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Financial integration in the EU28 equity markets: Measures and drivers

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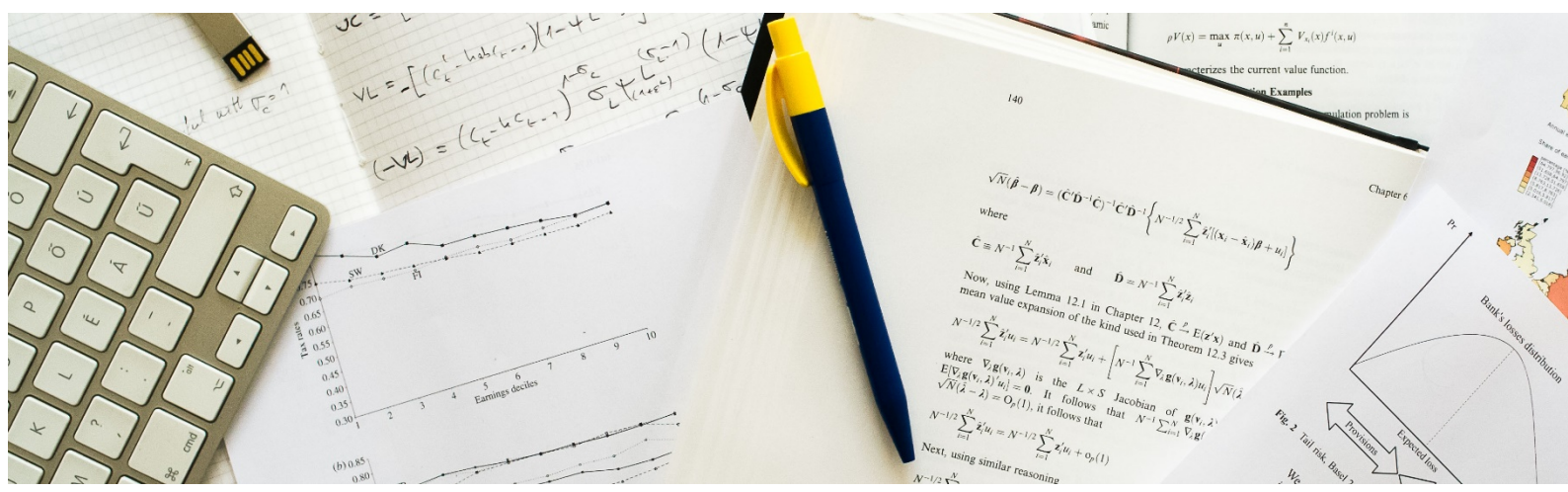
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Financial integration in the EU28 equity markets: measures and drivers

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Abstract

We examine time-invariant and time-varying market integration across European stock markets. Market integration has been increasing especially during the crisis period. Among others, market capitalization, technological developments and overall political uncertainty drive financial integration and systematic volatility, while macroeconomic variables do not impact idiosyncratic volatility. High market integration is associated with decreasing diversification benefit. During crisis periods investors select portfolios that are not explained only by firm characteristics.

JEL Classification: F3, C23.

Keywords: financial integration, equity markets, common factor approach, diversification benefits, drivers of integration

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1 Introduction

In Europe, the Economic and Monetary Union (EMU) has been an important driver for financial market liberalization (Berben and Jansen, 2009). Together with financial reforms, for example, the Financial Service Action Plan (1999), the directives and regulations for easing the trade of financial instruments (MIFID I 2004, MIFID II and MIFIR, 2014) and reducing the risk in financial operations (EMIR I 2012, EMIR II 2017) aimed to liberalize the financial market. Moving further towards a more integrated financial system, in 2012 the European Commission initiated the discussions for a banking union, while, in 2015 the Capital Markets Union action plan was put forward. We refer to the definition of financial integration introduced by the European Central Bank based on the idea that integration in a given market for financial instruments is achieved when all market participants with the same relevant characteristics: (i) face identical rules when they decide to deal with those financial products; (ii) have equal access to them and (iii) are treated equally when active in the market (see Baele et al., 2004). Financial integration definition is not unique and the literature proposes several frameworks in order to identify and measure it.

Our paper focuses on the European Union 28 (EU28) countries and contributes on the financial integration literature in various ways. First, we attempt to answer how the European integration process evolved over time, and, in particular after the introduction of the euro and during the financial and sovereign crisis. Are there any structural breaks present in the financial integration process? In order to answer to this questions, we provide an empirical application studying the co-movements of European stock market returns. From a theoretical point of view, we formalize the framework in Pukthuanthong and Roll (2009) assuming an approximate structure with latent factors for country index returns. Following Bai and Ng (2002), we define the number of latent common factor of returns, circumventing the heuristic inclusion of Pukthuanthong and Roll (2009). Moreover, we provide a methodological path to disentangle the integration level into the components of systematic and idiosyncratic volatilities. To our knowledge this is the first study that disentangle the two components from the integration index. A deeper understanding of the relationship, over time, between systematic and idiosyncratic volatilities with market integration could have important implications for investor decisions. For example, an investor might opt to avoid investing in a country that exhibits increased idiosyncratic volatility, although its integration levels are similar to a set of comparable countries. Our empirical findings provide evidence of time-varying integration index strongly positive correlated with the systematic volatility.

Second, we aim to answer what are the key determinants (i.e., macroeconomic and institutional factors) explaining financial integration, systematic and idiosyncratic volatilities, among European countries. Since our focus is on an harmonized market by policy actions, we do not consider institutional factors concerning, e.g., capital account openness or the legal origin, as for example in Lehkonen (2015). Moreover, as compared to other studies (see, e.g., Lehkonen, 2015), our interest is on the effect of the European sovereign crisis on

the integration process among the EU countries/regions. An additional contribution of this paper is that we study the factors explaining systematic and idiosyncratic volatilities. This offers useful economic insights to policy makers as the relevant policy measures to be taken in order to reduce these volatilities and increase market integration, could then be identified. We find that financial integration is mainly driven by macroeconomic variables, the level of development of the financial market, the overall political uncertainty, and technological developments. We show that these variables drive also the systematic volatility.

Finally, our paper contributes also to the portfolio diversification literature. We provide an empirical application to analyse how market integration implies a diversification benefit. Our methodological approach is similar to Cotter et al. (2019), where the authors provide empirical evidence of diversification benefits among cohorts of nations and across developed and emerging countries using multiple assets. Although our methodological steps are similar to Cotter et al. (2019), our goal is essentially different as we focus exclusively on a set of countries that are expected to be integrated by the definition of the Economic Monetary Union and through policy actions progressively implemented. We provide an empirical application studying a regime factor structure for 100 European portfolios from Kenneth French website. By mapping the regime-specific exposures to the weights of factor-mimicking portfolios, we analyse how the portfolios and the benefits of diversification change between the two regimes. In particular, we show that an European investor changes the asset allocation of its portfolio, reducing diversification benefits, during periods of high integration.

The paper is organized as follows. Section 2 formalizes the theoretical framework for the integration index and its components. Section 3 describes the data involved in the estimation of integration index. In section 4, we provide empirical results on the degree of integration among European equity markets, and robustness applications. In section 5, we analyse the drivers of financial integration and its components. Section 6 provides applications on portfolio allocation and on the benefits of diversification. Finally, Section 7 concludes.

2 Measuring integration

In this section, we provide an overview of the integration measures proposed in the literature. Then, we introduce our theoretical framework based on a linear model underlying the returns of stock indexes. Finally, we provide the definition of the integration index following Pukthuanthong and Roll (2009).

2.1 Overview of integration measures

Financial integration definition is not unique and the literature proposes several frameworks in order to identify and measure it.

A stream of literature measures financial integration on the basis of firms' and households' savings and investments decisions, essentially looking at "quantities" of savings,

investments, cross-border links. The seminal paper of Feldstein and Horioka (1980) looks at the relationship between domestic investments and savings. The idea is that under perfect integration at the world level, there should be no relation between domestic saving and domestic investment. Domestic savings would depend on worldwide opportunities and domestic investments would be financed by the worldwide pool of savings (see Blanchard and Giavazzi, 2002 for a comprehensive discussion). Darvas et al. (2015), instead, show for euro area countries a negative cross-country savings-investment correlation between 1999 and 2007, and a strong positive correlation in the period 2008-2014 (see also Hussain and Cleeton, 2017).

Along the same lines, an indirect way to look at integration barriers is measuring the extent of domestic consumption smoothing via cross-border links, namely risk sharing. If financial markets are indeed integrated, then in case of idiosyncratic shocks international markets would help to smooth domestic consumption by using cross-border channels. Pericoli et al. (2019) compute country measures of risk sharing for all the countries within the European Union showing that the cross-border capital markets are playing a small but increasing role in achieving risk sharing in case of domestic shocks. In the same vein, Volosovych (2011) shows that poor quality institutions are effective barriers to income insurance in case of country-specific shocks. Bai and Zhang (2012) find a similar result considering default risk as an implicit barrier to international risk-sharing. The importance of institutions in explaining international links is also found by Kalemli-Ozcan et al. (2010), who identify the removal of currency risk as the main driver of integration in euro area countries after the introduction of common currency. However, cross-border locational financial statistics are limited or very difficult to compile, making the analysis of cross-border investment flows rather cumbersome.

Another stream of literature offers measures based on 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 market 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. Notice that the definition of integration given above actually encompasses the law of one price: if the law of one price holds then no arbitrage opportunities can arise and market participants will be unconstrained by rules and access conditions. If the financial investment is non-discriminatory then investors will be free to exploit any arbitrage opportunity restoring the law of one price (Baele et al., 2004). 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).

The idea that co-movements of stock market returns are indicators of integration dates back to the 1990s with King et al. (1994); Lin et al. (1994), and later on with Longin and Solnik (2001) and Kearney and Lucey (2004). Since then, a large body of literature provides

results showing that measures of co-movement such as the correlation across markets are actually a poor measure of financial integration. Carrieri et al. (2007); Pukthuanthong and Roll (2009); Billio et al. (2015) show that the correlation coefficient tends to underestimate the integration degree. Carrieri et al. (2007) provide, instead, a generalized autoregressive conditional heteroskedasticity (GARCH) method to study the evolution of market integration. They show that correlations between country and world returns are significantly lower than estimated integration indices based on real activity. Pukthuanthong and Roll (2009) instead provide an integration measure based on the explanatory power of a multi-factor model. They propose to identify a set of common factors that can be interpreted as integration drivers across a set of countries (see also Berger et al., 2011; Berger and Pukthuanthong, 2012). With this approach financial integration is measured as the proportion of domestic returns that can be explained by common factors. If this proportion is small, then the domestic return is dominated by local influences. Otherwise, the country is considered being integrated. In the next section, we opt to develop our theoretical framework introducing the measure of integration provided by Pukthuanthong and Roll (2009). This definition of integration allows us to disentangle the risk components affecting the asset returns.

2.2 Theoretical framework

Let us define the daily stock index return $R_{c,t}$ at date $t = 1, \dots, T$, for each country c with $c = 1, \dots, C$. Daily returns $R_{c,t}$ are affected by two components of risk: a systematic and an idiosyncratic component. The idiosyncratic risk is country-specific, is residual and is approximately zero for each country c . On the opposite, systematic risk includes a set of common factors that characterize the returns of a group of countries. In order to model the daily returns of stock index, we introduce a linear model with latent factors. As in Pukthuanthong and Roll (2009), we identify a set of common factors that can be interpreted as integration drivers (see also Berger et al., 2011; Berger and Pukthuanthong, 2012).

Let us assume that the return $R_{c,t}$ satisfies the factor structure

$$R_{c,t} = \beta_c' F_t + \varepsilon_{c,t}, \quad (1)$$

where β_c is a vector of factor loadings, F_t is a vector of r common factors so that $\beta_c' F_t = \beta_{c,1} F_{t,1} + \dots + \beta_{c,r} F_{t,r}$, and $\varepsilon_{c,t}$ is the idiosyncratic term.¹ The markets are perfectly integrated when their assets returns are completely and exclusively driven by the same global factors F_t . If the returns of a group of countries are explained by the same global influences, there is a high degree of integration. On the opposite, if the degree of integration is low, returns should be explained by local factors (see, e.g., Stulz, 1981, 1987; Errunza and Losq, 1985).

¹The factor structure holds on converted returns in a common currency as shown is Solnik (1983).

By stacking the returns, we have $R_t = [R_{1,t}, \dots, R_{C,t}]'$ and

$$R_t = BF_t + \varepsilon_t, \quad (2)$$

where $\varepsilon_t = [\varepsilon_{1,t}, \dots, \varepsilon_{C,t}]'$ are $C \times 1$ vectors, and $B = [\beta_1, \dots, \beta_C]'$ is a $C \times r$ matrix. The r factors F_t are not directly observable.

We impose the standard conditions on matrices F_t and B in linear latent factor models:

(i) matrix $\frac{1}{T} \sum_t F_t F_t'$ converges to a positive definite matrix Σ_F , (ii) $\mu_r \left(\frac{1}{C} \sum_c \beta_c \beta_c' \right) \geq M$

w.p.a. 1 as $C \rightarrow \infty$ for a constant $M > 0$, where $\mu_r(\cdot)$ denotes the r -th largest eigenvalue of a symmetric matrix. These assumptions ensure a consistent estimator of B . Assumption (i) provides an identification condition of B . Assumption (ii) ensures that each factor has a nontrivial contribution to the variance of R_t . These assumptions correspond to the Assumptions A and B in Bai and Ng (2002) (see also Bai, 2009).

