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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. Financial integration increases during the sovereign debt crisis and is mainly driven by macroeconomic variables, market capitalization, political uncertainty, and technological developments. Higher market integration is associated with decreasing diversification benefits. During crises, investors select portfolios that are not only explained by firm characteristics.

1. Introduction

In Europe, the Economic and Monetary Union (EMU) has been an important driver for financial market liberalization (Berben and Jansen, 2009). Financial reforms aimed to liberalize financial markets, 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, 2014a, 2014b), and reducing the risk in financial operations (EMIR I 2012; EMIR II, 2017). 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 that is 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). There is no single definition of financial integration, and the literature proposes several frameworks to identify and measure it.

Our paper focuses on the European Union 28 (EU28) countries and contributes to the financial integration literature in various ways. First, we attempt to answer how the European integration process evolved over time; in particular, after the intro-

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duction of the euro and during the financial and sovereign debt crises. We explore whether there are any structural breaks present during the financial integration process. In order to answer these questions, we provide an empirical analysis, studying the co-movements of European stock market returns. From a theoretical point of view, we formalize the framework based on 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 factors 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, we are the first to disentangle the two components from the integration index. A deeper understanding of the relationship, over time, between systematic and idiosyncratic volatilities and 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, even though its integration levels are similar to a set of comparable countries. Our empirical findings provide evidence of a time-varying integration index that has a strong, positive correlation with systematic volatility.

Secondly, 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 a market harmonized by policy actions, we do not consider institutional factors concerning, for example, capital account openness or legal origins, as for example in Lehkonen (2015). Moreover, as compared to other studies (e.g., Lehkonen, 2015), our interest is on the effect of the European sovereign crisis on the integration process among 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 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, overall political uncertainty, and technological developments. We show that these variables also drive systematic volatility.

Finally, our paper also contributes to the portfolio diversification literature. We provide an application to analyze how market integration implies a diversification benefit. Our methodological approach is similar to Cotter et al. (2019), who 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 according to the definition of the EMU, and through implementation of progressive policy actions. We provide an empirical analysis, studying a regime factor structure for 100 European portfolios from Kenneth French's website. By mapping the regime-specific exposures to the weights of factor-mimicking portfolios, we analyze how the portfolios and the benefits of diversification change between the two regimes. In particular, we show that a European investor changes the asset allocation of their portfolio, reducing diversification benefits, during periods of high integration.

The paper is organized as follows. In Section 2, we formalize the theoretical framework for the integration index and its components. In Section 3, we describe the data involved in the estimation of the integration index. In Section 4, we provide results on the degree of integration among European equity markets, and robustness checks. In Section 5, we analyze the drivers of financial integration and its components. In Section 6, we provide applications of our findings on portfolio allocation and on the benefits of diversification. Finally, we conclude in Section 7.

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

There is no single definition of financial integration and the literature proposes several frameworks to identify and measure it.

A stream of literature measures financial integration based on firms' and households' savings and investments decisions, essentially looking at "quantities" of savings, investments, and cross-border links. Feldstein and Horioka (1980) look 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]. Conversely, Darvas et al. (2015) show a negative cross-country savings-investment correlation between 1999 and 2007 for euro area countries, and a strong positive correlation in 2008–2014 (see also Hussain and Cleeton, 2017).

Similarly, an indirect way to look at integration barriers is by measuring the extent of domestic consumption smoothing via cross-border links, namely risk sharing. If financial markets are indeed integrated, then in the 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 the case of domestic shocks. In the same vein, Volosovych (2011) shows that poor quality institutions are an effective barrier 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.

Researchers also propose measures based on the divergence from the law of one price (Adam et al., 2002). According to the law of one price, identical assets should be traded at the same price in different locations. In other words, with financial market integration, there should be no space for unexploited international arbitrage, and the prices of the same item in different currencies should 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) and Lin et al. (1994), and later on with Longin and Solnik (2001) and Kearney and Lucey (2004). Since then, many studies have provided results showing that measures of co-movement, such as the correlation across markets, are actually poor measures of financial integration. Carrieri et al. (2007), Pukthuanthong and Roll (2009), and Billio et al. (2017) show that the correlation coefficient tends to underestimate the degree of integration. Carrieri et al. (2007) instead provide 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 indexes based on real activity. Pukthuanthong and Roll (2009) 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 as being integrated. In the next subsection, 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, residual, and approximately zero for each country c, whereas, 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 indexes, 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).

We assume that the return $R_{c,t}$ satisfies the factor structure as follows

$$R_{c,t} = \beta_c' F_t + \varepsilon_{c,t}, \tag{1}$$

where β_c is a vector of factor loadings, F_t is a vector of r common factors so that $\beta_c' F_t = \beta_{c,1} F_{t,1} + \cdots + \beta_{c,r} F_{t,r}$, 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 contrary, if the degree of integration is low, returns should be explained by local factors (e.g., Stulz, 1981; 1987; Errunza and Losq, 1985).

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

$$R_t = BF_t + \varepsilon_t, \tag{2}$$

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 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, and (ii) $\mu_r\left(\frac{1}{C}\sum_c \beta_c \beta_c'\right) \geq M$ w.p.a. 1 as $C \to \infty$ for a constant $M > 0$, where $\mu_r(.)$ 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 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

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

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-sectional dependence allows for a block cross-sectional dependence between the returns of stock index countries that belong, for example, to 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 measuring the degree of integration based on the fraction of unexplained variance, namely the coefficient of determination of the linear multi-factor model in eq. (1) with estimated factors. Indeed, the integration index depends on factor volatilities and their factor loadings. In our context, the daily returns of the market indexes $R_{c,t}$ are not observed for all the same dates in the different countries, thus we introduce an indicator function $I_{c,t}$. This indicator assumes the values of 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 following integration index:

$$\rho^2_{c,adj} = 1 - \frac{T_c - 1}{T_c - r}(1 - \rho^2_c), \text{ with } \rho^2_c = \frac{ESS_c}{TSS_c}, \tag{3}$$

where the explained sum of squared return is $ESS_c = \sum_t I_{c,t}(\widehat{R}_{c,t} - \overline{\widehat{R}}_c)^2$ and the total sum of squares is $TSS_c = \sum_t I_{c,t}(R_{c,t} - \overline{R}_c)^2$, with $\widehat{R}_{c,t} = \widehat{\beta}'_c \widehat{F}_t$, $\overline{\widehat{R}}_c = \frac{1}{T_c}\sum_t I_{c,t}\widehat{R}_{c,t}$ and $\overline{R}_c = \frac{1}{T_c}\sum_t I_{c,t}R_{c,t}$.

