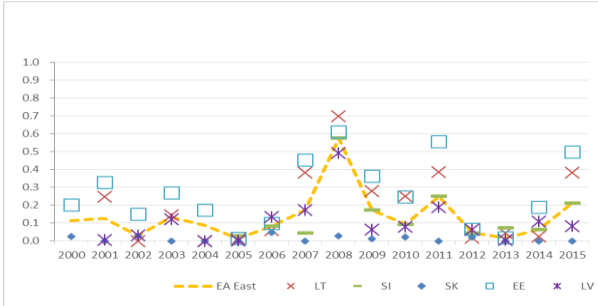


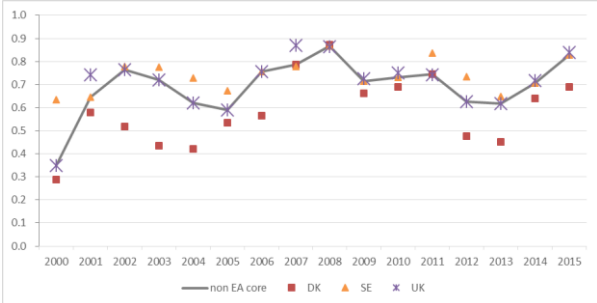


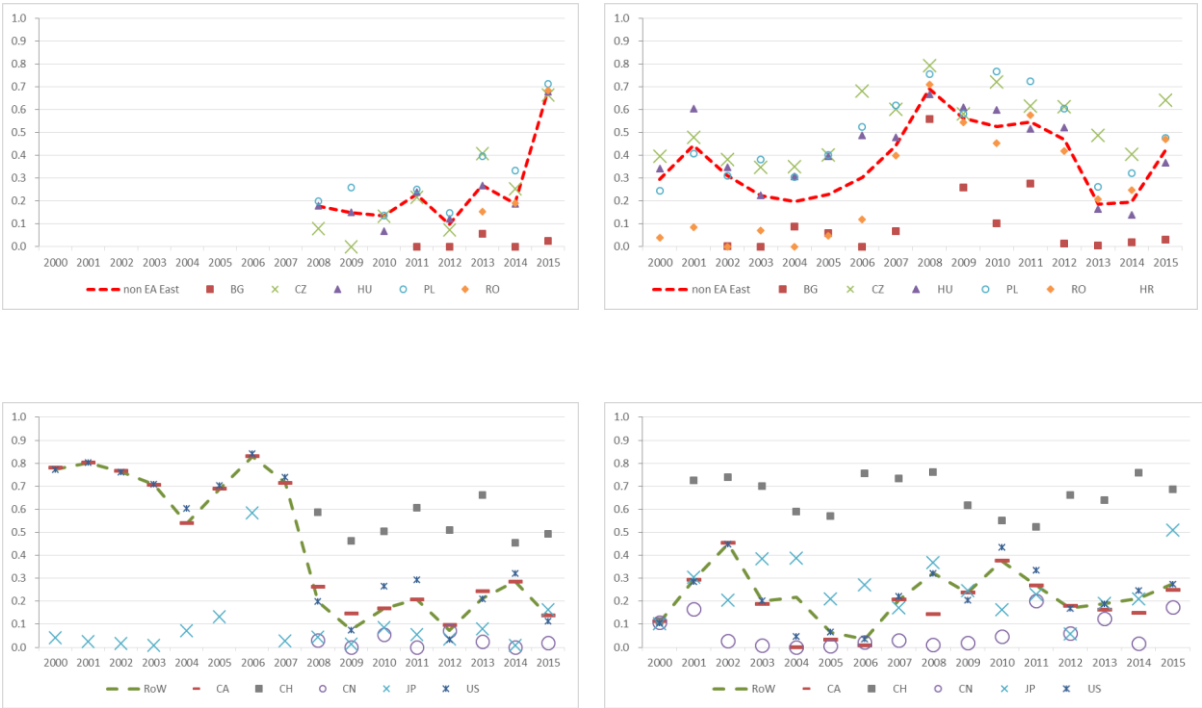
Equities











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.