Let Σ_ε denote the $C \times C$ conditional variance-covariance matrix of the error vector ε_t . Importantly, we impose an approximate factor structure for the error terms, i.e. the largest eigenvalue of Σ_ε is bounded as C approaches infinity (see Assumption C in Bai and Ng, 2002 and Assumption APR.3 in Gagliardini et al., 2016, see also Chamberlain and Rothschild, 1983). This assumption of weak cross-sectionally dependence allows for a block cross-sectional dependence between returns of stock index countries that belong, for example, in the same currency zone. In this framework, the vector F_t and the errors ε_t are weakly correlated, as shown in Bai and Ng (2002). This ensures that each of the r factors represents a pervasive source of systematic risk of returns.

Pukthuanthong and Roll (2009) propose to measure the degree of integration based on the fraction of unexplained variance, namely the coefficient of determination of the linear multi-factor model in Equation (1) with estimated factors, indeed the integration index depends on factor volatilities and their factors loadings. In our setting, the daily returns of the market indexes $R_{c,t}$ are not observed for the all same dates in the several countries, we introduce an indicator function $I_{c,t}$. This indicator assumes values one if the return of country c at date t is observed, and zero otherwise (Connor and Korajczyk, 1987). We define $T_c = \sum_t I_{c,t}$ the number of daily observations available for the index market of country c .

For each country c , we get the integration index

$$\rho_{c,adj}^2 = 1 - \frac{T_c - 1}{T_c - r} (1 - \rho_c^2), \quad \text{with } \rho_c^2 = \frac{ESS_c}{TSS_c}, \quad (3)$$

where the explained sum of squared return is $ESS_c = \sum_t I_{c,t} (\hat{R}_{c,t} - \bar{\hat{R}}_c)^2$ and the total

sum of squares is $TSS_c = \sum_t I_{c,t} (R_{c,t} - \bar{R}_c)^2$, with $\hat{R}_{c,t} = \hat{\beta}_c' \hat{F}_t$, $\bar{\hat{R}}_c = \frac{1}{T_c} \sum_t I_{c,t} \hat{R}_{c,t}$ and

$$\bar{R}_c = \frac{1}{T_c} \sum_t I_{c,t} R_{c,t}.$$

Let us define the following two components: (i) the systematic volatility

$$SystVol_c = \sqrt{\left(\frac{ESS_c}{T_c}\right)}, \quad (4)$$

and (ii) the idiosyncratic volatility

$$IdiVol_c = \sqrt{\left(\frac{RSS_c}{T_c}\right)}, \quad (5)$$

with $RSS_c = \sum_t I_{c,t} \hat{\varepsilon}_{c,t}^2$ and $\hat{\varepsilon}_{c,t} = \hat{R}_{c,t} - R_{c,t}$. Then, the R -squared in Equation (3) can be written as:

$$\rho_c^2 = \frac{SystVol_c^2}{SystVol_c^2 + IdiVol_c^2}, \quad (6)$$

and is positively affected by the proportion of systematic risk.² This notation allows us to identify the components of risk that affect the cross-country returns quantifying the proportion of variance explained by the r common factors. A proportional increase of systematic and idiosyncratic volatilities does not affect the integration index.

3 Market Data

Our empirical analysis is based on stock exchange price indexes for 28 EU countries downloaded from Bloomberg. We get an unbalanced dataset of daily continuously compounded returns that covers the period from 1st January 1999 to 30th June 2019. The Eurozone was established with the official launch of the euro (alongside national currencies) on 1st of January 1999, thus we consider this event as the starting date of the sample. Table 1 contains the list of indexes involved in our empirical application. We distinguish between four regions: (i) euro area core (EA-core), (ii) distressed euro area (EA distressed), (ii) rest of EA area, and (iv) non-euro area (non-EA) countries.³ Distressed euro area includes the countries that were mostly affected by the sovereign debt crisis (see, e.g., Lane, 2012). For some countries (i.e., Cyprus, Latvia, Lithuania, Bulgaria, Slovenia and Croatia), data are available later than January 1999. In order to include them in the analysis, and to avoid

²See Gagliardini et al. (2016).

³Analysing the pairwise correlation indexes across countries by ordering the countries w.r.t. the four regions in which they belong (i.e., EA-core, EA distressed, rest of EA countries and the non-EA countries), we get evidence of a correlation matrix with a block structure, i.e., we observe different degree of correlation between and among the regions. This justify the choice to provide an analysis distinguishing between four regions. In particular, the correlation among the EA-core and EA distressed is positive and high, while the rest of the EA countries (EE, LV, LT, MT, SK and SI) show a low correlation among them and between the rest of EU28. UK is highly and positively correlated with EA-core and EA distressed.

cumbersome computation due to unbalanced panel, we provide two separate analysis. The first one includes the 22 European countries for which data are available from 1st January 1999; the second one is performed on 28 European countries starting from 1st September 2004.⁴

Table 2 reports the descriptive statistics for the returns of the indexes. Statistics are reported from January 1999 for the 22 countries and from September 2004 for the 28 countries (reported in italics). The EA distressed countries are characterized by large negative returns w.r.t. the other countries. Comparing the two subsamples over time and focusing on EA-core, the average returns become positive and larger in the second subsample. However, if we consider the EA distressed, the average returns are negative and slightly more leptokurtic in the second subsample (see, e.g., Greece and Spain). For the non-EA countries, the mean of returns is in general positive across the two subsamples. The only exception is UK, that has a distribution similar to one for the EA-core countries. In general, normality tests are rejected for all countries. Indeed, data show a high level of kurtosis.

⁴We report the empirical results concerning the EU 28 countries in Section 4.1.

Table 1: List of stock market indexes. For each index, the table reports the reference country, the ISO code and the classification of the country w.r.t. the euro area (EA). The countries are distinguished between EA-core, EA distressed and rest-EA. Distressed euro area includes the countries that were mostly affected by the sovereign debt crisis. The table also reports the starting date of available data.

Index	Country	ISO code	Classification	Starting date
ATX Index	Austria	AT	EA-core	4-Jan-99
BEL20 Index	Belgium	BE	EA-core	4-Jan-99
HEX INDEX	Finland	FI	EA-core	4-Jan-99
CAC INDEX	France	FR	EA-core	4-Jan-99
DAX INDEX	Germany	DE	EA-core	4-Jan-99
LUXXX INDEX	Luxemburg	LU	EA-core	4-Jan-99
AEX INDEX	Netherlands	NL	EA-core	4-Jan-99
ASE INDEX	Greece	GR	EA distressed	4-Jan-99
ISEQ INDEX	Ireland	IE	EA distressed	4-Jan-99
FTSEMIB INDEX	Italy	IT	EA distressed	4-Jan-99
PSI20 INDEX	Portugal	PT	EA distressed	14-Jan-99
IBEX INDEX	Spain	ES	EA distressed	1-Apr-99
CYSMMAPA Index	Cyprus	CY	rest-EA	3-Sep-04
TALSE Index	Estonia	EE	rest-EA	4-Jan-99
RIGSE INDEX	Latvia	LV	rest-EA	1-Mar-00
VILSE INDEX	Lithuania	LT	rest-EA	1-Apr-00
MALTEX INDEX	Malta	MT	rest-EA	1-Apr-99
SBITOP INDEX	Slovenia	SI	rest-EA	4-Jan-03
SKSM INDEX	Slovakia	SK	rest-EA	1-Aug-99
SOFIX Index	Bulgaria	BG	non-EA	24-Oct-00
PX Index	Czech Republic	CZ	non-EA	1-Apr-99
KAX Index	Denmark	DK	non-EA	1-Apr-99
CRO Index	Croatia	HR	non-EA	14-Jun-02
WIG20 INDEX	Poland	PL	non-EA	4-Jan-99
BET INDEX	Romania	RO	non-EA	4-Jan-99
SBX INDEX	Sweden	SE	non-EA	4-Jan-99
BUX INDEX	Hungary	HU	non-EA	4-Jan-99
UKX INDEX	United Kingdom	UK	non-EA	4-Jan-99

Table 2: Summary statistics of daily returns. The table reports descriptive statistics from 1st January 1999 and from 1st September 2004 (in italics). The number of observations T , mean, standard deviation (sd), median, skewness and kurtosis are reported.

	Country	T	mean	sd	median	skewness	kurtosis
EA-core	AT	4877	0.010%	0.016	0.056%	-0.331	7.289
		<i>3526</i>	<i>0.003%</i>	<i>0.017</i>	<i>0.066%</i>	<i>-0.316</i>	<i>6.620</i>
	BE	5174	-0.008%	0.014	0.046%	-0.142	5.674
		<i>3762</i>	<i>0.002%</i>	<i>0.014</i>	<i>0.052%</i>	<i>-0.248</i>	<i>6.567</i>
	FI	5006	0.007%	0.018	0.037%	-0.231	6.201
		<i>3625</i>	<i>0.014%</i>	<i>0.015</i>	<i>0.031%</i>	<i>-0.054</i>	<i>5.412</i>
	FR	5181	-0.002%	0.015	0.038%	-0.042	6.440
		<i>3762</i>	<i>0.004%</i>	<i>0.015</i>	<i>0.040%</i>	<i>-0.028</i>	<i>8.301</i>
DE	5119	0.009%	0.016	0.051%	-0.091	4.924	
	<i>3703</i>	<i>0.024%</i>	<i>0.015</i>	<i>0.055%</i>	<i>-0.100</i>	<i>7.031</i>	
LU	5051	-0.001%	0.015	0.044%	-0.324	5.836	
	<i>3677</i>	<i>0.001%</i>	<i>0.015</i>	<i>0.039%</i>	<i>-0.290</i>	<i>5.565</i>	
NL	5183	-0.007%	0.015	0.053%	-0.144	7.611	
	<i>3762</i>	<i>0.008%</i>	<i>0.014</i>	<i>0.069%</i>	<i>-0.173</i>	<i>10.475</i>	
EA distressed	GR	4916	-0.024%	0.020	0.032%	-0.197	4.441
		<i>3550</i>	<i>-0.023%</i>	<i>0.021</i>	<i>0.063%</i>	<i>-0.251</i>	<i>4.696</i>
	IE	5092	-0.004%	0.015	0.051%	-0.724	8.693
		<i>3696</i>	<i>-0.003%</i>	<i>0.016</i>	<i>0.057%</i>	<i>-0.780</i>	<i>9.040</i>
	IT	5115	-0.019%	0.016	0.045%	-0.204	6.158
		<i>3703</i>	<i>-0.014%</i>	<i>0.017</i>	<i>0.054%</i>	<i>-0.224</i>	<i>6.548</i>
PT	5137	-0.021%	0.014	0.026%	-0.233	6.100	
	<i>3762</i>	<i>-0.014%</i>	<i>0.014</i>	<i>0.047%</i>	<i>-0.259</i>	<i>6.731</i>	
ES	5114	-0.011%	0.016	0.019%	-0.120	7.112	
	<i>3733</i>	<i>-0.002%</i>	<i>0.016</i>	<i>0.020%</i>	<i>-0.145</i>	<i>8.520</i>	
rest-EA	CY	<i>3552</i>	<i>-0.087%</i>	<i>0.025</i>	<i>-0.039%</i>	<i>0.042</i>	<i>6.423</i>
	EE	5033	0.046%	0.013	0.038%	0.326	8.302
		<i>3634</i>	<i>0.028%</i>	<i>0.012</i>	<i>0.024%</i>	<i>0.057</i>	<i>7.830</i>
	LV	<i>3591</i>	<i>0.028%</i>	<i>0.014</i>	<i>0.020%</i>	<i>0.269</i>	<i>7.328</i>
	LT	<i>3535</i>	<i>0.029%</i>	<i>0.012</i>	<i>0.047%</i>	<i>-0.385</i>	<i>14.114</i>
	MT	4889	0.023%	0.010	0.023%	0.720	9.191
		<i>3552</i>	<i>0.008%</i>	<i>0.009</i>	<i>0.023%</i>	<i>0.030</i>	<i>3.165</i>
	SI	<i>3570</i>	<i>-0.003%</i>	<i>0.012</i>	<i>0.004%</i>	<i>-0.306</i>	<i>6.162</i>
SK	4791	0.027%	0.014	0.041%	-0.430	7.178	
	<i>3498</i>	<i>0.020%</i>	<i>0.013</i>	<i>0.040%</i>	<i>-0.351</i>	<i>8.695</i>	
non-EA	BG	<i>3571</i>	<i>0.000%</i>	<i>0.013</i>	<i>0.021%</i>	<i>-0.999</i>	<i>9.702</i>
	CZ	4977	0.014%	0.016	0.068%	-0.465	9.974
		<i>3614</i>	<i>0.003%</i>	<i>0.017</i>	<i>0.061%</i>	<i>-0.532</i>	<i>11.723</i>
	DK	4996	0.022%	0.013	0.065%	-0.333	6.779
		<i>3613</i>	<i>0.027%</i>	<i>0.013</i>	<i>0.087%</i>	<i>-0.350</i>	<i>7.571</i>
	HR	<i>3521</i>	<i>0.013%</i>	<i>0.014</i>	<i>0.036%</i>	<i>-0.028</i>	<i>13.571</i>
	HU	4971	0.027%	0.019	0.075%	-0.061	7.808
		<i>3599</i>	<i>0.021%</i>	<i>0.020</i>	<i>0.082%</i>	<i>-0.054</i>	<i>8.116</i>
	PL	4975	0.006%	0.019	0.035%	-0.158	4.083
		<i>3596</i>	<i>0.006%</i>	<i>0.019</i>	<i>0.046%</i>	<i>-0.232</i>	<i>4.951</i>
	RO	4936	0.020%	0.018	0.052%	-0.577	11.310
		<i>3612</i>	<i>0.014%</i>	<i>0.018</i>	<i>0.067%</i>	<i>-0.493</i>	<i>7.872</i>
	SE	5001	0.027%	0.017	0.066%	0.006	5.294
		<i>3623</i>	<i>0.036%</i>	<i>0.017</i>	<i>0.069%</i>	<i>0.040</i>	<i>7.067</i>
UK	5066	-0.004%	0.013	0.053%	-0.180	9.499	
	<i>3668</i>	<i>0.002%</i>	<i>0.013</i>	<i>0.065%</i>	<i>-0.200</i>	<i>11.851</i>	

4 Financial integration in EU equity markets

Let us consider the sample of daily returns for the 22 European countries from January 1999. In order to study how financial integration among the European countries evolves over time, we split the sample in three subsamples: (i) from January 1999 to December 2007, i.e., the non-crisis/normal subsample, (ii) from January 2008 to December 2012, i.e., the subsample referring to the European sovereign crisis, (iii) from January 2013 to June 2019, i.e., the post-crisis subsample.