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

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

and (ii) the idiosyncratic volatility

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

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

$$\rho^2_c = \frac{SystVol^2_c}{SystVol^2_c + IdiVol^2_c}, \tag{6}$$

and is positively affected by the proportion of systematic risk (Gagliardini et al., 2016). 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 the 28 EU countries. Data are downloaded from Bloomberg. We get an unbalanced dataset of continuously compounded daily returns that covers the period from January 1, 1999 to June 30, 2019. The eurozone was established with the official launch of the euro (alongside national currencies) on January 1, 1999. Thus, we consider this event as the starting date of our sample. Table 1 contains the list of indexes involved in our analysis. We distinguish between four regions: (i) core euro area (EA-core), (ii) distressed euro area (EA distressed), (ii) rest of the EA, and (iv) non-euro area (non-EA) countries.[2] The distressed euro area includes the countries that were mostly affected by the sovereign debt crisis (e.g., Lane, 2012). For some countries (i.e., Cyprus, Latvia, Lithuania, Bulgaria, Slovenia, and Croatia), data are only available later than January 1999. In order to include them in the analysis, and to avoid cumbersome computation due to an unbalanced panel, we provide two separate analyses. The first one includes the 22 European countries for which data are available from January 1, 1999. The second one is performed on the 28 European countries starting from September 1, 2004.[3]

Table 2 reports the descriptive statistics for index returns. Statistics are reported from January 1999 for the 22 countries and from September 2004 for the 28 countries. The EA distressed countries are characterized by large negative returns with respect to the other countries. Comparing the two subsamples over time and focusing on the EA-core, the average returns become positive and larger in the second subsample. However, if we consider the EA distressed countries, the average returns are negative and slightly more leptokurtic in the second subsample (e.g., Greece and Spain). For the non-EA countries, the mean

[2] Analyzing the pairwise correlation indexes across countries by ordering the countries with respect to the four regions in which they belong (i.e., EA-core, EA distressed, rest of the EA countries, and the non-EA countries), we get evidence of a correlation matrix with a block structure (i.e., we observe different degrees of correlation between and among the regions). This justifies the choice to provide an analysis distinguishing between four regions. In particular, the correlation among the EA-core and EA distressed countries 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 the EU28. The UK is highly and positively correlated with EA-core and EA distressed countries.

[3] We report the results concerning the 28 EU countries in Subsection 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 with respect to the euro area (EA). The countries are distinguished between EA-core, EA distressed, and rest-EA. The distressed EA includes the countries that were most 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

of returns is, in general, positive across the two subsamples. The only exception is the United Kingdom, which has a distribution similar to one of the EA-core countries. In general, normality tests are rejected for all countries. Indeed, the data show a high level of kurtosis.

4. Financial integration in EU equity markets

We next 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 into 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 debt crisis, and (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 of Pukthuanthong and Roll (2009), taking into account 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 principal components, 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) note that the pattern of the integration index is similar, but with a slight 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 the variation in the return of assets. In our context, we prefer to introduce a selection criterion, in order to loosen any priori-assumptions on the number of factors and ensure parsimony in the number of parameters to estimate. The selected number of factors $\hat{r}$, as defined in eq. (A.1), equals, on average, 2.[4] 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 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 Fig. 1 for Germany. Fig. 1 provides the scree plots of the first ten eigenvalues computed over the full sample and over 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

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

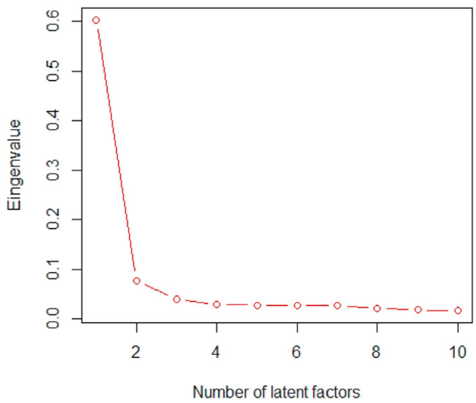
Table 2
Summary statistics of daily returns. The table reports descriptive statistics from January 1, 1999 and from September 1, 2004 (in italicized). The number of observations *T*, mean, standard deviation (st.dev.), median, skewness and kurtosis are reported.

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

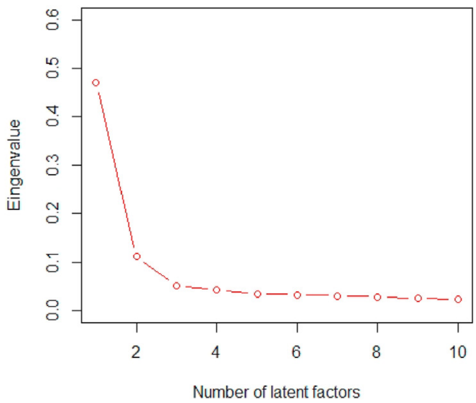
the proportion explained by the subsequent factors. Across all countries, the contribution of the $\hat{r}+1$ eigenvalue is about 4% (on average over the subsamples) and it is a marginal contribution with respect to the first $\hat{r}$ eigenvalues.

Table 3 reports the estimated integration indexes (i.e., the coefficients of determination $\hat{\rho}^2_{adj,c}$) over the full sample and the three subsamples over time. The degree of integration for EA-core and EA distressed countries is high and further increases during the crisis period. The rest of the EA and the non-EA countries exhibit a low degree of integration. However, during the crisis period, the degree of financial integration also more than doubled in the rest of the EA and the non-EA. After the crisis, for most of the EA and non-EA 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 out-of-sample principal components with respect to years and country, as described in Appendix A. For each country, we get a time-series of the integration index. Figs. 2–5 display the estimated time-varying integration index by calendar year, for each country, grouped by the country regions presented in Table 1. For illustrative purposes, the median of the static integration indexes, computed over the full sample (dashed line), as



(a) Germany, 1999-2019, full sample



(b) Germany, 2008-2012, crisis period

Fig. 1. Number of latent factors for Germany. 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
Time-invariant integration index. Time-invariant integration index $\widehat{\rho}^2_{adj}$ computed on the daily returns from January 1999 to June 2019 of the 22 market indexes. $\widehat{\rho}^2_{adj}$ 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 $\widehat{\rho}^2_{adj}$ across countries.

$\widehat{\rho}^2_{adj}$	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

well as over the subsamples (solid lines), are also shown. In terms of the median of the time-varying integration indexes, over the full sample, EA-core countries 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 for most countries. If we move further through the time-varying integration indexes, the patterns are even more informative. For example, the financial integration index for 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 Figs. 2–5, we also plot the patterns of the two components of financial integration: the time-varying systematic volatility (two-dashed triangle) and idiosyncratic volatility (dotted diamond). We observe that, as expected, a positive relation exists between the systematic component and the integration index. Systematic volatility is higher than idiosyncratic volatility, corresponding to high