3.3 Robustness checks

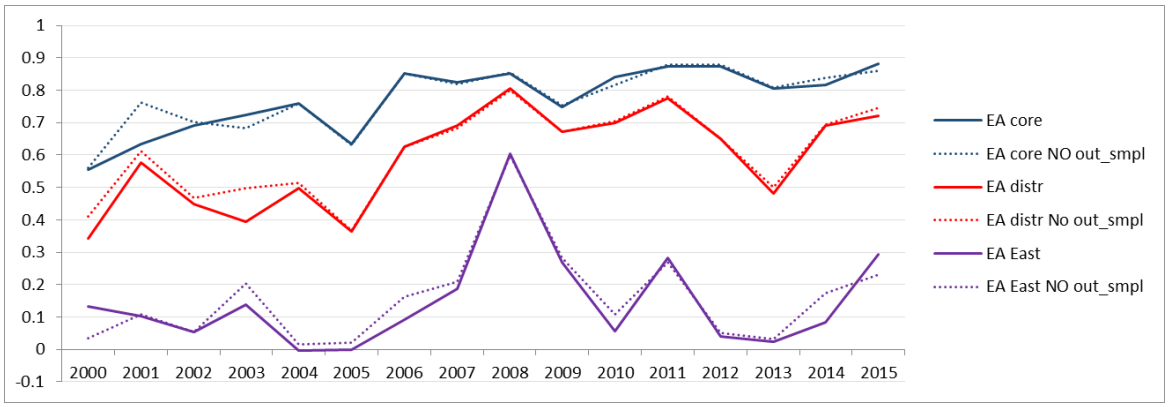
Two robustness checks have been carried out to verify the performance of common factor portfolio model for the bond and equity market. The first is related to the use of "out of sample" PCA. In order to make the best use of the available information the eigenvectors in time *(t)* are multiplied by the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

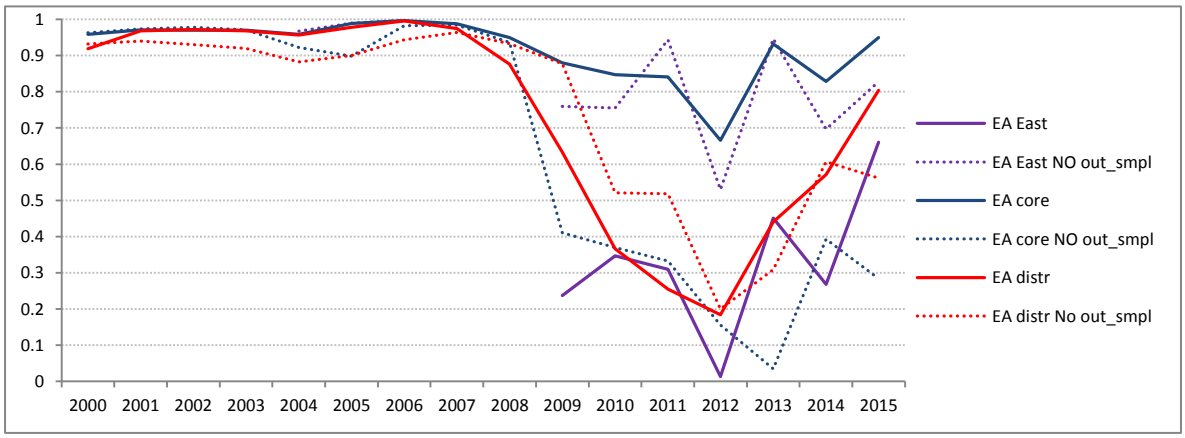
As displayed in Chart 10 results for equity markets are moderately affected from the "out of sample" assumption. For equities, the methodology used by Pukthuanthong and Roll (2009) and BCE (2014-15) produces a slight underestimation of the convergence that would be higher without the out-of-sample assumption. The largest differences are visible for the group of *EA East*, while the 2001 spike for the *Euro Area core* is due to AT, BE and FI. 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 (LT) and Ireland (IE). 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)*[18] 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. Median of adjusted R^2 for different sets of countries with and without the "out of sample" PCA .