For each subsample over time, we estimate the time-invariant integration index following the methodology by Pukthuanthong and Roll (2009) dealing with unbalanced panels and estimating the number of latent factors, as described in Appendix A. Unlike Pukthuanthong and Roll (2009), in order to reduce the number of parameters to estimate, we apply the BIC selection criteria as in Bai and Ng (2002). Pukthuanthong and Roll (2009) estimate loadings β_i by regressing the returns on the first ten PCs, which account for close to 90% of the cumulative eigenvalues. Their selection is based only on an heuristic approach. In their robustness checks, Pukthuanthong and Roll (2009) get that the pattern of integration index is similar, but with a slightly difference in the levels, by selecting just a single factor, rather than three or ten. Arouri et al. (2014) extract the set of factors that explain at least 70% of return variation of assets. In our setting, we prefer to introduce a selection criteria in order to loosen any priori-assumption on the number of factors and ensure thrift in the number of parameters to estimate. The selected number of factors \hat{r} equals, on average, 2.⁵ The selected factors explain, on average across countries, about 70% of the variance over the full sample. Similar percentages are observed for the three subsamples. In particular, the two factors explain 60%, 79% and 69% of the variance in each subsample. Thus, we do not need to select a large number of factors in order to explain the returns. Indeed, adding other factors does not increase the proportion of explained variance in a relevant measure, as shown, for example, in Figure 1 for Germany. Figure 1 provides the scree plots of the first ten eigenvalues computed over the full sample and the crisis period. The selected number of factors for Germany is 1 for the full sample and 2 for the crisis period. The proportion of variance explained by the \hat{r} factors is clearly more relevant than the proportion explained by the subsequent factors. Across all countries, the contribution of the $\hat{r} + 1$ eigenvalue is about 4% (on average over the subsamples) and it is a marginal contribution w.r.t. the first \hat{r} eigenvalues.

⁵As expected, the first estimated factor $\hat{F}_{1,t}$ is mostly correlated with the European market index (i.e., the STOXX Europe total market). The exposures to the second factor is highly correlated among countries.

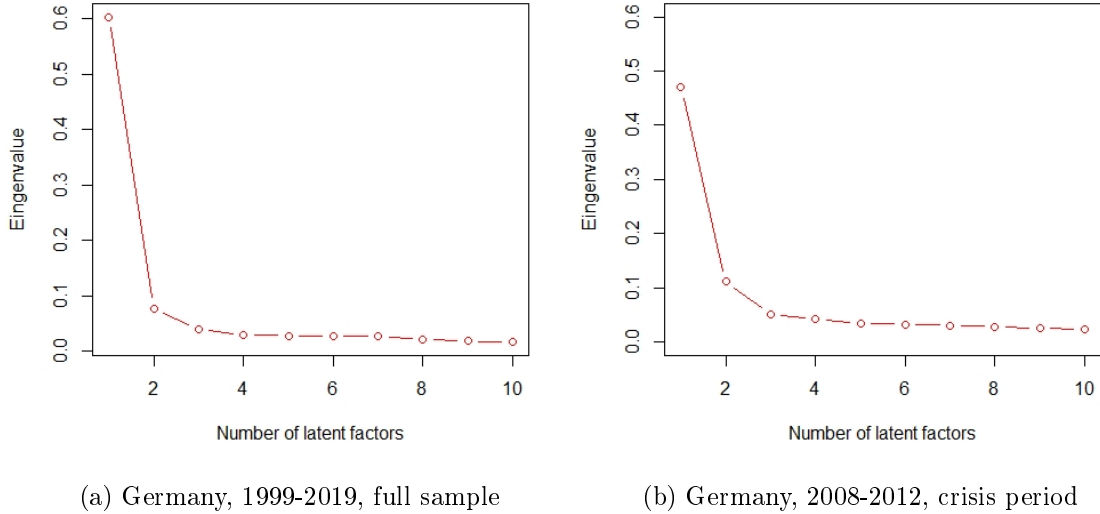


Figure 1: Scree plots of eigenvalues corresponding to the first ten latent factors for Germany. The eigenvalues are computed on the variance-covariance matrix of R_{-c} , i.e., the daily returns for all countries excluding country c , as explained in Appendix A, of the full-sample and the crisis-period.

Table 3 reports the estimated integration indexes (i.e., the coefficients of determination $\hat{\rho}_{adj,c}^2$) over the full sample and the three subsamples over time. The degree of integration for the EA-core and EA distressed countries is high and is further increased during the crisis period. The rest of the euro area and the non-euro area countries exhibit a low degree of integration, however, also for them during the crisis period the degree of financial integration more than doubled. After the crisis period, for most of the euro area and non-euro area countries, integration remained stable or slightly decreased. As shown by the results in Table 3, computing the analysis on several subsamples over time allows us to capture a certain dynamic of the financial integration. Indeed, focusing only on the full sample and using a time-invariant estimator implies a loss of information on the dynamic.

Thus, we opt to study the time-varying integration index, applying an out-of-sample principal components w.r.t. years and country, as described in Appendix A. For each country, we get a time-series of the integration index. Figures 2-5 display the estimated time-varying integration index on calendar year for each country grouped by countries' regions presented in Table 1. For illustrative purposes the median of the static integration indexes computed over the full sample (dashed black line) as well as over the subsamples (solid blue lines) are also shown. In terms of the median of time-varying integration indexes,

Table 3: Time-invariant integration index $\hat{\rho}_{adj}^2$ computed on the daily returns from January 1999 to June 2019 of the 22 market indexes. $\hat{\rho}_{adj}^2$ is also reported for the three subsamples over time (i.e., pre-crisis, crisis and post-crisis periods). Finally, the table reports the median, the mean and the standard deviation of $\hat{\rho}_{adj}^2$ across countries.

$\hat{\rho}_{adj}^2$	Country	Full sample 1999-2019	Pre-crisis 1999-2007	Crisis 2008-2012	Post-crisis 2013-2019
EA-core	AT	0.703	0.456	0.838	0.729
	BE	0.781	0.599	0.879	0.864
	FI	0.609	0.474	0.854	0.750
	FR	0.850	0.870	0.936	0.896
	DE	0.743	0.711	0.879	0.841
	LU	0.541	0.375	0.713	0.479
	NL	0.815	0.811	0.920	0.874
EA distressed	GR	0.362	0.289	0.490	0.259
	IE	0.621	0.495	0.700	0.635
	IT	0.807	0.756	0.873	0.748
	PT	0.661	0.483	0.796	0.633
	ES	0.802	0.745	0.841	0.788
rest-EA	EE	0.327	0.247	0.417	0.350
	MT	0.099	0.099	0.289	0.255
	SK	0.099	0.076	0.177	0.102
non-EA	CZ	0.584	0.370	0.723	0.573
	DK	0.681	0.553	0.817	0.561
	HU	0.513	0.332	0.671	0.389
	PL	0.503	0.273	0.718	0.453
	RO	0.256	0.029	0.536	0.325
	SE	0.768	0.670	0.848	0.740
	UK	0.765	0.662	0.833	0.752
median		0.641	0.478	0.806	0.634
mean		0.586	0.472	0.716	0.591
st.dev.		0.218	0.232	0.200	0.222

over the full sample, EA-core exhibit a significantly higher degree of financial integration compared to EA distressed. With reference to the subsamples over time, the median degree of integration progressively increases during the crisis period for the most countries. If we further move to the time-varying integration indexes the patterns are even more informative. For example, the financial integration index of Greece is far more volatile than the one computed for Germany. Moreover, during the crisis years financial integration in Greece had a sharp decrease, while for Germany it remained rather stable. Furthermore, in Figures 2-5, we also plot the patterns of the two components of the financial integration: the time-varying systematic (two-dashed yellow triangle) and idiosyncratic (dotted green diamond) volatilities. We observe that a positive relation exists between the systematic component and the integration index, as expected. The systematic volatility is higher than the idiosyncratic volatility by correspondence of high levels of integration. In that case, the index returns are well explained by the selected common factors. The idiosyncratic volatility and the integration index have a strong negative correlation during the crisis period. The volatilities have a similar path over time, however we can observe differences across the regions. Focusing on the EA-core, we observe a large pick of the systematic volatility in 2009 and 2011, capturing the effect of the financial and sovereign crisis. The idiosyncratic volatility is always characterized by a less volatile path over time. This does not hold for all the EA distressed countries. For example, the idiosyncratic volatility shows large picks and jumps for Greece and Ireland, during and after the crisis periods. In particular, for Greece, we observe an evident specular trajectories of the two components during and after the sovereign crisis, showing that the returns of this countries are more explained by local factors. The idiosyncratic volatility for some countries, e.g., Hungary, Poland, Denmark, among others, feature a larger pick than the systemic volatility during the crisis period. Finally, the path of systemic volatility of United Kingdom is similar to the one observed for the EA-core countries.

In Figure 6, we report the cross-sectional distribution of integration indexes computed over the yearly subsamples for all countries. The median across countries of the adjusted $R-squared$ is the indicator of financial market integration as described in Pukthuanthong and Roll (2009). It is worthy noting that the time-invariant financial integration index (red line) corresponds approximately to the average, over years, of the values of the median, computed across countries. Using the graphic representation in Figure 6, we are able to check the volatility of the integration index among the EU countries. Indeed, we observe that financial integration increases and is more homogeneous across countries during the crisis period. On the same time, the integration index decreases after the crisis and the heterogeneity across countries is more evident.

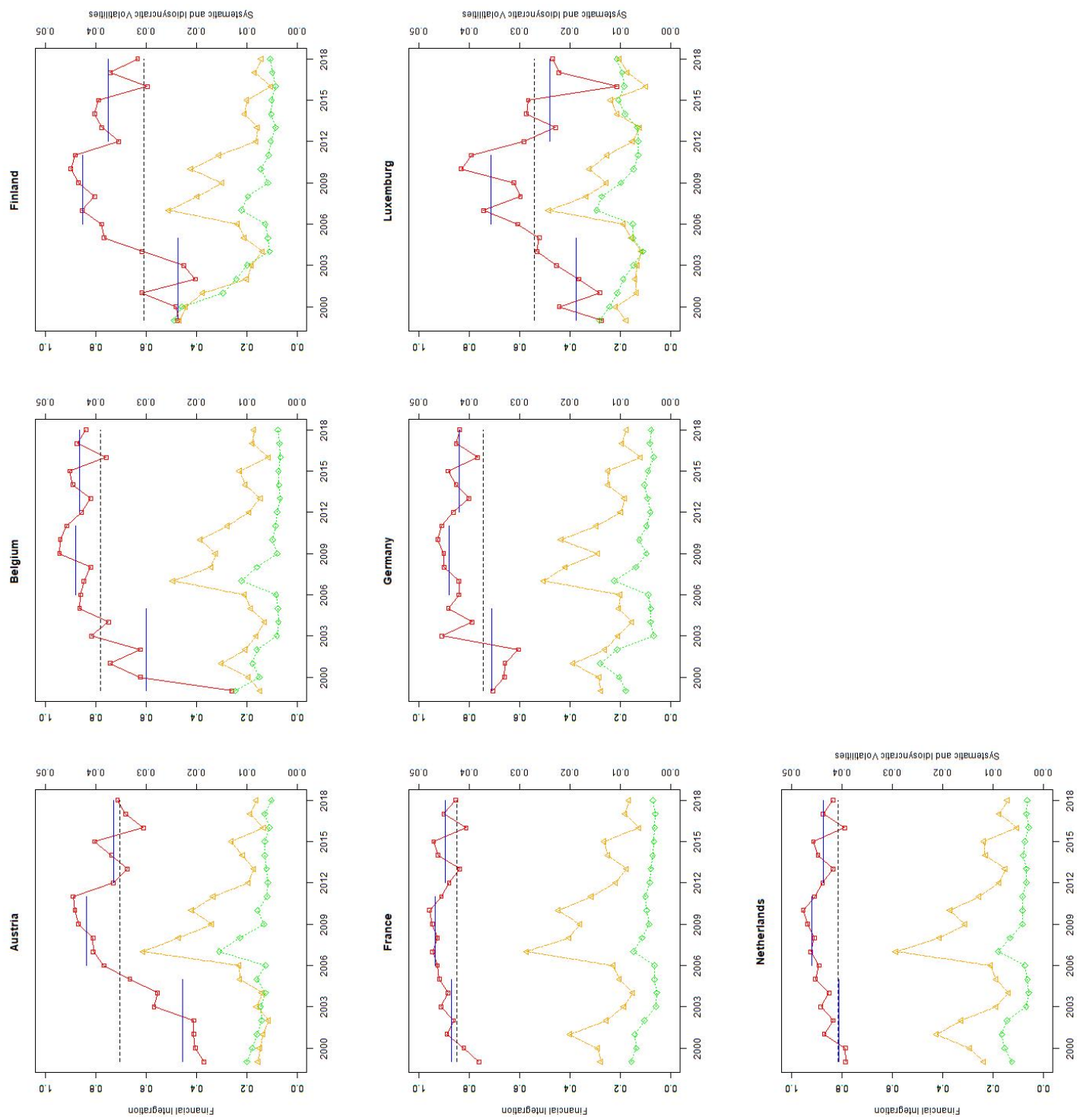


Figure 2: Financial integration (red squared) index over time for the EA-core countries. The plots reports also the static estimation of the financial integration over the full sample (dashed black line) and the three periods (solid blue lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed yellow triangle) and idiosyncratic (dotted green diamond) volatilities over time are also reported on the right axis.