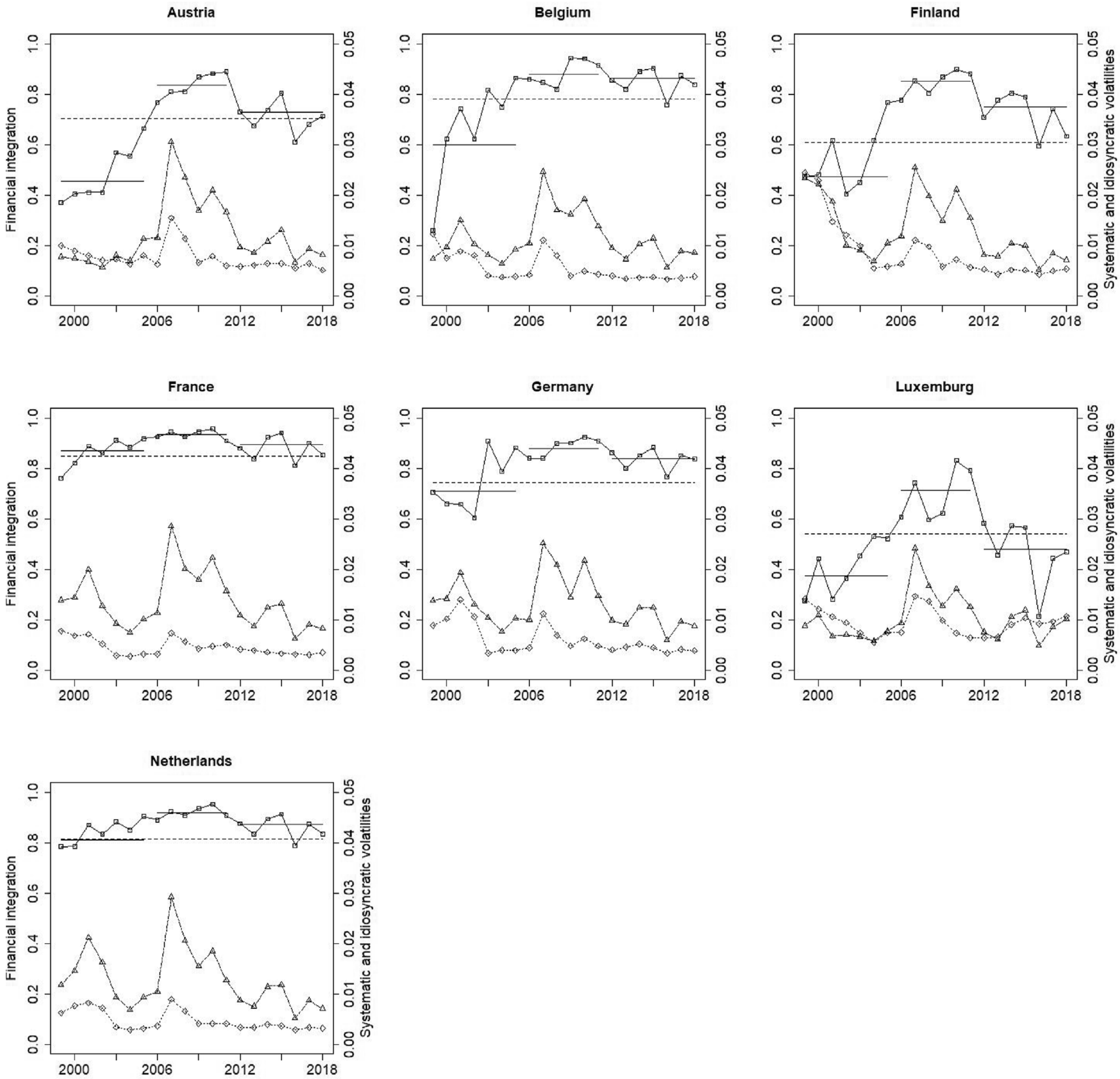


Fig. 2. Financial integration index of the EA-core countries. The plots report the time-varying integration index (solid square), the static estimation of the financial integration over the full sample (dashed line) and the three periods (solid lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed triangle) and idiosyncratic (dotted diamond) volatilities are also reported on the right axis.

levels of integration. In that case, the index returns are well explained by the selected common factors. Idiosyncratic volatility and the integration index have a strong negative correlation during the crisis. 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 peak of systematic volatility in 2009 and 2011, capturing the effect of the financial and sovereign crises. Idiosyncratic volatility is always characterized by a less volatile path over time. This does not hold for all EA distressed countries. For example, idiosyncratic volatility shows large peaks and high variation for Greece and Ireland, during and after the crises. In particular, for Greece, we observe evident specular trajectories of the two components during and after the sovereign crisis, showing that the returns of these countries are better explained by local factors. Idiosyncratic volatility for some countries (e.g., Hungary, Poland, Denmark, among others) features a larger peak than systemic volatility during the crisis periods. Finally, the path of systemic volatility of the UK is similar to the one observed for the EA-core countries.

In Fig. 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 worth noting that the time-invariant financial integration index approximately corresponds to

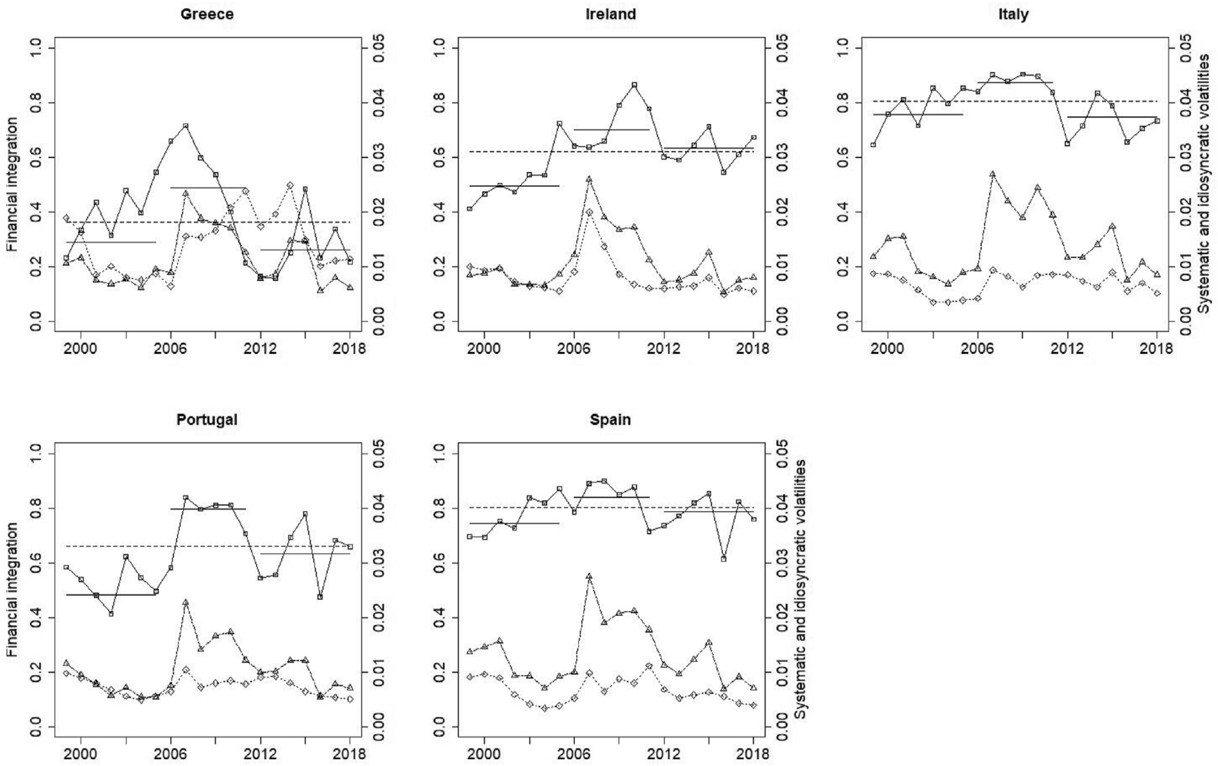


Fig. 3. Financial integration index of the EA distressed countries. The plots report the time-varying integration index (solid square), the static estimation of the financial integration over the full sample (dashed line) and the three periods (solid lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed triangle) and idiosyncratic (dotted diamond) volatilities are also reported on the right axis.

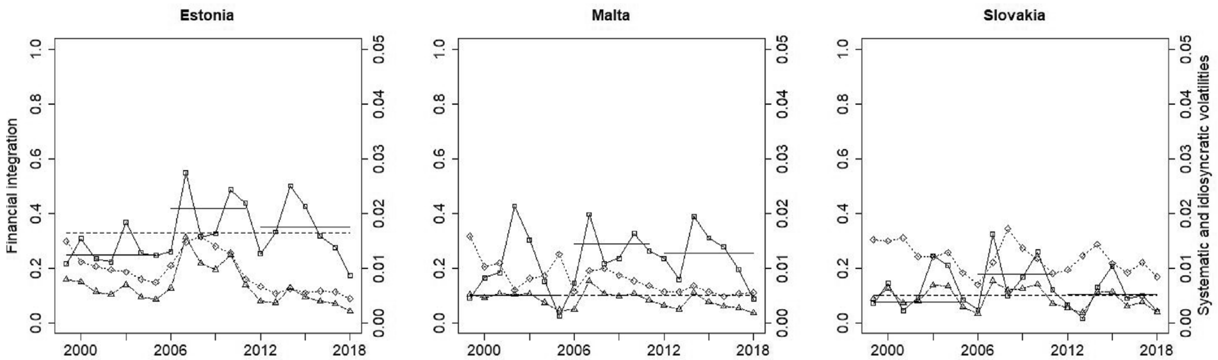


Fig. 4. Financial integration index of the rest-EA countries. The plots report the time-varying integration index (solid square), the static estimation of the financial integration over the full sample (dashed line) and the three periods (solid lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed triangle) and idiosyncratic (dotted diamond) volatilities are also reported on the right axis.

the average, over years, of the values of the median, computed across countries. Using the graphic representation in Fig. 6, we are able to check the volatility of the integration index among the EU countries. We find that financial integration increases and is more homogeneous across countries during the sovereign debt crisis. At the same time, the integration index decreases after the crisis and the heterogeneity across countries is more evident.