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.

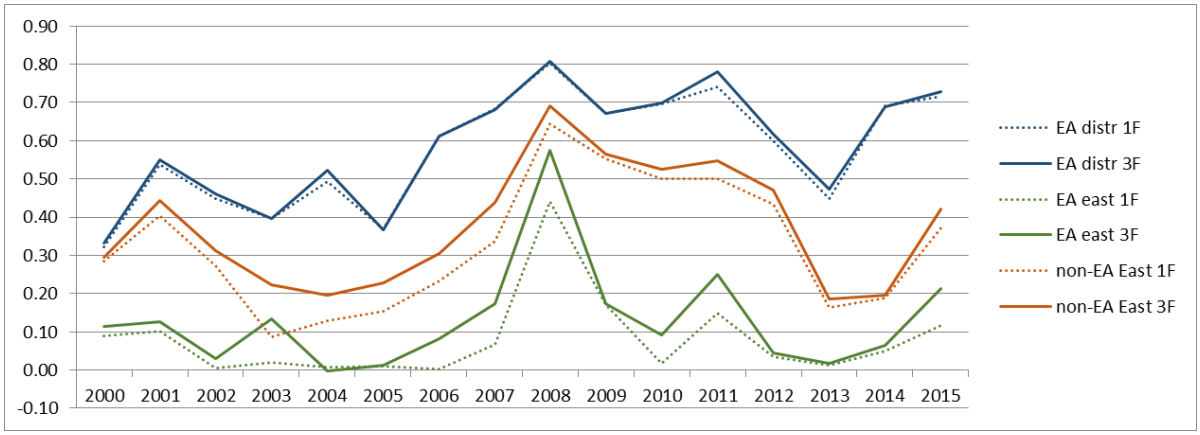
The yearly inspection of the three global factors obtained with the PCA highlights that the first factor (which usually takes about 40% to 60% of the total variance of the equity

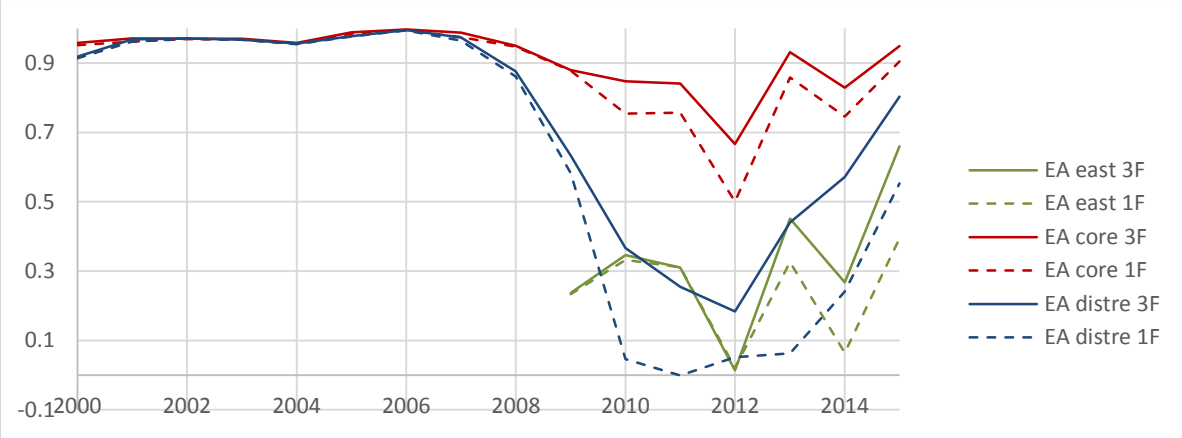
[18] This is the geometric interpretation of the out-of-sample assumption.

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 PL and HU 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 CA 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 (NL, DK, CZ, GB, SE, FR) from the main EA distressed countries (PT, IT, GR, ES) 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 HU, CZ, EE and LT 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.