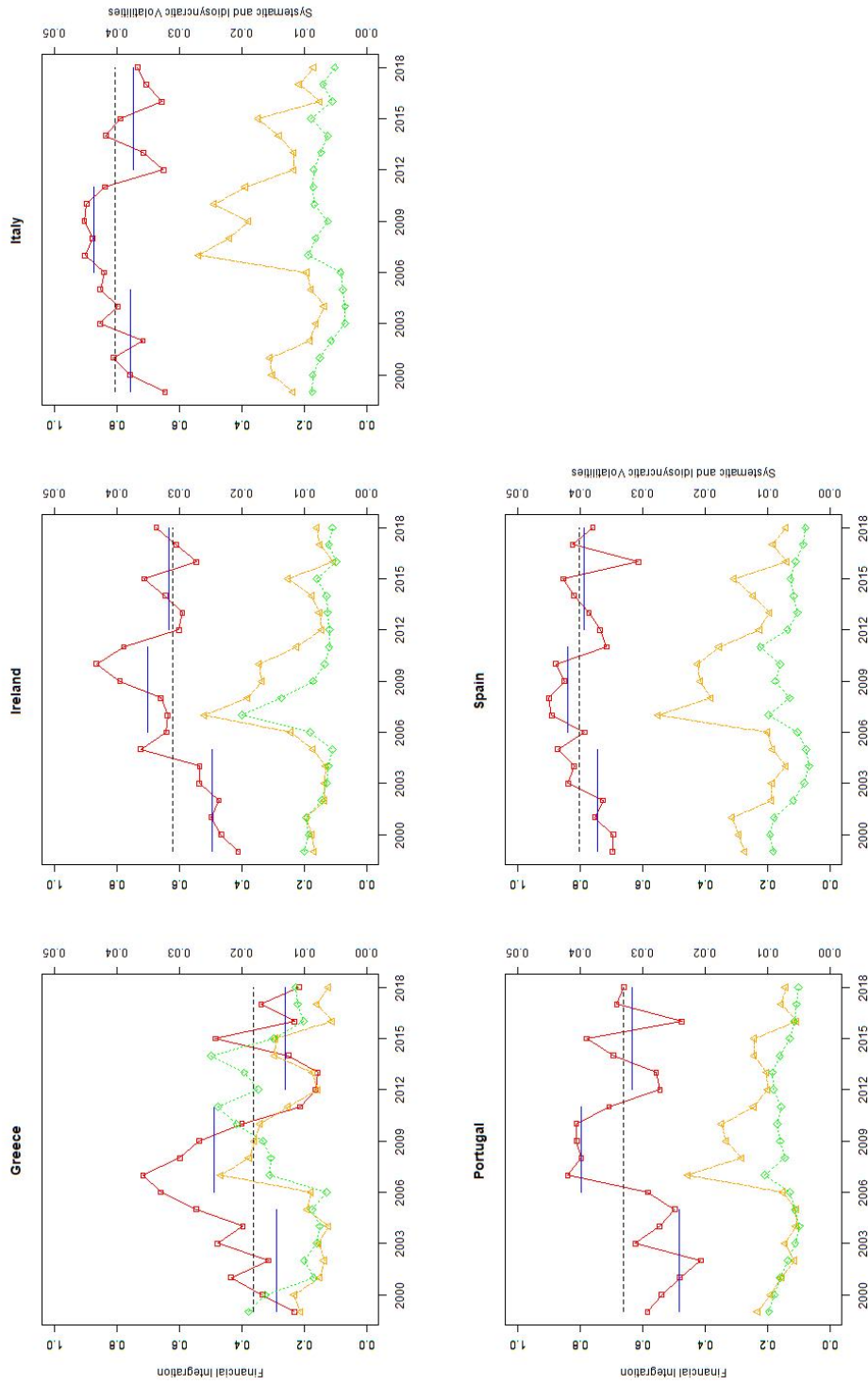


Figure 3: Financial integration (red squared) index over time for the EA distressed countries. The plots reports also the static estimation of the financial integration over the full sample (dashed black line) and the three subsamples (solid blue lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed yellow triangle) and idiosyncratic (dotted green diamond) volatilities over time are also reported on the right axis.

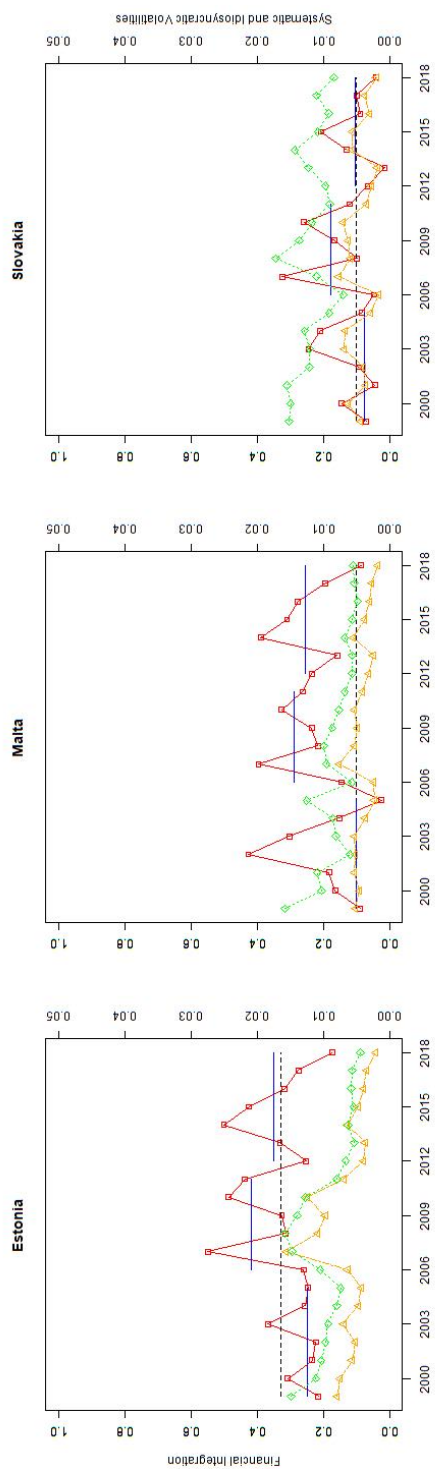


Figure 4: Financial integration (red squared) index over time for the rest-EA countries. The plots reports also the static estimation of the financial integration over the full sample (dashed black line) and the three subsamples (solid blue lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed yellow triangle) and idiosyncratic (dotted green diamond) volatilities over time are also reported on the right axis.

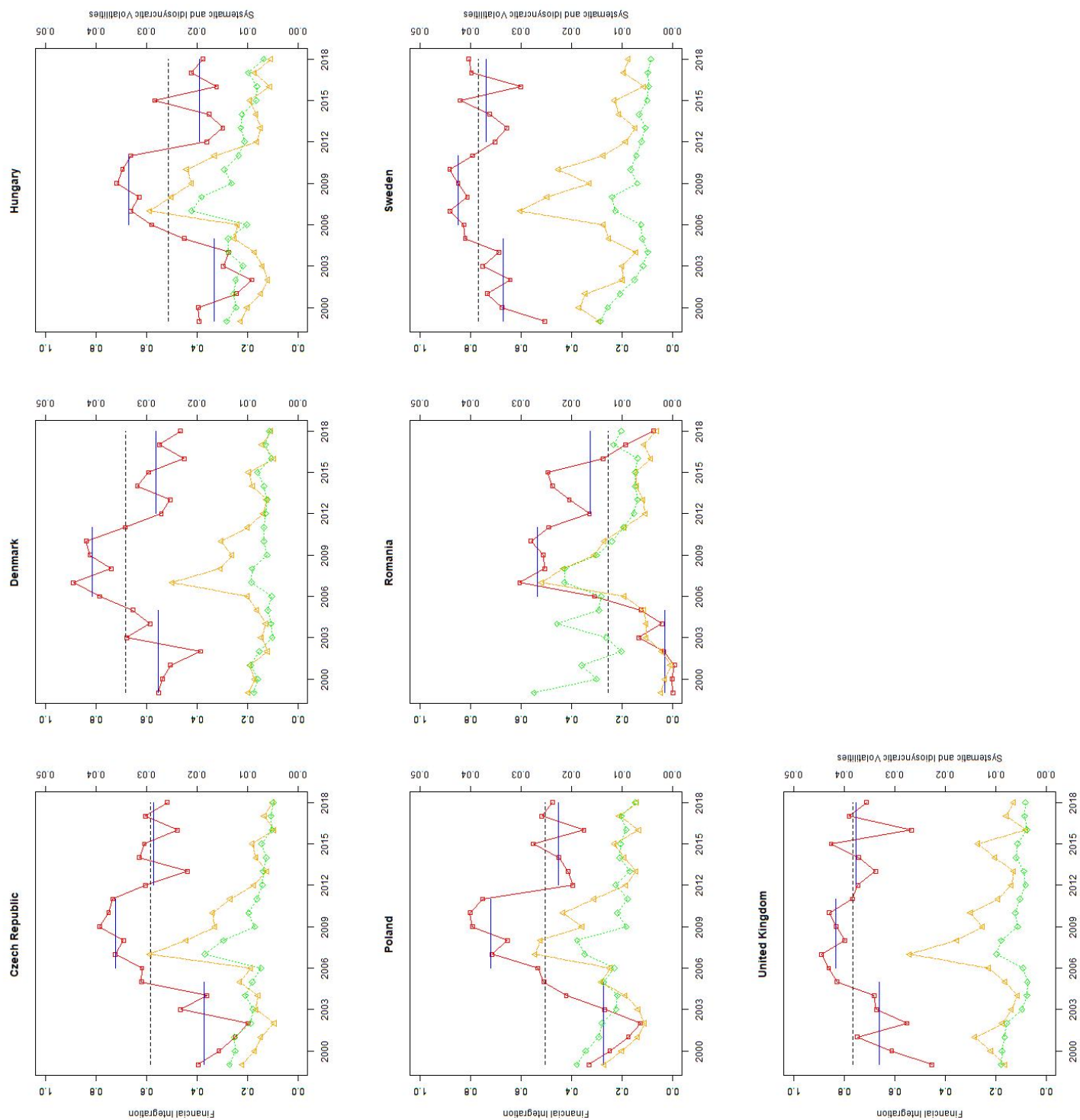


Figure 5: Financial integration (red squared) index over time for the non-EA countries. The plots reports also the static estimation of the financial integration over the full sample (dashed black line) and the three subsamples (solid blue lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed yellow triangle) and idiosyncratic (dotted green diamond) volatilities over time are also reported on the right axis.

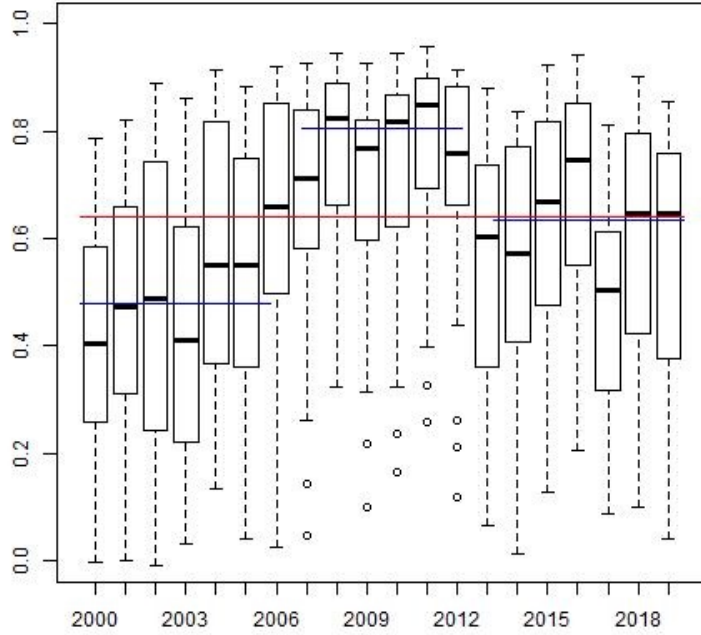


Figure 6: Distribution of cross-sectional integration index computed on yearly samples of stock market indexes returns from January 2000 to June 2019. The median of the time-invariant integration indexes computed over the full sample (red line) as well as over the three sub-samples (blue lines) are provided. The three sub-samples over time correspond to pre-crisis (1999-2007), crisis (2008-2012) and post-crisis (2013-2019) periods.