In order to analyze the heterogeneity of the financial integration indexes across the regions, in Fig. 7, we plot 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 the integration index. Focusing on the EA distressed countries, we observe a relevant structural break in 2011 and its large confidence interval covers both the financial and the sovereign crises. The integration index of the non-EA countries shows a change during the sovereign crisis. Focusing on the EA-core, we observe

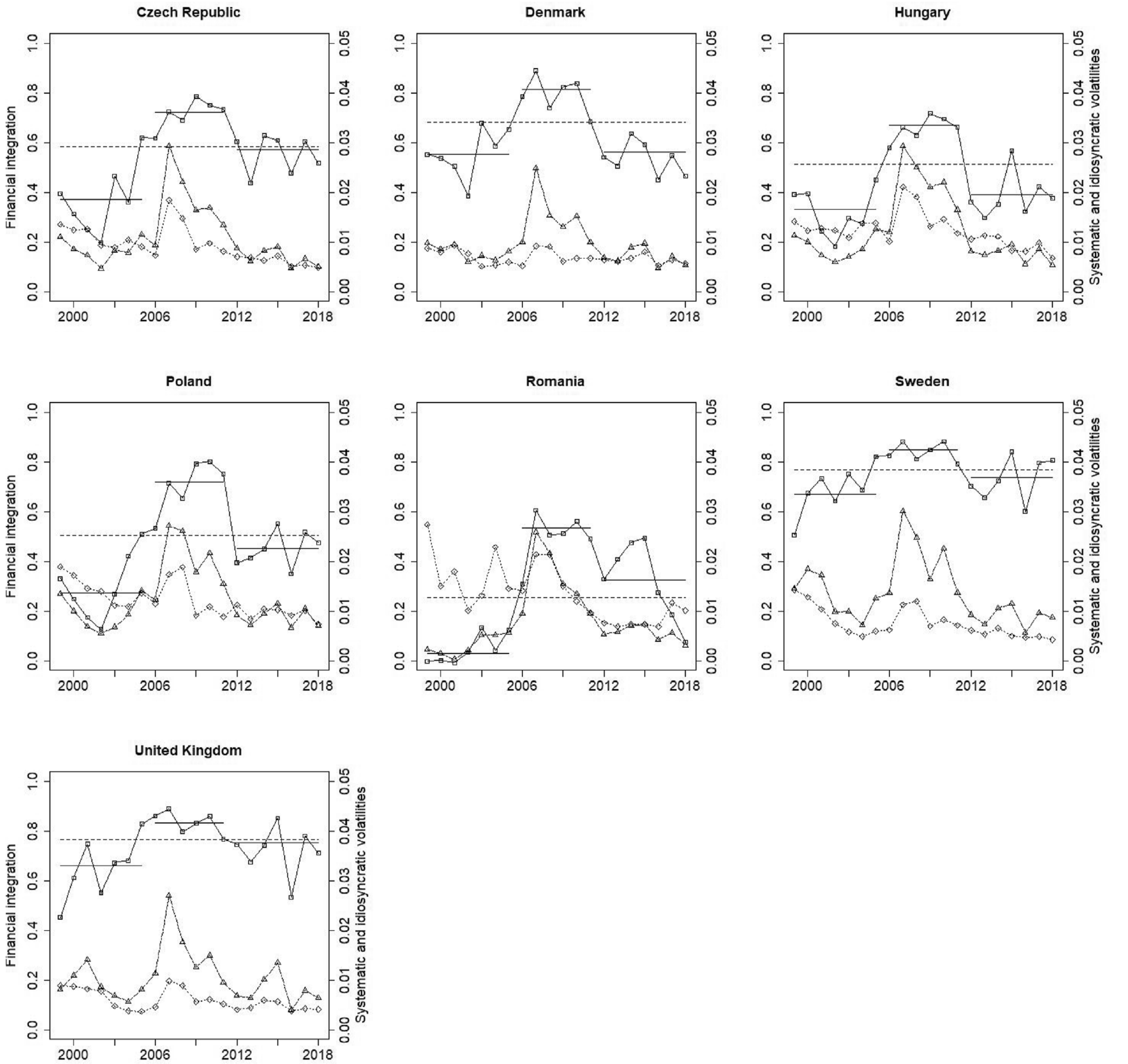


Fig. 5. Financial integration index of the non-EA countries. The plots report the time-varying integration index (solid square), the static estimation of the financial integration over the full sample (dashed line) and the three periods (solid lines, pre-crisis, crisis and post-crisis). Systematic (two-dashed triangle) and idiosyncratic (dotted diamond) volatilities are also reported on the right axis.

a change in 2003 in the mean of the integration index.[5] We also observe that in 2005, the time series for EA distressed and non-EA countries displays a structural break characterized by tighter confidence intervals as compared to the others breaks. It could reflect the market anticipation of the collapse of the housing bubble as by mid-2005 there were already some public discussions. Finally, the median of the integration index computed for the rest of the EA countries seems not to be affected by any structural breaks. These results provide evidence that studying the dynamic of the integration index is crucial.

4.1. Robustness checks

In order to verify the results, 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

[5] The break in 2003 could reflect the energy crisis affecting the real economy.

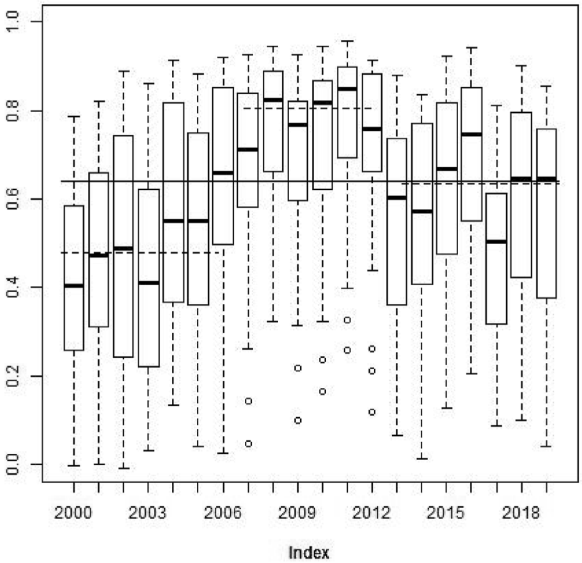


Fig. 6. Distribution of cross-sectional integration index estimated on the 22 market indexes. Distribution of cross-sectional integration index computed on yearly samples of stock market index returns from January 2000 to June 2019. The median of the time-invariant integration indexes computed over the full sample (solid line), as well as over the three sub-samples (dashed lines) are provided. The three sub-samples over time correspond to the pre-sovereign debt crisis (1999–2007), crisis (2008–2012), and post-crisis (2013–2019) periods.

the estimation analysis on the European sample of MSCI indexes. The results on MSCI indexes are reported in Appendix B.