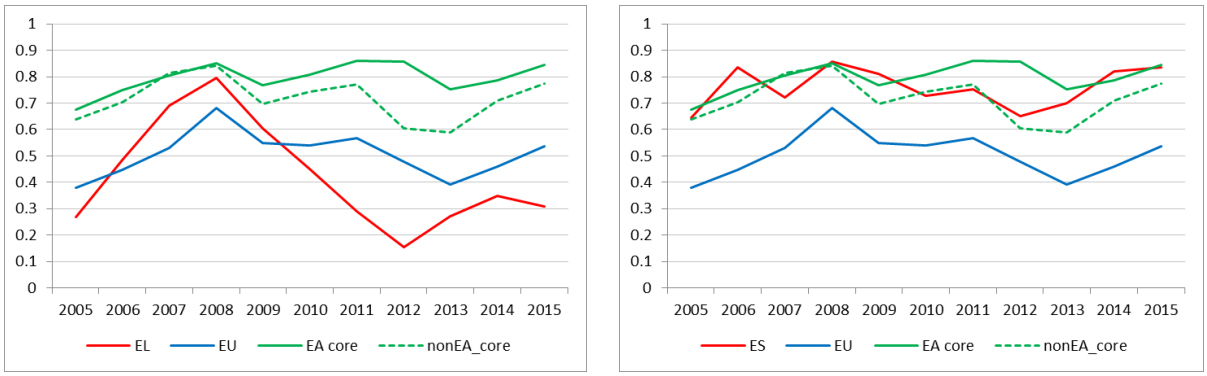
Chart 11. Comparison of results: equity (above) and bond (below) market integration based on common factor portfolios estimated from 1 or 3 factors for the following group of countries: *EA distressed*, *EA East*, *non-EA East*.



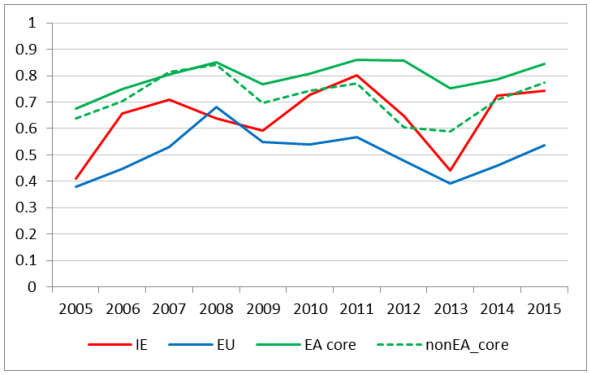


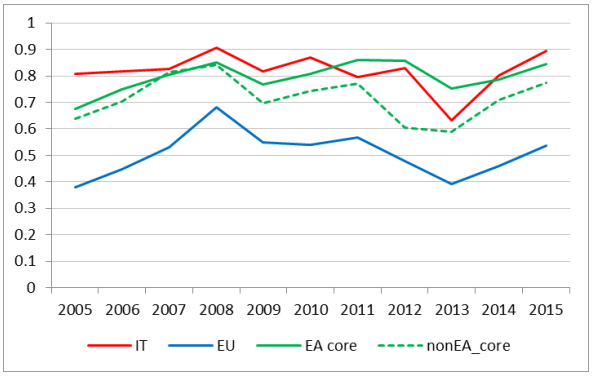
We propose an alternative and simpler way to have a first snapshot of country integration within the framework of a Principal Component Analysis. The squares of factor loadings, the communalities, calculated for the first factor and plotted for the available time span, can be seen as a measure of how each country *behaves* with respect to the EU common driver (representing the integration within EU) [19]. 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 2008 (especially in 2012 with the Greek turmoil) and the process of recovery (or lack of it for EL) 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 Financial Stability Facility in 2012.