In order to analysis the heterogeneity of the financial integration indexes across the regions, Figure 7 plots the time series of the median adjusted $R - squared$ by grouping countries. Furthermore, we perform the Chow test to determine the presence of structural breaks, that could explain changes in the level of integration index. Focusing on the EA distressed countries, a relevant structural break is observed in 2011 and its large confidence interval covers both the financial and sovereign crisis. The integration index of the non-EA countries shows a change during the sovereign crisis. Focusing on EA-core, we observe a change in the mean in 2003 of integration index.⁶ We also observe that in 2005, the time series for EA distressed and non-EA countries display a structural break characterized by tighter confidence intervals as compared to the others breaks. It could reflect the market

⁶The break on 2003 could reflect the energy crisis affected the real economy.

anticipation on the burst of the housing bubble as by mid-2005 there were already some public discussions. Finally, the median of integration index computed among the rest of EA countries seems not affected by any structural breaks. These results give the evidence that studying the dynamic of integration index is crucial.

4.1 Robustness checks

In order to verify the results gathered in the previous section, we provide two robustness checks. In the first exercise, we opt to increase the number of European countries involved in the estimation to the disadvantage of the time-series dimension. In the second exercise, we perform the estimation analysis on the European sample of MSCI indexes. The results on MSCI indexes are reported in Appendix C.

Let us consider daily returns from 1st September 2004 to 30th June 2019 for the 28 European countries listed in Table 1. This cross-sectional enlargement allows us to include Cyprus, Latvia, Lithuania and Slovenia (as rest of EA countries) and Bulgaria and Croatia (as non-EA countries). The estimation of the financial integration is not heavily affected by the inclusion of these countries characterized by a small financial markets. However, in Table 7 i Appendix C, we observe that the time-invariant integration index computed on the full sample and on the subsamples slightly increases for most countries as compared to the $\hat{\rho}_{adj}^2$ in Table 3. Moreover, again, we observe that the integration index increases during the crisis period, however its median value is slightly smaller than the corresponding one for the 22 countries. These results are also confirmed in the time-varying estimation as shown in Figure 8.

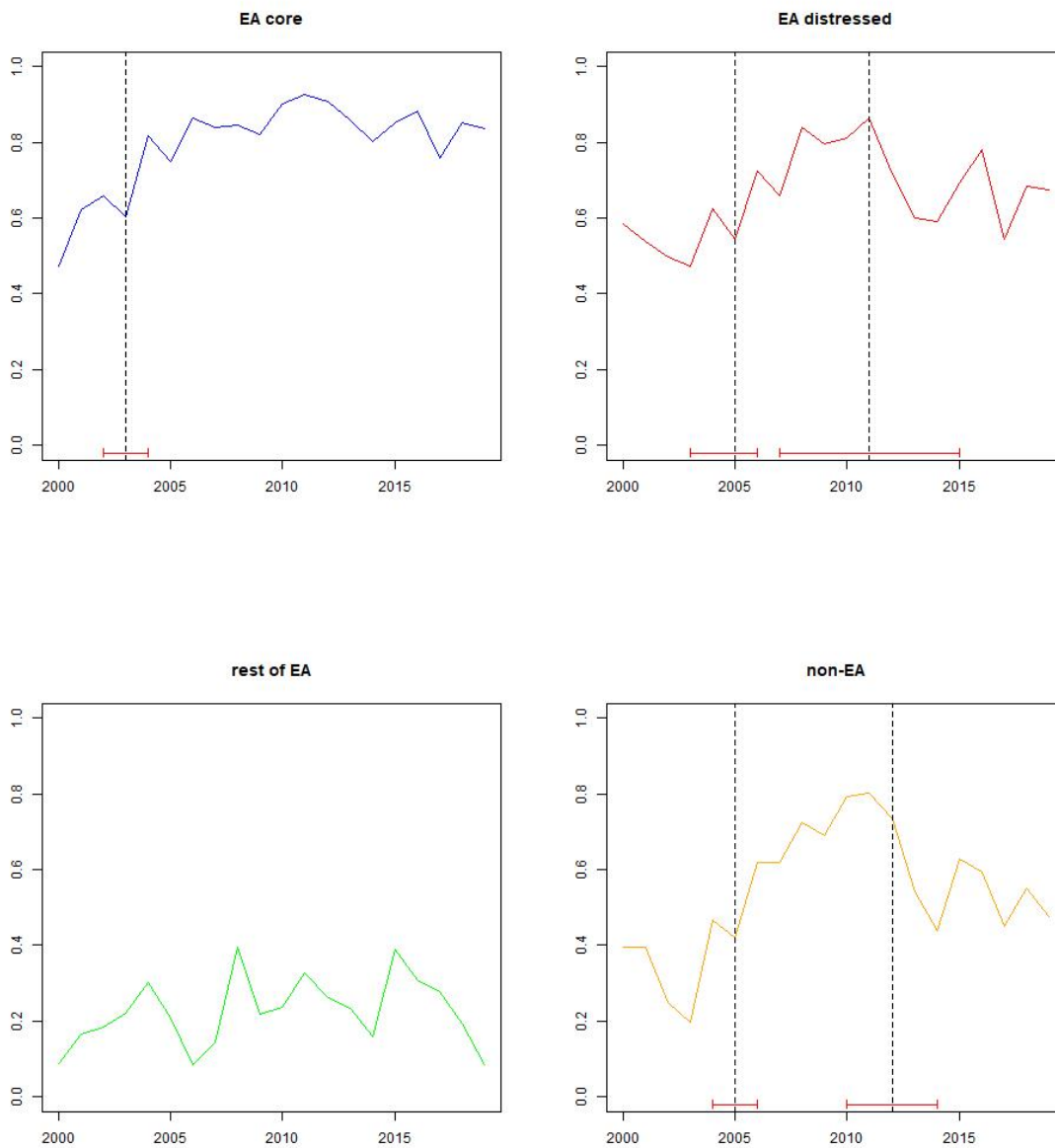


Figure 7: Time series of the median financial integration index computed by grouping countries in the four EA regions defined in Table 1. For each series, the Chow test is performed. The dotted vertical lines indicate the break dates and the horizontal red lines correspond to their confidence intervals.

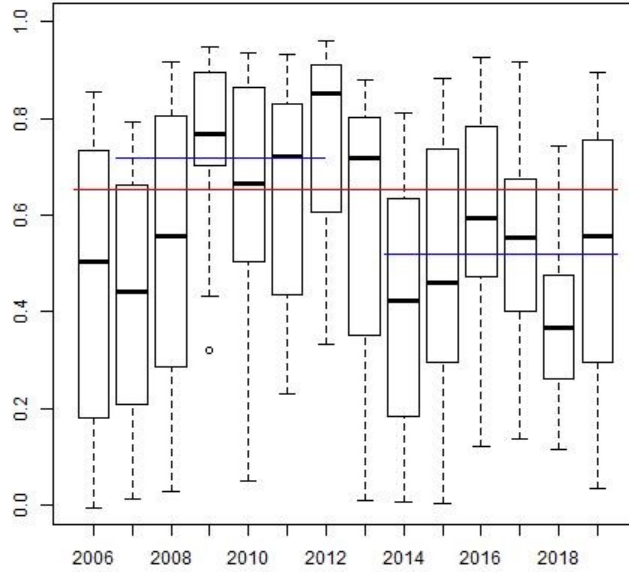


Figure 8: Distribution of cross-sectional integration index computed on yearly samples of stock market indexes returns from January 2006 to June 2019. The median of the time-invariant integration indexes computed over the full sample (red line) as well as over the two sub-samples (blue lines) are provided. The three sub-samples over time correspond to pre-crisis (1999-2007), crisis (2008-2012) and post-crisis (2013-2019) periods.

5 The drivers of financial integration

In this section, we investigate what promotes integration exclusively among EU countries. We also attempt to further identify the key factors that explain the systematic and the idiosyncratic volatilities in our set of countries.

5.1 Review of literature on the determinants of integration

Several factors like the overall macroeconomic environment, barriers to trade or the level of development of the financial markets could affect the degree of integration. Lane and Milesi-Ferretti (2008), using external assets and liabilities as a measure of integration, show that financial integration depends on the development of the domestic financial market and the overall economic development. The authors also point into the advanced degree of integration of the EU15 countries. However, their estimations are based in a single

year excluding any possible dynamics. Carrieri et al. (2007) construct an integration index for a set of six emerging countries and use panel regressions to further look into possible determinants of integration. Their results stress the importance of the development of the domestic financial market (proxied by the ratio of market capitalization to GDP). They also find that financial liberalization policies improved integration. Similarly to Lane and Milesi-Ferretti (2008), trade openness (i.e. trade to GDP ratio) is not found to be a significant driver for emerging countries. Volosovych (2011) using a long time series of sovereign bond data for 15 advanced economies shows that both policy related variables (e.g., inflation, government deficit), as well as, the global market environment (proxied by trade openness) are associated with the evolution process of financial integration. In Lehkonen (2015) the focus is on the effect of the financial crisis on the integration process on a wide set of developed and emerging countries. The integration measure used is the one by Pukthuanthong and Roll (2009). Lehkonen (2015) considers numerous possible drivers for integration, reflecting financial development, openness, world overall uncertainty, country specific risk factors, growth and various information variables (e.g. telephone lines, internet connections). In general, his results are in line with the previous literature suggesting that openness, country's investment profile and global risk factors are related to the degree of integration.

The introduction of the euro and the associated elimination of foreign exchange risk together with actions towards a single market where capital moves freely, unquestionable contributed to an increased degree of integration among EMU countries. In general, the determinants of financial integration for EU countries as examined, thus far, in the literature are similar to the ones found in world-wide studies. In an early study by Hardouvelis et al. (2006) the authors, by analysing stock market data for 11 euro-area countries plus the UK, from 1992 to 1998, examine whether convergence towards the single currency affected the integration process of European countries. The degree of integration conditioned to a set of monetary, currency, and business cycle variables used as proxies for the European convergence. Movements of forward interest rate differentials with Germany (used as an indicator of the probability to join the common currency) turned out to be the variable closely associated with integration. In Buttner and Hayo (2011) market capitalization, foreign exchange risk, interest rate spreads and business cycle synchronization are the most important determinants of stock market integration among EU countries. Bekaert et al. (2013) use a measure of segmentation for a set of EMU, EU non-EMU as well as six non-EU countries. Interestingly, they conclude that it is the EU membership and not the euro adoption the leading factor for 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 sovereigns' credit rating influence the integration process.

With respect to other studies (e.g. Lehkonen, 2015) our focus is restricted in EU countries, that are harmonized in terms of financial environment (e.g. free movement of capital, harmonized banking systems, a common framework for the coordination of economic poli-

cies). Thus, many of the possible integration drivers used in other studies do not apply in our context.

5.2 Data on the European determinants of integration

We consider a set of variables as possible drivers of financial integration related to the country's financial development, the macro-economic profile, and business characteristics. First, we consider the GDP growth (*GDPgrowth*) as an overall indicator of the economic performance of a country. Moreover, a country more open to trade should be more integrated as this variable acts as an indicator of capital mobility. Thus, we consider the ratio of sum of exports and imports of goods and services over GDP (*TRDGDP*). Another indicator closely related to financial integration is market capitalization (as a share of GDP, *MarketCapGDP*). Furthermore, inflation (*Inflation*) could also be an integration driver since it is closely related to competitiveness, growth and financial development. Technological improvements, as reflected by the share of a country's population using the Internet (*Internet*) and a sovereign's expenditure on research and development (as a share of GDP, *RD*), could also have an impact on integration. The indicators described above are downloaded from the World Bank for the time period 1998-2018.

We also attempt to examine whether the overall quality of governance of a sovereign has an impact on integration. A country with a better governance quality could attract more foreign investors, and thus, exhibit a higher degree of integration. We thus consider the governance indicators produced by the World Bank. The indicators capture various dimensions of the quality of governance such as the overall effectiveness of the government (*GovernEffectiv*), general political stability (*PoliticalStab*), how well governments policies and regulations promote the private sector development (*RegulQuality*) and citizens' freedoms (*VoiceAccount*).

An indicator not tested in the EU related integration literature, to the best of our knowledge, is the total amount of projects financed by the European Investment Bank in each country.⁷ This variable could serve as an indicator of the forthcoming prospects of the respective country. The variable (*EIB_financing*) is calculated on an annual basis as the total amount of financed projects by the European Investment Bank in a country divided by the total amount of projects financed the EU for the respective year.

Finally, we also control for any possible effect of the overall European policy uncertainty. We introduce an indicator constructed on a monthly frequency and based on newspaper articles regarding policy uncertainty.⁸ As our analysis is based on annual frequency, the uncertainty (*Uncertainty*) indicator is calculated as the twelve month median for each respective year.

Tables 8 and 9 in Appendix B provides a description and the relevant sources of the financial integration indicators, while, Table 10 in Appendix B reports the summary statis-

⁷This indicator is available on the European Investment Bank's website.

⁸The uncertainty indicator is download from <https://www.policyuncertainty.com/index.html>.

tics of the considered variables. All indicators are well populated, with the only exception for the variable on the market capitalization (for example, for Estonia, Lithuania, Latvia the time series is missing, while for the Czech Republic we only have 10 years).