Next we consider daily returns from September 1, 2004 to June 30, 2019 for the 28 European countries listed in Table 1. This cross-sectional enlargement allows us to include Cyprus, Latvia, Lithuania, and Slovenia (as the 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, which are characterized by a small financial market. However, in Table A1 in Appendix B, 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 $\widehat{\rho}^2_{adj}$ in Table 3. Moreover, we again observe that the integration index increases during the crisis period, although 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 Fig. 8.

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 systematic and idiosyncratic volatilities in our set of countries.

5.1. Review of literature on the determinants of integration

Several factors could affect the degree of integration, such as the overall macroeconomic environment, barriers to trade, or the level of development of the financial markets. 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 overall economic development. The authors also point to the advanced degree of integration of the EU15 countries. However, their estimations are based on 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 of Pukthuanthong and Roll (2009). Lehkonen (2015) considers numerous possible drivers for integration, reflecting financial development, openness, overall global uncertainty, country-specific risk factors, growth, and various information technology variables (e.g., telephone lines, Internet connections). In general, his results are in line with previous studies suggesting that openness, a country's investment profile, and global risk factors are related to the degree of integration.

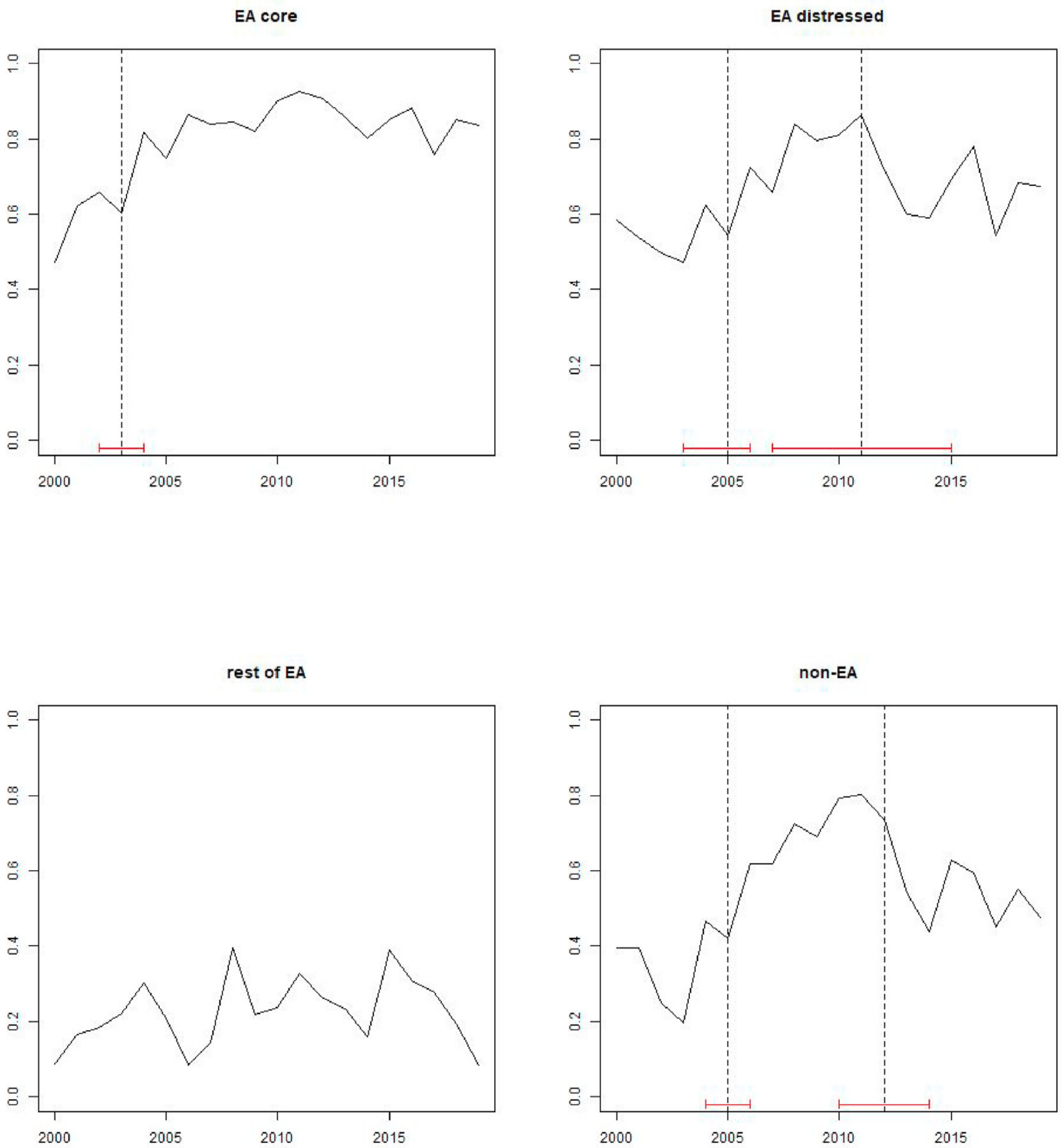


Fig. 7. Structural breaks of integration indexes. Time series of the median financial integration index computed by grouping countries in the four EA regions defined in Table 1. For each series, the Chow test is performed. The dotted vertical lines indicate the break dates and the horizontal lines correspond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

The introduction of the euro, and the associated elimination of foreign exchange risk, together with actions towards a single market, where capital moves freely, undoubtedly 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 worldwide studies. In an early study by Hardouvelis et al. (2006), by analyzing stock market data for 11 euro-area countries plus the UK, from 1992 to 1998, the authors examine whether convergence towards the single currency affected the integration process of European countries. The degree of integration is conditioned on a set of monetary, currency, and business cycle variables, which are used as proxies for European convergence. Movements of forward interest rate differentials in Germany (used as an indicator of the probability of joining the common currency) turned out to be the variable most 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 that is 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 a sovereigns' credit rating all influence the integration process.

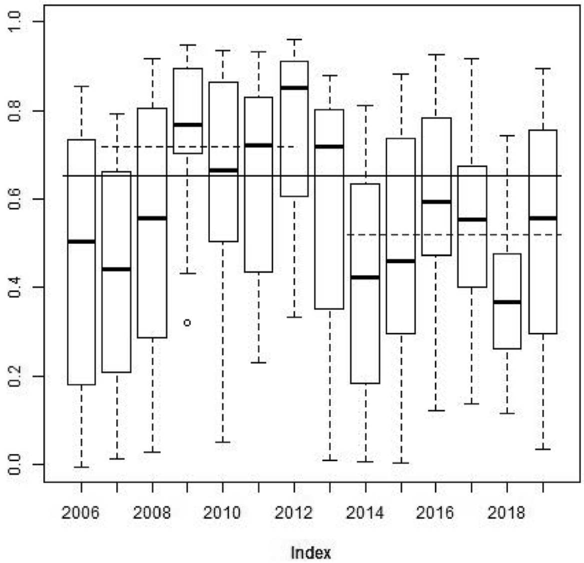


Fig. 8. Distribution of cross-sectional integration index estimated on the EU 28 market indexes. Distribution of cross-sectional integration index computed on yearly samples of stock market index returns from January 2006 to June 2019. The median of the time-invariant integration indexes computed over the full sample (solid line) as well as over the three sub-samples (dashed lines) are provided. The three sub-samples over time correspond to the pre-sovereign debt crisis (1999–2007), crisis (2008–2012), and post-crisis (2013–2019) periods.

With respect to other studies (e.g., Lehkonen, 2015), our focus is restricted to EU countries that are harmonized in terms of financial environment (e.g., free movement of capital, harmonized banking systems, and a common framework for the coordination of economic policies). 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, macro-economic profile, and business characteristics. First, we consider GDP growth (*GDPgrowth*) as an overall indicator of the economic performance of a country. A country that is more open to trade should be more integrated as this variable acts as an indicator of capital mobility. Thus, we consider the ratio of the 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 were downloaded from the World Bank for the 1998–2018 period.