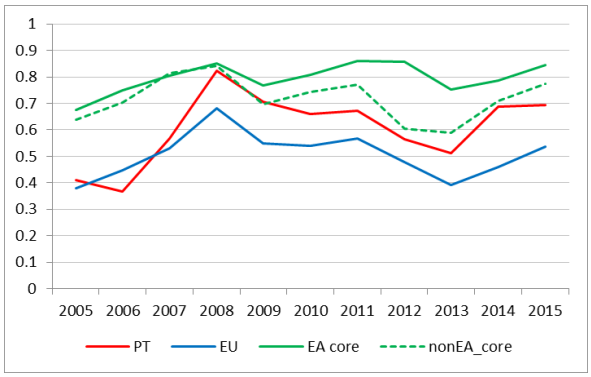
Chart 12. Equity market: communalities on the first factor of the PCA for EA distressed countries and comparison with *EU28*, *EA Core* (AT, BE, FI, FR, DE, LU, NL) and *nonEA_Core* (SE, DK, UK) countries.



[19] 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.







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[20]. For equity market, hierarchical clustering confirms the outlier status of SK, MT and CY and to some extent of EL, from the 2008 crisis (Chart 13). Clustering clearly shows 3 separated clusters the first grouping mainly EU28 core countries (AT, BE, FI, FR, DE, NL, IT, ES, SE and UK), the second grouping (LU, EL, IE, PT, DK, CZ, HU, PL) 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 (UK is slightly below the rest of EU countries). After 2008 cluster analysis supplies a richer picture with respect to equity market. While AT, BE, DK, FI, FR, DE, and NL cluster together on the top part of the graph, Spain and Italy but especially Greece and Portugal display decreasing trends. UK and SE single out for a stable trend and Eastern countries (CZ, HU, PL, SK) for idiosyncratic factors.

[20] 2005 is the first year for a complete dataset, so results are displayed from that date.

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.

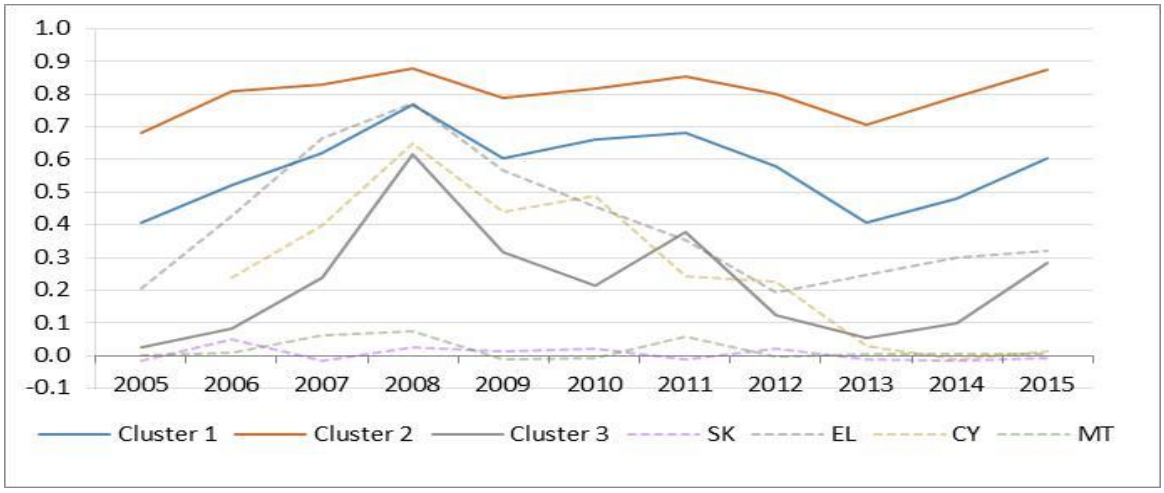
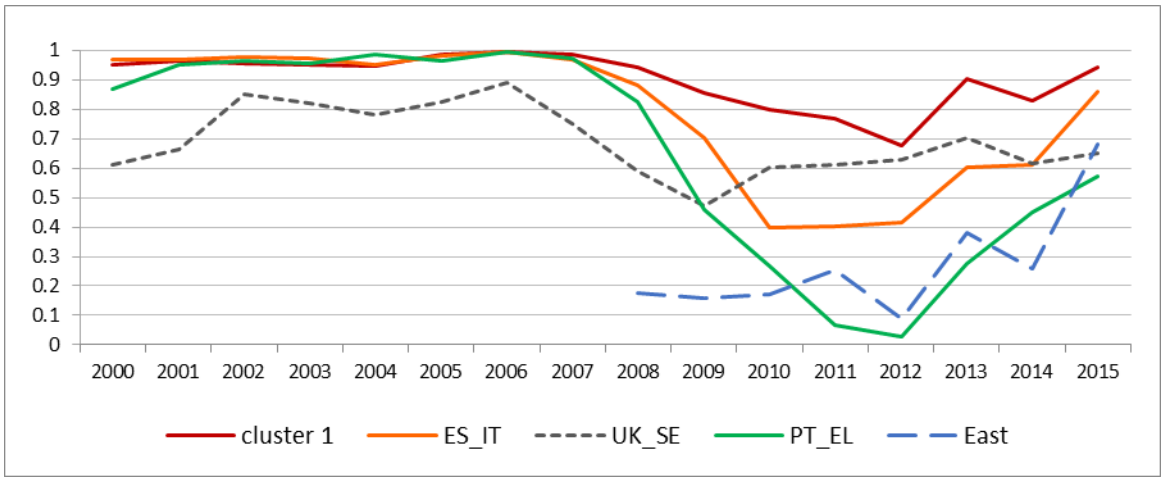