5.3 Empirical Results

In order to study the relation between the yearly integration index $\hat{\rho}_{adj,c,\tau}^2$, defined for each country c at each year τ with $c = 1, \dots, C$ and $\tau = 1, \dots, T$, and its possible drivers, we estimate the following country fixed effects unbalanced panel model:

$$\hat{\rho}_{adj,c,\tau}^2 = \alpha_0 + \alpha_1 \hat{\rho}_{adj,c,\tau-1}^2 + \alpha_2 Crisis_\tau + \alpha_3 Uncertainty_{\tau-1} + \beta' X_{c,\tau-1} + e_{c,\tau} \quad (7)$$

where $X_{c,\tau-1}$ is a vector containing the lagged values of the integration drivers, $Crisis$ is the dummy variable for the crisis period, i.e., it assumes value 1 between 2008-2012 and 0 elsewhere, $Uncertainty$ is the overall political uncertainty in the EU, and $e_{c,\tau}$ is the residual term. The lagged dependent variables allow us to avoid any contemporaneous feedbacks among the independent and the explanatory variables. Since the financial integration index is correlated with systematic and idiosyncratic volatilities, as shown in Equation (6), we also analyse the factors that might influence the systematic and idiosyncratic volatilities. In particular, we estimate the panel regression in Equation (7) for the dependent variables $SystVol$ and $IdiVol$, as defined in Equations (4) and (5) respectively.⁹

Table 4 presents the estimation results of Equation (7) using robust standard errors. In particular, columns (A), (B) and (C) gather results based on the integration index, systematic and idiosyncratic volatilities estimated from the 22 European countries listed in Table 1.¹⁰

Focusing on column (A) of Table 4, as the positive sign of the lagged dependent variable $\hat{\rho}_{adj,c,\tau-1}^2$ indicates, an integrated country most likely will continue being an integrated one. The rate at which a country's economy is growing, expressed by the lagged $GDPgrowth$, is marginally significant, while trade openness ($TRDGDP$) appears to be not significant. A sovereign's expenditure on research and development (RD) positively and strongly significantly affects the integration degree of the respective country. Expenditure on research and development promotes economic growth, innovation and job creation, a country thus becomes more competitive and attracts more international opportunities resulting to a higher degree of integration. The same conclusion also holds for the level of technological development as expressed by the share of population that use the Internet. The share of population that use digital services, communication and information technologies impacts the ease of doing business and a country's openness and affects the integration level. The overall policy-related economic uncertainty results in investors' loss of confidence in the government's ability to sustain the current economic environment and potentially leads to

⁹*SystVol* and *IdiVol* have been normalized using the min-max transformation.

¹⁰Slovakia, Estonia and UK are not included in the estimations as with respect to these countries *TRDGDP*, *MarketCapGDP* and *EIB_financing* are not populated.

disinvestment of capital and negatively affects integration among European countries. Not surprisingly, market capitalization as a share of GDP affects in a significant and positive way the degree of integration. In line with the literature (see, e.g., Volosovych, 2011), a negative relationship between inflation and integration is evident, as low inflation reduces uncertainty and is closely related to economic stability expectations. Regarding the governance indicators, only the voice and accountability indicator (*VoiceAccount*) appears to be significant with a positive coefficient. As documented in the literature (see, e.g., Elbahnasawy and Revier, 2012) *VoiceAccount* is associated with a country's corruption level, thus, impacts integration. Finally, we observe a positive effect, stemming from the amount of projects financed by the European Investment Bank, on a country's degree of integration as it attracts investors and thus promotes integration. As expected, in view of the results presented in the Section 4, the crisis positively affected integration.¹¹

Table 4, column (B), gathers the estimation results for the systematic volatility. Since the evidence of the positive correlation between integration index and systematic volatility, one should expect that most of the factors affecting integration should be aligned with the factors affecting *SystVol*. Indeed, from Table 4, we can conclude that the macroeconomic variable *GDPgrowth*, market capitalization *MarketCapGDP*, the overall policy-related uncertainty and the technological progress significantly affect the systematic volatility. However, *EIB_financing* and *RD* are no longer significant when *SystVol* is considered. As discussed above expenditure on research and development promotes integration, however, the rational would be that this variable has no direct association with a risk component. Indeed, *RD* is not significant as can be seen from Table 4. The same rational also holds for *EIB_financing* i.e. although the total amount of projects financed by the European Investment Bank, promotes economic growth and job creation thus a country becomes more competitive and attracts international investors, however this variable has no direct association with a risk component. For the governance indicators, an interesting result is that *VoiceAccount* has a negative impact on the systematic volatility component. Finally, the crisis dummy remains significant. Furthermore, column (C) provides the estimation results for the idiosyncratic volatility. As *Uncertainty* is not country specific we haven't included it in the panel regressions fixed effects for idiosyncratic volatility. From the results in Table 4, we conclude that the most important driver for the idiosyncratic risk index is the level of financial development of the respective country as expressed by the *MarketCapGDP* variable. Regarding the sign of the respective coefficient, the rational is that if a country has a large financial market as compared to its GDP, then if for the respective country the financial market is enlarged further, one would also expect an increase in its idiosyncratic risk. Moreover, *VoiceAccount* is only marginally significant with a decrease in the voice and accountability levels being associated with an increase in the

¹¹For robustness checks, we estimate Equation (7) using only the euro area countries. Results remain unchanged with the only exception being the Inflation variable that becomes not significant. However, when Equation (7) is estimated using the non-euro area countries results slightly vary. *GDPgrowth*, *RD* and *EIBfinancing* are not significant, while, *RegulQuality* marginally is.

idiosyncratic volatility.

We provide robustness checks to verify the results presented above by performing the same econometric analysis on the European sample of MSCI indexes. In general results (see Table 15 in Appendix C) are comparable and in line with the ones shown in Table 4.

Table 4: Estimation results from Equation (7) using as dependent variable the yearly integration indexes (column A), the yearly systematic and idiosyncratic volatilities (column B and C, respectively), estimated from the 22 countries. Yearly data are span from 1999 to 2018. For the analysis on systematic and idiosyncratic volatilities, the natural logarithm transformation for the variables *MarketCapGDP*, *TRDGDP* and *Uncertainty* is applied in order to scale the data properly. Moreover, the global factor *Uncertainty* is not included in the analysis of the idiosyncratic volatility. L denotes the lag operator. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. N denotes the number of observations and $R-squared$ is the coefficient of determination. Robust standard errors are in parentheses.

Dependent Variable	Integration Index	Systematic volatility	Idiosyncratic volatility
	(A)	(B)	(C)
$L.\hat{\rho}_{adj}^2$	0.3433*** (0.0558)		
L.SystVol		0.2530*** (0.0542)	
L.IdiVol			0.4540*** (0.0679)
L.GDPgrowth	0.0050* (0.0028)	0.0003*** (0.0001)	0.0001 (0.0001)
L.TRDGDP	0.0000 (0.0001)	-0.0001 (0.0010)	-0.0000 (0.0011)
L.Uncertainty	-0.0011*** (0.0002)	-0.0058*** (0.0008)	
L.RD	0.1114*** (0.0297)	0.0010 (0.0014)	-0.0013 (0.0011)
L.MarketCapGDP	0.0004** (0.0002)	0.0021** (0.0008)	0.0018*** (0.0005)
L.Internet	0.0024*** (0.0006)	0.0001** (0.0000)	-0.0000 (0.0000)
L.Inflation	-0.0055*** (0.0009)	-0.0000 (0.0001)	0.0001 (0.0000)
L.VoiceAccount	0.1496** (0.0629)	-0.0052** (0.0022)	-0.0039* (0.0020)
L.PoliticalStab	0.0387 (0.0225)	0.0021 (0.0015)	-0.0000 (0.0008)
L.GovernEffectiv	-0.0092 (0.0407)	-0.0023 (0.0018)	-0.0018 (0.0011)
L.RegulQuality	0.0352 (0.0563)	0.0001 (0.0019)	-0.0007 (0.0015)
EIB_financing	0.8431*** (0.2477)	-0.0003 (0.0158)	-0.0144 (0.0136)
crisis	0.0894*** (0.0118)	0.0077*** (0.0008)	0.0024*** (0.0004)
Constant	-0.0537 (0.0700)	0.0277*** (0.0051)	0.0071 (0.0041)
Observations	259	259	259
$R-squared$	0.6941	0.7663	0.4249
Number of countries	19	19	19
Country FE	YES	YES	YES

6 Application on portfolio allocation and diversification

In this section, we derive implications of financial integration for risk management. We study the dynamics of portfolio diversification across two regimes characterized by a different level of financial integration. Let $\hat{\rho}_\tau^2$ be the yearly median across countries of the country-specific financial integration $\hat{\rho}_{adj,c,\tau}^2$. We define *Regime 1* as the low integrated regime for which $\hat{\rho}_\tau^2 < \theta$, and *Regime 2* as the high integrated regime with $\hat{\rho}_\tau^2 \geq \theta$, where θ is the threshold parameter. Referring to the empirical results for the 22 European stock market indexes in Figure 6, we fix θ equals to the median of $\hat{\rho}_\tau^2$, i.e., $\theta = 0.647$.¹²

We consider a combined set of $N = 100$ European portfolios available from Kenneth French website: 25 portfolios sorted by size and book-to-market ratio; 25 portfolios sorted by size and operating profitability; 25 portfolios sorted by size and investment; 25 portfolios sorted by size and momentum. Our sample is defined by daily returns from 1st January 2000 to 30th June 2019. We assume that the daily return $R_{i,t}$ on portfolio i , with $i = 1, \dots, N$, at date $t = 1, \dots, T$ satisfies the following linear factor structure:

$$R_{i,t} = \mathbf{I}_{1,t}\beta'_{1,i}F_{1,t} + \mathbf{I}_{2,t}\beta'_{2,i}F_{2,t} + \varepsilon_{i,t}, \quad (8)$$

where $F_{j,t}$ are latent regime-specific factors with $j = 1, 2$, and $\beta_{1,i}$ and $\beta_{2,i}$ are the parameters to be estimated. $\mathbf{I}_{1,t}$ and $\mathbf{I}_{2,t}$ are the indicator functions defining the two regimes at each day $t \in \tau$. Based on the previous analysis, we assume that the factors explaining the systematic component of risk can be differ between the two regimes. In particular, factor loadings $\beta_{1,i}$ and $\beta_{2,i}$ measure the p_1 and p_2 risk exposures to factors $F_{1,t}$ and $F_{2,t}$ during low and high integrated regimes, respectively.

From the dataset of portfolios, we estimate the number of latent factors p_1 and p_2 using the BIC criteria defined in Appendix A. Then, we estimate the latent factors $F_{1,t}$ and $F_{2,t}$, and the corresponding risk exposures applying the principal components analysis on Equation (8). Furthermore, we use the estimated vectors of risk exposures $\hat{\beta}_{j,i}$ to construct $P = p_1 + p_2$ portfolios that bear only the systematic risks with weights $w_{i,j} = \hat{\beta}_{j,i}(\hat{\beta}'_{j,i}\hat{\beta}_{j,i})^{-1} = \hat{\beta}_{j,i}/N$ with $j = 1, 2$ (see Lehmann and Modest, 2005). DeMiguel et al. (2009) empirically investigate the out-of-sample performance of a naive strategy, which equally allocates wealth across all assets and outperforms optimization strategies that rely on historical data. The portfolio weights are normalized to ensure they add up to one. The P portfolios $r_{p,j,t} = \sum_i w_{i,j,p}R_{i,t}$, with $p = 1, \dots, p_1$ ($p = 1, \dots, p_2$) if $j = 1$ ($j = 2$), mimic the estimated factors $\hat{F}_{1,t}$ and $\hat{F}_{2,t}$. Table 5 provides summary statistics for the resulting portfolio weights. The average weight is $1/N$ by construction. The first factors $\hat{F}_{j,1,\tau}$ are likely the market factors: the weights associated to them are always positive and are characterized by the minimum standard deviation, and thus the higher Sharpe ratio. The first factors among the two regimes are strongly correlated (0.852) and display not relevant

¹²The two regimes are populated by the same number of time-series observations, i.e. 2,606 daily observations.

variation among the regimes. All the other portfolios allow for long and short positions. In order to identify the portfolios, we perform a correlation analysis between the P portfolios and the European factors available on the French’s website.¹³ Indeed, by construction, the returns of the 100 European portfolios should be explained by the five Fama-French factors. Focusing on the low integrated regime, the five portfolios are strongly correlated with the five European Fama-French factors (see Fama and French, 2015).¹⁴ Focusing on *Regime 2*, we observe that the first two portfolios clearly correspond to the European market and size portfolios. The third seems correlated with profitability portfolio. However, it seems difficult to have a clear conclusion on the fourth portfolio. Thus, a classical five-factors models explain the returns in a low integrated regime. However, we cannot conclude the same for a more integrated regime, where the fourth factor is more difficult to identify. This mean that during a crisis period corresponding to integrated regime as shown in Section 4, a classical model for portfolio returns does not hold. The systematic risk, represented by $F_{2,t}$ factor, might be explained by other drivers of integration as shown in Section 5.

Table 5: Summary statistics of portfolio weights. Table reports the descriptive statistics for the $p_1 = 5$ and $p_2 = 4$ portfolio weights. The mean, standard deviation (sd), median, minimum, maximum, skewness and kurtosis are reported.

	mean	sd	median	min	max	skew	kurtosis
<i>Regime 1</i>							
$w_{1,1}$	0.01	0.001	0.010	0.008	0.011	-1.294	1.509
$w_{1,2}$	0.01	0.275	-0.062	-0.358	0.588	0.554	-0.973
$w_{1,3}$	0.01	0.604	-0.111	-1.040	1.325	0.567	-0.660
$w_{1,4}$	0.01	0.822	-0.089	-2.521	2.600	0.173	2.082
$w_{1,5}$	0.01	0.426	-0.056	-0.873	0.796	0.036	-1.028
<i>Regime 2</i>							
$w_{2,1}$	0.01	0.000	0.010	0.009	0.010	-1.075	1.492
$w_{2,2}$	0.01	12.455	0.978	-20.562	19.725	-0.202	-1.168
$w_{2,3}$	0.01	1.276	-0.069	-3.463	4.975	0.296	2.686
$w_{2,4}$	0.01	0.657	-0.177	-1.582	1.116	0.030	-1.197

In order to study the dynamics of portfolio diversification, we perform regime-specific regressions of the return of each portfolios $R_{i,t}$ on each estimated factor. Then, we compute the average, across portfolios, $R - squared$ associated to each factor, within each regime.