We also attempt to examine whether the overall quality of governance of a sovereign state has an impact on integration. A country with better quality governance could attract more foreign investors, and thus, exhibit a higher degree of integration. We therefore 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 a government's policies and regulations promote private sector development (*RegulQuality*), and citizens' freedoms (*VoiceAccount*).

An indicator that, to the best of our knowledge, has not been tested in EU related integration literature is the total amount of projects financed by the European Investment Bank in each country.[6] 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 projects financed by the European Investment Bank in a particular country, divided by the amount of projects financed by the EU overall for the respective year.

Finally, we also control for any possible effect of overall European policy uncertainty. We introduce an indicator constructed on a monthly basis that is based on newspaper articles regarding policy uncertainty.[7] As our analysis has an annual frequency, the uncertainty (*Uncertainty*) indicator is calculated as the twelve-month median for each respective year.

[6] This indicator is available on the European Investment Bank's website https://www.eib.org/en/projects/loans/index.htm.

[7] The uncertainty indicator is download from https://www.policyuncertainty.com/index.html.

Tables A2 and A3 in Appendix C provide a description and the relevant sources of the financial integration indicators, while Table A4 in Appendix C reports the summary statistics of the considered variables. All indicators are well populated, with the only exception being the variable for market capitalization (e.g., for Estonia, Lithuania, and Latvia, the time series is missing, while for the Czech Republic, we only have 10 years of data).

5.3. Results

In order to study the relationship between the yearly integration index $\widehat{\rho}^2_{adj,c,\tau}$, defined for each country c in 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:

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

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 takes the value 1 between 2008 and 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 feedback among the independent and explanatory variables. Since the financial integration index is correlated with systematic and idiosyncratic volatilities, as shown in eq. (6), we also analyze the factors that might influence the systematic and idiosyncratic volatilities. In particular, we estimate the panel regression in eq. (7) for the dependent variables *SystVol* and *IdiVol*, as defined in eqs. (4) and (5) respectively.[8]

Table 4 presents the estimated results of eq. (7) using robust standard errors. In particular, columns (1), (2) and (3) gather results based on the integration index, systematic and idiosyncratic volatilities estimated from the 22 European countries listed in Table 1.[9]

Focusing on column (1) of Table 4, as the positive sign of the lagged dependent variable $\widehat{\rho}^2_{adj,c,\tau-1}$ indicates, an integrated country will most likely continue to be 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 not be significant. A sovereign's expenditure on research and development (*RD*) positively and strongly significantly affects the degree of integration in 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 in a higher degree of integration. The same conclusion also holds for the level of technological development as expressed by the share of population that uses the Internet. The share of population that uses digital services, communication, and information technology impacts the ease of doing business and a country's openness and affects the integration level. 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 disinvestment of capital and negatively affects integration among European countries. Not surprisingly, market capitalization as a share of GDP impacts the degree of integration in a significant and positive way. In line with the literature (e.g., Volosovych, 2011), a negative relationship between inflation and integration is evident, as low inflation reduces uncertainty and is closely related to expectations of economic stability. Regarding the governance indicators, only the voice and accountability indicator (*VoiceAccount*) appears to be significant with a positive coefficient. As documented in the literature (e.g., Elbahnasawy and Revier, 2012), *VoiceAccount* is associated with a country's corruption level, which impacts integration. Finally, we observe a positive effect in a country's degree of integration, stemming from the amount of projects financed by the European Investment Bank, as this attracts investors and thus promotes integration. As expected, in view of the results presented in Section 4, the sovereign debt crisis positively affected integration.[10]

Table 4, column (2), presents the estimation results for the systematic volatility. Given the evidence of the positive correlation between the 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*, overall policy-related uncertainty, and technological progress significantly affect systematic volatility. However, *EIB_financing* and *RD* are no longer significant when *SystVol* is considered. As discussed above, expenditures on research and development promote integration; however, the rationale 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 rationale also holds for *EIB_financing*, although the total amount of projects financed by the European Investment Bank does promote economic growth and job creation, and therefore 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 idiosyncratic volatility. As *Uncertainty* is not country-specific, we have not 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

[8] *SystVol* and *IdiVol* have been normalized using the min-max transformation.

[9] Slovakia, Estonia, and the UK are not included in the estimations as *TRDGDP*, *MarketCapGDP*, and *EIB_financing* are not populated for these countries.

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

Table 4
Drivers of financial integration, systematic and idiosyncratic volatilities. Estimation results from eq. (7) using as dependent variables the yearly integration indexes (column 1), and the yearly systematic and idiosyncratic volatilities (columns 2 and 3, respectively), using the sample of 22 European countries. The yearly data 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%, respectively. $R-squared$ is the coefficient of determination. Robust standard errors are in parentheses.

Dependent Variable	Integration Index (1)	Systematic volatility (2)	Idiosyncratic volatility (3)
L.$\widehat{\rho}^2_{adj}$	0.3433***		
	(0.0558)		
L.SystVol		0.2530***	
		(0.0542)	
L.IdiVol			0.4540***
			(0.0679)
L.*GDPgrowth*	0.0050*	0.0003***	0.0001
	(0.0028)	(0.0001)	(0.0001)
L.*TRDGDP*	0.0000	−0.0001	−0.0000
	(0.0001)	(0.0010)	(0.0011)
L.*Uncertainty*	−0.0011***	−0.0058***	
	(0.0002)	(0.0008)	
L.*RD*	0.1114***	0.0010	−0.0013
	(0.0297)	(0.0014)	(0.0011)
L.*MarketCapGDP*	0.0004**	0.0021**	0.0018***
	(0.0002)	(0.0008)	(0.0005)
L.*Internet*	0.0024***	0.0001**	−0.0000
	(0.0006)	(0.0000)	(0.0000)
L.*Inflation*	−0.0055***	−0.0000	0.0001
	(0.0009)	(0.0001)	(0.0000)
L.*VoiceAccount*	0.1496**	−0.0052**	−0.0039*
	(0.0629)	(0.0022)	(0.0020)
L.*PoliticalStab*	0.0387	0.0021	−0.0000
	(0.0225)	(0.0015)	(0.0008)
L.*GovernEffectiv*	−0.0092	−0.0023	−0.0018
	(0.0407)	(0.0018)	(0.0011)
L.*RegulQuality*	0.0352	0.0001	−0.0007
	(0.0563)	(0.0019)	(0.0015)
EIB_financing	0.8431***	−0.0003	−0.0144
	(0.2477)	(0.0158)	(0.0136)
Crisis	0.0894***	0.0077***	0.0024***
	(0.0118)	(0.0008)	(0.0004)
Constant	−0.0537	0.0277***	0.0071
	(0.0700)	(0.0051)	(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

as expressed by the *MarketCapGDP* variable. Regarding the sign of the respective coefficient, the rationale is that in a country with a large financial market as compared to its GDP, if the financial market in that respective country 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 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, these results (see Table A9 in Appendix B) are comparable to and in line with the ones shown in Table 4.

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 $\widehat{\rho}^2_\tau$ be the yearly median across countries of the country-specific financial integration $\widehat{\rho}^2_{adj,c,\tau}$. We define *Regime 1* as the low integrated regime for which $\widehat{\rho}^2_\tau < \theta$, and *Regime 2* as the high integrated regime with $\widehat{\rho}^2_\tau \geq \theta$, where θ is the threshold parameter. Referring to the results for the 22

Table 5
Summary statistics of portfolio weights. The table reports the descriptive statistics of portfolio weights $w_{i,j,p}$, with $i = 1, \ldots, N, j = 1, 2$, and $p = p_1 = 5\,(p = p_2 = 4)$ when $j = 1\,(j = 2)$. The mean, standard deviation (std.dev.), median, minimum, maximum, skewness and kurtosis are reported.