Chart 14. Bond market: Cluster analysis on the adjusted R2. Cluster 1: AT, BE, DK, FI, FR, DE, and NL; East: CZ, HU, PL, SK; SE and EL have data starting from 2008.



4. Conclusions

In this report we compute three possible measures of financial markets integration based on the sensitivity of domestic European stock and bond markets to global, US or European shocks. We implement the approach 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. We show that 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. For Denmark, Sweden and UK 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.

The third method, based on common factor portfolios, 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. Our results for the equity market indicate that Euro area distressed countries present lower integration for all the period analysed with the largest gaps appearing in 2002-2004 (due to Ireland and Greece) and in 2013 triggered by the Greek sovereign crisis. Denmark, Sweden and UK show patterns similar to core Euro Area countries 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. The disintegration phase after 2008 is much more evident in the bond market where idiosyncratic effects prevail especially for distressed Euro area countries. We also analyse the robustness of the common factor portfolio model analysing the implications of model assumptions in the results.

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Appendix

Table 1. List of stock market indices

Country		Index
Euro area	AT	AUSTRIAN TRADED ATX INDX
	BE	BEL 20 INDEX
	CY	GENERAL MARKET INDEX CSE
	EE	OMX TALLINN OMXT
	FI	OMX HELSINKI INDEX
	FR	CAC 40 INDEX
	DE	DAX INDEX
	EL	Athex Composite Share Pr
	IE	IRISH OVERALL INDEX
	IT	FTSE MIB INDEX
	LV	OMX RIGA OMXR
	LT	OMX VILNIUS OMXV
	LU	LUXEMBOURG LuxX INDEX
	MT	MALTA STOCK EXCHANGE IND
	NL	AEX-Index
	PT	PSI 20 INDEX
	SI	Slovenian Blue Chip Idx
	SK	SLOVAK SHARE INDEX
	ES	IBEX 35 INDEX
Rest of EU28	BG	SOFIX INDEX
	CZ	PRAGUE STOCK EXCH INDEX
	DK	OMX COPENHAGEN INDEX
	HR	CROATIA ZAGREB CROBEX
	HU	BUDAPEST STOCK EXCH INDX
	PL	WSE WIG INDEX
	RO	BUCHAREST BET INDEX
	SE	OMX STOCKHOLM 30 INDEX
	UK	FTSE 100 INDEX
RoW	CA	S&P/TSX COMPOSITE INDEX
	CH	SWISS MARKET INDEX
	CN	SZSE COMPONENT INDEX
	JP	TOPIX 500 INDEX
EU benchmark		STOXX Europe 600
US benchmark		S&P 500 INDEX

Table 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.

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