¹³See results in Table 11 in Appendix B.

¹⁴A similar conclusion can be achieved by providing analysis on the estimated factors $\hat{F}_{1,t}$. Indeed, in Regime 1, we also observe strong correlation between the European market, size, value portfolios. The operative and the profitability portfolios are mildly correlated with the fourth and fifth factors.

We compute the diversification benefits mapping a regime-specific exposures to the weights of factor-mimicking portfolios, as explained above. Contrary to Cotter et al. (2019), we do not assume that investor allocates its wealth in a set of country indexes, but we assume that investor maximizes his wealth investing in portfolios defined on characteristics of the firms. Table 6 reports the averages of $R - squared$ for the two regimes. Since the estimated factors are mutually orthogonal, the sum of the average of $R - squared$ for each factor in each regime, is a measure of diversification. In Table 6, we observe that during the *Regime 2* the benefits from diversification are lower than in *Regime 1*. Indeed, we observe a slight difference between the sum of averages $R - squared$ in the two regimes. The benefits from diversification diminish when financial integration is high, as systematic factors become stronger during this period.

Table 6: Average values of $R - squared$ associated to each factor within each regime. $R - squared$ are computed from the regime-specific regressions of each Fama-French portfolio on estimated factor $\hat{F}_{j,t}$ with $j = 1, 2$. The last column of the table reports the sum of the individual average $R - squared$.

Factor	p_j	(1)	(2)	(3)	(4)	(5)	Sum
<i>Regime 1</i>	5	0.796	0.074	0.0215	0.016	0.011	0.918
<i>Regime 2</i>	4	0.910	0.030	0.0105	0.008	-	0.958

7 Conclusion

Over the past years, several European policy actions took place to create deeper and more integrated capital markets. In this paper, we answer to the following questions: (i) how does European integration evolved after the introduction of the euro, and in particular during the sovereign crisis? (ii) what are the key factors (i.e., macro and institutional factors) explaining financial integration, systematic and idiosyncratic volatilities, among European countries? and (iii) what are the implications of financial integration for risk management?.

We provide an empirical application studying the co-movements of European stock market returns. We estimate the time-invariant integration index over the full sample and over three subsamples, distinguishing pre-crisis, crisis and post-crisis periods, showing the importance to account for the time-variation over time. Grouping the results by cross-country regions, we show less heterogeneity of financial integration across clusters, e.g., the countries that were most affected by the sovereign crisis. Financial integration increases and is less heterogeneous across countries during the crisis period. Indeed, the analysis provides evidence of the heterogeneity of integration indexes across countries and cross-sectional regions during the pre-crisis and post-crisis periods. These results are robust w.r.t. a larger cross-sectional dimension and a difference base assets used in the application.

Furthermore, we study the factors affecting the integration index and its component,

namely the systematic and idiosyncratic volatilities. Financial integration is mainly driven by macroeconomic variables, i.e., GDP growth and inflation, and by the level of development of the financial market, the overall political uncertainty, and technological developments. Interestingly, the integration index is driven also by the amount of projects financed by the European Investment Bank. In the same vein, we study the factors explaining systematic and idiosyncratic volatilities. In particular, the factors affecting the systematic component, that is positive correlated with the integration index, are in line with the ones explaining the integration index.

Finally, we study a regime factor models for a set of European portfolios. We show that the risk exposures of portfolio mimicking latent factors change between periods of low and high integration. Furthermore, we show that the five factor Fama- French model explains the portfolio returns only during low integrated periods. We also derive implication for risk management showing that the benefits of diversification are reduced during periods of high integration.

Our empirical evidence suggest that European policy makers should further enforce the policy actions that will promote integration among EU countries, especially for the regions that exhibit a lower degree of integration. This could be achieved by for example further enforcing the technological improvements, the research and development expenditure or the amount of projects financed by the common funds. Further, our results stress on the policy importance of creating and implementing financial stability tools as in a crisis period diversification benefits are limited.

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A Empirical methodology

In this section, we describe how we compute the time-invariant integration index, i.e., a constant indicator of market integration on the reference sample. Then, we describe the dynamic methodology applied in order to get the time-varying integration index, based on the estimated number of factor from the reference sample.

For each country c , we define as R_{-c} the $(C - 1) \times T$ matrix of daily returns for all countries excluding country c . In that way, we avoid that country's return c are biased by heavy weights in the principal components for the selected country. As a preliminary step, we impute the missing values of the dataset using the iterative Expectation-Maximization algorithm (see Stock and Watson, 2002). We estimate the number of factors r from the data. Since we have $C \ll T$, the Bayesian Information Criterion estimator $BIC_3(r)$ studied in Bai and Ng (2002) is suitable for a dataset with small cross-sectional dimension.¹⁵ Let Ω be the $C \times C$ variance-covariance matrix computed on the standardized returns $\bar{R}_t = [\bar{R}_{1,t}, \dots, \bar{R}_{C,t}]'$. The selected number of factors is

$$\hat{r} = \arg \min_{0 \leq r \leq r_{max}} BIC_3(r), \quad (9)$$

where

$$BIC_3(r) = V(r) + r\hat{\sigma}^2 \frac{(C + T - r) \ln(CT)}{CT}, \quad (10)$$

with

$$V(r) = \frac{1}{CT} \sum_{j=r+1}^C \mu_j(\Omega) \quad \text{and} \quad \hat{\sigma}^2 = \sum_{j=r_{max}+1}^C \mu_j(\Omega).$$

The penalty term, involved in Equation (10), reflects the effective number of observations (i.e., CT) and the total number of parameters being estimated $r(C + T - r)$. The estimated factor matrix, denoted by $\hat{F}_t = [\hat{F}_{1,t}, \dots, \hat{F}_{\hat{r},t}]'$, corresponds to the first \hat{r} principal components. We propose to apply an in-sample Principal Components in order to use the whole information available in the sample from $t = 1$. The corresponding matrix of factor loading and the indicator for integration ρ_c^2 are estimated via OLS regression. The integration index ρ_c^2 is constant over the sample and is country specific.

¹⁵Bai and Ng (2002) show that the criterion $BIC_3(r)$ performs better than the penalty term used in standard criteria for time-series applications (i.e., AIC_1 and BIC_1) when $C \ll T$. Others criteria in order to define the number of latent factors are available in the literature (see, e.g., Ahn and Horenstein, 2013; Gagliardini et al., 2019 developing criteria when the cross-sectional dimension is larger or comparable to the time-series dimensions). Due to the dimensions of our dataset, for which $C \ll T$, we select the criteria proposed in Bai and Ng (2002).

In order to get a time-varying integration index, we apply an out-of-sample principal components with respect to time and country. We choose yearly window, denoted by τ and we build the return matrix $R_{-c,\tau-1}$ for all countries than country c for the year $\tau - 1$. From the yearly sample, we extract the principal components have lagged factor loadings. The $\hat{\tau}$ principal components are used to estimate the vector of common factors. The number of common factors is estimated on the reference sample in which year τ belongs.

B Additional Tables

This section provides tables that are commented in the main sections of the paper.

Table 7: Time-invariant integration index $\hat{\rho}_{adj}^2$ computed on the daily returns from September 2004 to June 2019 of the EU 28 market indexes. The indexes $\hat{\rho}_{adj}^2$ are also reported for the three subsamples over time (i.e., pre-crisis, crisis and post-crisis periods). Finally, the table reports the median, the mean and the standard deviation of $\hat{\rho}_{adj}^2$ across countries.

$\hat{\rho}_{adj}^2$	Country	Full sample 1999-2019	Pre-crisis 1999-2007	Crisis 2008-2012	Post-crisis 2013-2019
EA-core	AT	0.800	0.687	0.838	0.728
	BE	0.869	0.824	0.877	0.864
	FI	0.816	0.725	0.850	0.749
	FR	0.924	0.877	0.937	0.893
	DE	0.862	0.800	0.881	0.839
	LU	0.630	0.557	0.718	0.481
	NL	0.904	0.851	0.920	0.872
EA distressed	GR	0.416	0.539	0.512	0.260
	IE	0.676	0.627	0.696	0.634
	IT	0.825	0.796	0.874	0.748
	PT	0.713	0.558	0.797	0.633
	ES	0.826	0.799	0.845	0.787
rest-EA	CY	0.271	0.231	0.340	0.104
	EE	0.497	0.340	0.545	0.467
	LV	0.289	0.207	0.355	0.207
	LT	0.513	0.311	0.578	0.476
	MT	0.251	0.136	0.300	0.344
	SI	0.396	0.210	0.477	0.322
	SK	0.144	0.145	0.165	0.137
non-EA	BG	0.352	0.137	0.448	0.300
	CZ	0.677	0.515	0.738	0.566
	DK	0.742	0.701	0.822	0.561
	HR	0.498	0.219	0.598	0.406
	PL	0.571	0.420	0.665	0.384
	RO	0.616	0.481	0.716	0.458
	SE	0.451	0.169	0.579	0.343
	HU	0.820	0.786	0.848	0.738
	UK	0.809	0.796	0.830	0.749
median		0.653	0.548	0.717	0.521
mean		0.613	0.516	0.670	0.538
st.dev.		0.226	0.261	0.212	0.236

Table 8: Description of financial integration indicators (I).

Variable	Description	Sample period	Source
GDPgrowth	Annual percentage growth rate of GDP at market prices based on constant local currency. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.	1998-2018	World Bank Open Data
TRDGDP	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	1998-2018	World Bank Open Data
MarketCapGDP	Market capitalization is the share price times the number of shares outstanding for listed domestic companies. Investment funds, unit trusts, and companies whose only business goal is to hold shares of other listed companies are excluded. End of year values	1998-2018	World Bank Open Data
Inflation	Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.	1998-2018	World Bank Open Data
Internet	Individuals using the Internet (% of population) Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.	1998-2018	World Bank Open Data
RD	Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.	1998-2018	World Bank Open Data

Table 9: Description of financial integration indicators (II).

Variable	Description	Sample period	Source
GovernEffectiv	Government effectiveness 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	1998-2018	Worldwide Governance Indicator -World Bank
PoliticalStab	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism	1998-2018	Worldwide Governance Indicator -World Bank
RegulQuality	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	1998-2018	Worldwide Governance Indicator -World Bank
VoiceAccount	Voice and accountability 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.	1998-2018	Worldwide Governance Indicator -World Bank
EIBFinancing	The data contain the list of contracts signed by the European Investment Bank (project's name, date of signature, country, sector, amount in EUR). The EIB finances projects costing over EUR 25m with direct loans. The variable (EIBFinancing) is calculated on an annual basis as the total amount of financed projects by the European Investment Bank in a country divided by the total amount of projects financed in the EU for the respective year	1998-2018	European Investment Bank
European policy uncertainty	For european policy-related economic uncertainty an index based on newspaper articles regarding policy uncertainty is constructed. The index takes into account the number of newspaper articles containing the terms uncertain or uncertainty, economic or economy, and one or more policy-relevant terms. The countries under consideration are France, Germany, Italy, Spain and UK. Two newspapers per country are drawn. The index is calculated on a monthly basis	1998-2018	Economic Policy Uncertainty

Table 10: Summary statistics of integration drivers for EU28 from 1998 to 2018. The overall number of observations N , mean, standard deviation (sd), median, minimum and maximum are reported.

	N	mean	sd	median	min	max
TRDGDP	560	115.2	64.70	99.16	44.73	416.4
RD	521	1.433	0.872	1.233	0.216	3.914
VoiceAccount	560	1.121	0.341	1.124	-0.292	1.801
PoliticalStab	560	0.792	0.430	0.826	-0.474	1.760
GovernEffectiv	560	1.140	0.621	1.088	-0.569	2.354
RegulQuality	560	1.186	0.457	1.162	-0.109	2.098
Uncertainty	588	143.9	54.96	132.8	65.17	230.2
EIB_financing	549	0.038	0.053	0.01	0.000	0.209
MarketCapGDP	393	51.73	42.45	40.56	0.584	326.4
Internet	560	57.58	25.69	63.31	2.698	98.14
Inflation	560	2.672	3.816	2.130	-4.478	45.80
GDPgrowth	560	2.506	3.487	2.621	-14.81	25.12

Table 11: Correlation between estimated portfolios and factors, and the European factors. For each regime, correlation is computed between the estimated portfolios $r_{p,j}$, the estimated factors $F_{p,j}$, with $p = 1, \dots, p_1$ ($p = 1, \dots, p_2$) if $j = 1$ ($j = 2$), and the portfolios available on the French's website. The European portfolios correspond to the market (MKT), size (SMB), value (HML), profitability (RMW), investment (CMA) and momentum (WML) portfolios. Size portfolio is defined as the average return on small caps minus the average return on big caps; value portfolio is defined as the average return on the value portfolio (i.e. stocks that have market value that is small relative to the book value) minus the average return on the growth portfolio; profitability portfolio is defined as the average return on the most profitable firms minus the least profitable; investment portfolio is defined as the average return on conservative firms minus aggressive firms; momentum portfolio is defined as the average of the returns for the winner portfolio, based on past returns, minus the average of the returns for the loser portfolio.