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

European stock market indexes in Fig. 6, we fix θ equal to the median of $\widehat{\rho}^2_\tau$, i.e., $\theta = 0.647$.[11]

We consider a combined set of $N = 100$ European portfolios available from Kenneth French's 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; and 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 $i = 1, \ldots, N$, at date $t = 1, \ldots, T$ satisfies the following linear factor structure:

$$R_{i,t} = \boldsymbol{I}_{1,t}\beta'_{1,i}F_{1,t} + \boldsymbol{I}_{2,t}\beta'_{2,i}F_{2,t} + \varepsilon_{i,t}, \tag{8}$$

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. $\boldsymbol{I}_{1,t}$ and $\boldsymbol{I}_{2,t}$ are the indicator functions defining the two regimes on each day $t \in \tau$. Based on the previous analysis, we assume that the factors explaining the systematic component of risk can be different 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 eq. (8). Furthermore, we use the estimated vectors of risk exposures $\widehat{\beta}_{j,i}$ to construct $P = p_1 + p_2$ portfolios that bear only the systematic risks with the following weights: $w_{i,j} = \widehat{\beta}_{j,i}(\widehat{\beta}'_{j,i}\widehat{\beta}_{j,i})^{-1} = \widehat{\beta}_{j,i}/N$ with $j = 1, 2$ (see Lehmann and Modest, 2005). DeMiguel et al. (2009) empirically investigate the out-of-sample performance of a naïve 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 $p = 1, \ldots, p_1\,(p = 1, \ldots, p_2)$ if $j = 1\,(j = 2)$, mimic the estimated factors $\widehat{F}_{1,t}$ and $\widehat{F}_{2,t}$. Table 5 provides summary statistics for the resulting portfolio weights. The average weight is $1/N$ by design. The first factors $\widehat{F}_{j,1,\tau}$ are likely the market factors: the weights associated with 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 irrelevant variation among the regimes. All the other portfolios allow for long and short positions, and change sign and/or dimension when the regime changes. We observe a different dynamic of weights between regimes. For example, for the second portfolio, the distribution of weights $w_{i,2,2}$ is characterized by larger variation and values compared to the distribution of weights $w_{i,1,2}$ in *Regime 1*, suggesting that the allocation of portfolios is more concentrated in some assets in *Regime 2*. In order to identify the portfolios, we perform a correlation analysis between the P portfolios and the European factors available on Kenneth French's website.[12] Indeed, by design, 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).[13] 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 the profitability portfolio. However, it seems difficult to have a clear conclusion on the fourth portfolio. Thus, a classical five-factor model explains 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 means that during a crisis, for an integrated regime, as shown in Section 4, a classical model for portfolio returns does not hold. Systematic risk, represented by the $F_{2,t}$ factor, might be explained by other drivers of integration as shown in Section 5. Our results confirm that factor structure changes over time, and asset allocation changes

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

[12] See results in Table A5 in Appendix C.

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

Table 6
Benefits of portfolio diversification. Average values of R-squared associated with each factor within each regime. R-squared values are computed from the regime-specific regressions of each Fama-French portfolio on the estimated factor $\widehat{F}_{j,t}$ 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
Regime 1	5	0.796	0.074	0.0215	0.016	0.011	0.918
Regime 2	4	0.910	0.030	0.0105	0.008	–	0.958

between regimes, as dealt with in studies on regime shift models (e.g., Ang and Timmermann, 2012; Massacci, 2021, among others).

In order to study the benefits of portfolio diversification, we perform regime-specific regressions of the return of each portfolio $R_{i,t}$ on each estimated factor. Then, we compute the average, across the portfolios, R-squared associated with each factor, within each regime. We compute the diversification benefits, mapping regime-specific exposures, to the weights of factor-mimicking portfolios, as explained above. Contrary to Cotter et al. (2019), we do not assume that an investor allocates his wealth in a set of country indexes, but we assume that an investor maximizes his wealth investing in portfolios defined on the 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.[14] In Table 6, we observe that during *Regime 2*, the benefits from diversification are lower than in *Regime 1*. Indeed, we observe a slight difference between the sum of the average R-squared in the two regimes. The benefits from diversification diminish when financial integration is high, as systematic factors become stronger during this period. In general, investing only in European assets could offer potential diversification benefits. However, portfolio managers could also lose benefits from a diversification strategy by investing only in European assets during crisis periods.

7. Conclusion

Over recent years, several European policy actions took place to create deeper and more integrated capital markets. In this paper, we answer to the following questions: (1) How has European integration evolved after the introduction of the euro, and in particular during the sovereign debt crisis? (2) What are the key factors (i.e., macro and institutional factors) explaining financial integration, systematic and idiosyncratic volatilities, among European countries? and (3) What are the implications of financial integration for risk management?

We provide an 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 of accounting for 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 debt crisis). Financial integration increases and is less heterogeneous across countries during the crisis. 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 with respect to a larger cross-sectional dimension and a different asset base used in the application.

Furthermore, we study the factors affecting the integration index and its component, namely systematic and idiosyncratic volatilities. Financial integration is mainly driven by macroeconomic variables (i.e., GDP growth and inflation), market capitalization, the level of development of the financial market, overall political uncertainty, and technological developments. Interestingly, the integration index is also driven 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, which is positively correlated with the integration index, are in line with the factors explaining the integration index.

Finally, we study 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 integration periods. During crisis, investors select portfolios that are not only explained by firm characteristics. We also derive implications for risk management, showing that the benefits of diversification are reduced during periods of high integration.

Our evidence suggests 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 technological improvements, research and development expenditures, or the amount of projects financed by the common funds. Furthermore, our results stress the policy importance of creating and implementing financial stability tools given that diversification benefits are limited in crises.

[14] The intuition is the same as for the integration index defined in Pukthuanthong and Roll (2009).

Appendix 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 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 $\overline{R}_t = [\overline{R}_{1,t}, \dots, \overline{R}_{C,t}]'$.[16] The selected number of factors is:

$$\hat{r} = \arg \min_{0 \le r \le rmax} BIC_3(r), \tag{A.1}$$

where

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

with

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

The penalty term, involved in eq. (A.2), 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.

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 a yearly window, denoted by τ, and 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 that have lagged factor loadings. The $\hat{r}$ 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.

Appendix B. 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 A6 from January 1, 1999 to June 30, 2019. Table A7 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 factors increases up to two during the crisis period for most 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 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 A8 and in Fig. A1. Indeed, the path of the integration over time is similar to the one in Figs. 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 perform further robustness checks using the MSCI indexes. We study the relationship between the yearly integration index $\hat{\rho}^2_{adj,c,\tau}$ and its possible drivers, by estimating eq. (7). We provide results based on the integration indexes from MSCI indexes in Table A9 column (1). The results are comparable with and similar to the ones

[15] Bai 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 to define the number of latent factors are available in the literature [see e.g., Ahn and Horenstein (2013) and Gagliardini et al. (2019) developing criteria when the cross-sectional dimension is larger or comparable to the time-series dimension]. Considering the dimensions of our dataset, we use the criteria proposed in Bai and Ng (2002).

[16] Please, see (2) for notation.

we 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.[17] In column (2) of Table A9, 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 (2). The main difference is that the governance indicator *PoliticalStab* has a positive and significant impact. Results are also in line with the main application, when we consider idiosyncratic volatility (column 3). The governance indicators *VoiceAccount* and *GovernEffectiv* also have a significant and negative impact on idiosyncratic volatility.