	European portfolios					
	MKT	SMB	HML	RMW	CMA	WML
<i>Regime 1</i>						
$r_{1,1}$	0.931	-0.310	-0.233	-0.158	-0.251	-0.009
$r_{2,1}$	0.732	-0.974	-0.158	-0.253	-0.150	-0.055
$r_{3,1}$	0.400	-0.127	-0.819	0.270	-0.739	0.018
$r_{4,1}$	0.059	-0.105	-0.104	-0.301	-0.210	-0.004
$r_{5,1}$	-0.015	-0.318	0.221	0.011	0.326	-0.021
$\hat{F}_{1,1}$	0.914	-0.266	-0.222	-0.151	-0.240	-0.006
$\hat{F}_{2,1}$	-0.390	0.944	0.073	0.201	0.052	0.058
$\hat{F}_{3,1}$	0.066	-0.008	-0.782	0.324	-0.695	0.023
$\hat{F}_{4,1}$	-0.015	0.035	-0.116	-0.252	-0.218	0.006
$\hat{F}_{5,1}$	0.080	-0.149	0.179	0.009	0.273	-0.006
<i>Regime 2</i>						
$r_{1,2}$	0.982	-0.581	0.417	-0.210	-0.375	0.012
$r_{2,2}$	0.831	-0.941	0.352	-0.155	-0.312	0.000
$r_{3,2}$	-0.334	0.103	-0.583	0.555	0.076	-0.039
$r_{4,2}$	-0.020	-0.375	0.105	-0.103	0.184	0.031
$\hat{F}_{1,2}$	0.976	-0.558	0.412	-0.207	-0.373	0.013
$\hat{F}_{2,2}$	-0.193	0.756	-0.060	-0.017	0.082	0.018
$\hat{F}_{3,2}$	0.053	-0.162	-0.448	0.503	-0.070	-0.035
$\hat{F}_{4,2}$	0.077	-0.272	0.116	-0.103	0.151	0.037

C Robustness checks: Application on MSCI indexes

In this section, we provide robustness checks to verify the results gathered by using stock market indexes. We perform the analysis on the European sample of MSCI indexes, that are a measurement of stock market performance in a particular country. The MSCI indexes select high liquidity equities, indeed these indexes are usually used as benchmarks for mutual funds and exchange-traded funds. We collect daily returns, downloaded from Bloomberg, for the indexes listed in Table 12 from 1st January 1999 to 30th June 2019. Table 13 confirms that the distribution of returns for MSCI indexes is similar to the corresponding stock market indexes in Table 2. For example, the distributions of EA distressed countries are more leptokurtic than the ones for the EA-core.

We estimate the time-invariant and the time-varying integration indexes. The number of estimated factors is on average equal to one when we consider the full sample. However, when we perform the estimation over subsamples we observe that the number of factor increases up to two during the crisis period for the most of countries. In particular, we observe that the proportion of variance explained by the \hat{r} factors is larger during the crisis period than in the other subsamples. Using the stock market indexes, the number of selected factors was equal to two for the most countries over the subsamples. However, the evidence in terms of explained variance was also captured (see Section 4). The results are close to the ones provided by using market indexes as shown in Table 14 and in Figure 9. Indeed, the path of the integration over time is similar to the one in Figures 6 and 8. The cross-sectional distribution of the integration indexes $\hat{\rho}^2$ is less volatile during the crisis period than in the normal period.

Regarding the possible integration drivers, we further perform robustness checks using the MSCI indexes. We study the relation between the yearly integration index $\hat{\rho}_{adj,c,\tau}^2$ and its possible drivers, by estimating Equation (7). We provide results based on the integration indexes from MSCI indexes in Table 15 column (A). Results are comparable and similar with the ones get from the integration indexes estimated from the 22 European countries. The main difference observed is that market capitalization and inflation become not significant. Moreover, political stability (*PoliticalStab*) is now significant and positively relates to integration as political stability promotes integration through the tradability of stock markets.¹⁶ In column (B) of Table 15, we provide results based on the systematic volatility from the MSCI indexes. The results are comparable and in line with the ones shown in Table 4 column (B). The main difference is that the governess indicator *PoliticalStab* has a positive and significant impact. Results are also in line with the main application, when we consider the idiosyncratic volatility (column C). The governess indicators *VoiceAccount* and *GovernEffectiv* have also a significant and negative impact on the idiosyncratic volatility.

¹⁶For robustness checks, we estimate Equation (7) based on the integration index estimated from the EU28 sample. This sample is characterized by a smaller number of overall observations, and the estimation results are affected by that. Indeed, market capitalization, research and development expenditure and inflation continue as being significant, while the rest lose their statistical significance.

Table 12: List of MSCI indexes. For each index, the table reports the reference country, the ISO code and the classification of the country w.r.t. the euro area (EA). The countries are distinguished between EA-core, EA distressed and rest-EA. Distressed euro area includes the countries affected by the sovereign crisis. The table also reports the starting date of available data.

Index	Country	ISO code	Classification	Starting date
MSDUAT	Austria	AT	EA-core	1-Jan-99
MSDUBE	Belgium	BE	EA-core	1-Jan-99
MSDUFI	Finland	FI	EA-core	1-Jan-99
MSDUFR	France	FR	EA-core	1-Jan-99
MSDUGR	Germany	DE	EA-core	1-Jan-99
MSDUNE	Netherlands	NL	EA-core	1-Jan-99
M3GR	Greece	GR	EA distressed	1-Jan-99
MSDUIE	Ireland	IE	EA distressed	1-Jan-99
MSDUIT	Italy	IT	EA distressed	1-Jan-99
MSDUSPT	Portugal	PT	EA distressed	1-Jan-99
MSDUSP	Spain	ES	EA distressed	1-Jan-99
MSEUSCZ	Czech Republic	CZ	non-EA	1-Jan-99
MSEUSHG	Hungary	HU	non-EA	1-Jan-99
MSDUNO	Norway	NO	non-EA	1-Jan-99
MSEUSPO	Poland	PL	non-EA	1-Jan-99
MSDUSW	Sweden	SW	non-EA	1-Jan-99
MSDUUK	United Kingdom	UK	non-EA	1-Jan-99

Table 13: Summary statistics of MSCI returns. The table reports descriptive statistics from 1st January 1999. The number of observations T , mean, median, standard deviation (sd), median, skewness and kurtosis are reported.

	Country	T	mean	sd	median	skewness	kurtosis
E-A-core	AT	5345	0.004%	0.017	0.041%	-0.227	7.738
	BE	5345	-0.003%	0.014	0.026%	-0.388	7.936
	FI	5345	0.004%	0.021	0.000%	-0.359	7.461
	FR	5345	0.008%	0.015	0.046%	-0.076	6.486
	DE	5345	0.006%	0.015	0.037%	-0.085	4.988
	NL	5345	0.007%	0.014	0.032%	-0.187	6.678
EA distressed	GR	5280	-0.062%	0.024	0.000%	-0.447	9.003
	IE	5345	-0.016%	0.017	0.002%	-0.688	10.235
	IT	5345	-0.011%	0.016	0.021%	-0.220	6.811
	PT	5345	-0.017%	0.014	0.007%	-0.176	6.167
	ES	5345	0.001%	0.016	0.007%	-0.074	7.957
non-EA	CZ	5345	0.025%	0.016	0.052%	-0.178	11.753
	HU	5345	0.017%	0.021	0.050%	-0.038	8.638
	NO	5345	0.018%	0.018	0.049%	-0.423	7.779
	PL	5345	0.010%	0.019	0.018%	-0.190	4.368
	SW	5345	0.016%	0.018	0.036%	-0.001	4.881
	UK	5345	-0.001%	0.013	0.027%	-0.238	9.517

Table 14: Time-invariant integration index $\hat{\rho}_{adj}^2$ computed on the MSCI returns from January 1999 to June 2019. The indexes $\hat{\rho}_{adj}^2$ are also reported for the three subsamples over time (i.e., pre-crisis, crisis and post-crisis periods). Finally, the tables reports median, mean and standard deviation of the integration indexes computed across countries.

$\hat{\rho}_{adj}^2$	country	Full sample 1999-2019	Pre-crisis 1999-2007	Crisis 2008-2012	Post-crisis 2013-2019
EA-core	AT	0.626	0.346	0.791	0.619
	BE	0.661	0.570	0.746	0.672
	FI	0.510	0.390	0.778	0.648
	FR	0.885	0.808	0.945	0.893
	DE	0.777	0.670	0.889	0.829
	NL	0.818	0.733	0.915	0.816
EA distressed	GR	0.276	0.243	0.428	0.192
	IE	0.537	0.402	0.594	0.600
	IT	0.789	0.696	0.878	0.733
	PT	0.602	0.399	0.760	0.576
	ES	0.778	0.695	0.833	0.763
non-EA	CZ	0.411	0.251	0.614	0.252
	HU	0.477	0.271	0.653	0.394
	NO	0.612	0.440	0.750	0.526
	PL	0.474	0.232	0.716	0.467
	SW	0.708	0.579	0.839	0.716
	UK	0.748	0.639	0.840	0.741
median		0.626	0.440	0.778	0.648
mean		0.629	0.492	0.763	0.614
st.dev.		0.165	0.193	0.132	0.197

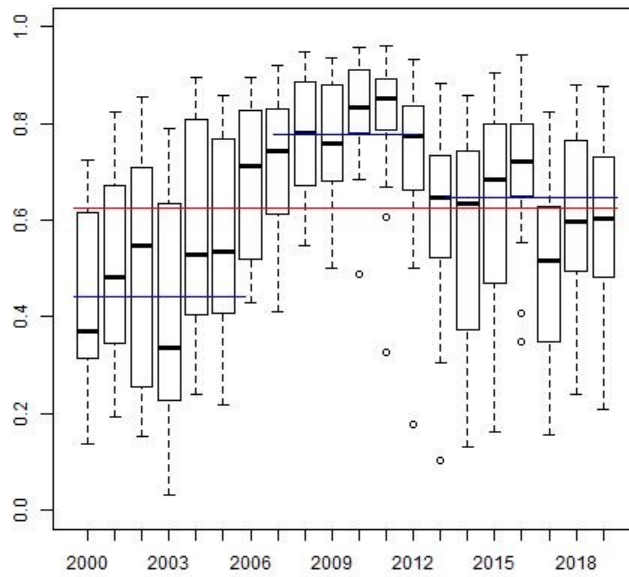


Figure 9: Distribution of cross-sectional integration index computed on yearly samples of the MSCI indexes returns from January 1999 to June 2019. The median of the time-invariant integration indexes computed over the full sample (red line) as well as over the two sub-samples (blue lines) are provided. The three sub-samples over time correspond to pre-crisis (1999-2007), crisis (2008-2012) and post-crisis (2013-2019) periods.

Table 15: Estimation results from Equation (7) using as dependent variable the yearly integration indexes (column A), the yearly systematic and idiosyncratic volatilities (column B and C, respectively), estimated from the MSCI indexes. Yearly data are span from 1999 to 2018. For the analysis on systematic and idiosyncratic volatilities, the natural logarithm transformation for the variables *MarketCapGDP*, *TRDGDP* and *Uncertainty* is applied in order to scale the data properly. Moreover, the global factor *Uncertainty* is not included in the analysis of the idiosyncratic volatility. Moreover, the global factor *Uncertainty* is not included in the analysis of the idiosyncratic volatility. L denotes the lag operator. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. N denotes the number of observations and $R - squared$ is the coefficient of determination. Robust standard errors are in parentheses.

Dependent Variable	Integration Index	Systematic volatility	Idiosyncratic volatility
	(A)	(B)	(C)
$L.\hat{\rho}_{adj}^2$	0.3566*** (0.0396)		
L.SystVol		0.2785*** (0.0549)	
L.IdiVol			0.4903*** (0.0641)
L.GDPgrowth	0.0046* (0.0024)	0.0002** (0.0001)	0.0000 (0.0001)
L.TRDGDP	-0.0003 (0.0002)	-0.0013 (0.0008)	-0.0007 (0.0013)
L.Uncertainty	-0.0013*** (0.0002)	-0.0062*** (0.0011)	
L.RD	0.0962** (0.0360)	0.0020 (0.0017)	-0.0012 (0.0016)
L.MarketCapGDP	0.0006 (0.0004)	0.0032*** (0.0010)	0.0024*** (0.0005)
L.Internet	0.0031*** (0.0007)	0.0001* (0.0000)	-0.0000 (0.0000)
L.Inflation	-0.0041 (0.0056)	-0.0001 (0.0002)	0.0001 (0.0002)
L.VoiceAccount	0.1662** (0.0610)	-0.0056* (0.0029)	-0.0069** (0.0026)
L.PoliticalStab	0.0779** (0.0271)	0.0028** (0.0012)	-0.0002 (0.0009)
L.GovernEffectiv	-0.0003 (0.0552)	-0.0035 (0.0020)	-0.0030* (0.0014)
L.RegulQuality	0.0010 (0.0619)	-0.0008 (0.0021)	-0.0001 (0.0016)
EIB_financing	0.7934*** (0.2580)	-0.0063 (0.0184)	-0.0250 (0.0188)
crisis	0.0889*** (0.0135)	0.0080*** (0.0008)	0.0023*** (0.0004)
Constant	-0.0745 (0.0823)	0.0332*** (0.0052)	0.0126** (0.0058)
Observations	219	219	219
$R - squared$	0.7020	0.7788	0.4338
Number of countries	15	15	15
Country FE	YES	YES	YES

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