Appendix C. Additional tables and figures

This section provides additional tables and figures.

Table A1
Time-invariant integration index of the EU 28 market indexes. Time-invariant integration index $\hat{\rho}^2_{adj}$ computed on the daily returns from September 2004 to June 2019 of the EU 28 market indexes. $\hat{\rho}^2_{adj}$ 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 $\hat{\rho}^2_{adj}$ across countries.

$\hat{\rho}^2_{adj}$	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

[17] For robustness checks, we estimate eq. (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 expenditures, and inflation continue to be significant, while the rest loose their statistical significance.

Table A2
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 three 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 A3
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 projects financed 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 the UK. Two newspapers per country are drawn. The index is calculated on a monthly basis	1998–2018.	Economic Policy Uncertainty

Table A4
Summary statistics of integration drivers for EU28 from 1998 to 2018. The overall number of observations *N*, mean, standard deviation (st.dev.), median, minimum and maximum are reported.

	N	mean	st.dev.	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 A5
Correlation between estimated portfolios, factors, and the European Fama-French factors. For each regime, correlation is computed between the estimated portfolios $r_{p,j}$, the estimated factors $F_{p,j}$, with $p = 1, \ldots, p_1$ ($p = 1, \ldots, p_2$) if $j = 1$ ($j = 2$), and the portfolios available on the Kenneth 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 lest 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
Regime 1						
$r_{1,1}$	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
$\widehat{F}_{1,1}$	0.914	−0.266	−0.222	−0.151	−0.240	−0.006
$\widehat{F}_{2,1}$	−0.390	0.944	0.073	0.201	0.052	0.058
$\widehat{F}_{3,1}$	0.066	−0.008	−0.782	0.324	−0.695	0.023
$\widehat{F}_{4,1}$	−0.015	0.035	−0.116	−0.252	−0.218	0.006
$\widehat{F}_{5,1}$	0.080	−0.149	0.179	0.009	0.273	−0.006
Regime 2						
$r_{1,2}$	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
$\widehat{F}_{1,2}$	0.976	−0.558	0.412	−0.207	−0.373	0.013
$\widehat{F}_{2,2}$	−0.193	0.756	−0.060	−0.017	0.082	0.018
$\widehat{F}_{3,2}$	0.053	−0.162	−0.448	0.503	−0.070	−0.035
$\widehat{F}_{4,2}$	0.077	−0.272	0.116	−0.103	0.151	0.037

Table A6
List of MSCI indexes. For each index, the table reports the reference country, the ISO code and the classification of the country with respect to the euro area (EA). The countries are distinguished between EA-core, EA distressed, and rest-EA. The distressed euro area includes the countries that were most affected by the sovereign debt 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 A7
Summary statistics of MSCI returns. The table reports descriptive statistics from 1st January 1999. The number of observations *T*, mean, median, standard deviation (st.dev.), median, skewness and kurtosis are reported.

	Country	T	mean	st.dev.	median	skewness	kurtosis
EA-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 A8
Time-invariant integration index estimated on the MSCI returns. The table reports $\widehat{\rho}^2_{adj}$ computed from January 1999 to June 2019. The indexes $\widehat{\rho}^2_{adj}$ 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.

$\widehat{\rho}^2_{adj}$	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

Table A9
Drivers of financial integration, systematic and idiosyncratic volatilities for the MSCI indexes. Estimation results from eq. (7) using as dependent variables the yearly integration indexes (column 1), and the yearly systematic and idiosyncratic volatilities (column 2 and 3, respectively), are estimated for the MSCI indexes. The yearly data 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. *L* denotes the lag operator.∗, ∗∗, and ∗∗∗ denote statistical significance at 10%, 5%, and 1%, respectively. $R - squared$ is the coefficient of determination. Robust standard errors are in parentheses.

Dependent Variable	Integration Index (1)	Systematic volatility (2)	Idiosyncratic volatility (3)
L.$\widehat{\rho}^2_{adj}$	0.3566∗∗∗		
	(0.0396)		
L.SystVol		0.2785∗∗∗	
		(0.0549)	
L.IdiVol			0.4903∗∗∗
			(0.0641)
L.GDPgrowth	0.0046∗	0.0002∗∗	0.0000
	(0.0024)	(0.0001)	(0.0001)
L.*TRDGDP*	−0.0003	−0.0013	−0.0007
	(0.0002)	(0.0008)	(0.0013)
L.*Uncertainty*	−0.0013∗∗∗	−0.0062∗∗∗	
	(0.0002)	(0.0011)	
L.*RD*	0.0962∗∗	0.0020	−0.0012
	(0.0360)	(0.0017)	(0.0016)
L.*MarketCapGDP*	0.0006	0.0032∗∗∗	0.0024∗∗∗
	(0.0004)	(0.0010)	(0.0005)
L.*Internet*	0.0031∗∗∗	0.0001∗	−0.0000
	(0.0007)	(0.0000)	(0.0000)

(*continued on next page*)

Table A9 *(continued)*

Dependent Variable	Integration Index	Systematic volatility	Idiosyncratic volatility
	(1)	(2)	(3)
L.*Inflation*	−0.0041	−0.0001	0.0001
	(0.0056)	(0.0002)	(0.0002)
L.*VoiceAccount*	0.1662**	−0.0056*	−0.0069**
	(0.0610)	(0.0029)	(0.0026)
L.*PoliticalStab*	0.0779**	0.0028**	−0.0002
	(0.0271)	(0.0012)	(0.0009)
L.*GovernEffectiv*	−0.0003	−0.0035	−0.0030*
	(0.0552)	(0.0020)	(0.0014)
L.*RegulQuality*	0.0010	−0.0008	−0.0001
	(0.0619)	(0.0021)	(0.0016)
EIB_financing	0.7934***	−0.0063	−0.0250
	(0.2580)	(0.0184)	(0.0188)
crisis	0.0889***	0.0080***	0.0023***
	(0.0135)	(0.0008)	(0.0004)
Constant	−0.0745	0.0332***	0.0126**
	(0.0823)	(0.0052)	(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

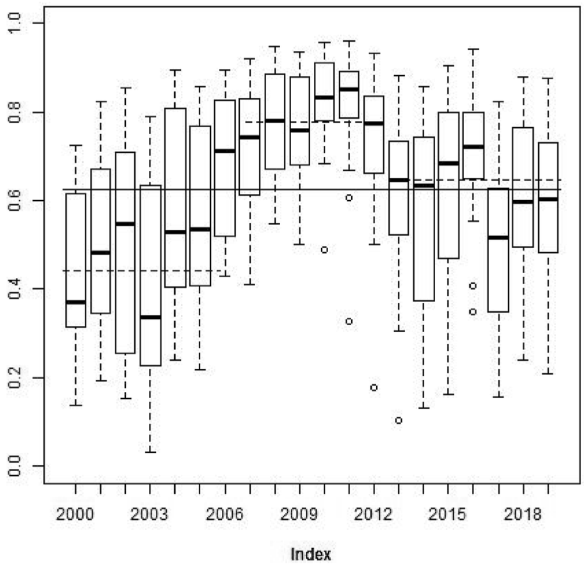


Fig. A1 Distribution of cross-sectional integration index computed on yearly samples of the MSCI index. Distribution of cross-sectional integration indexes computed on yearly returns of MSCI indexes from January 1999 to June 2019. The median of the time-invariant integration indexes computed over the full sample (solid line) as well as over the two sub-samples (dashed lines) are provided. The three sub-samples over time correspond to the pre-crisis (1999–2007), crisis (2008–2012) and post-crisis (2013–2019) periods.

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