Financial Integration before and after the Crisis: Euler Equations (Re)visit the European Union[1]

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Abstract

This paper aims to provide a rare application of several types of Euler equation tests to estimate the degree of financial integration of 28 EU countries with the Eurozone. The analysis is done separately for risk-free and risky assets in three types of financial markets (bond, stock and money markets). To examine whether the recent crisis impacted the levels of financial integration in EU member states, all models were estimated for the entire period of available quarterly data (1995 – 2014), as well as for the pre-crisis period only. We construct an Euler integration index (EII) that measures the integration level of countries across financial markets and show that the old member states (OMS) recorded higher integration levels than the new member states (NMS) in the pre-crisis period. The crisis has considerably decreased the gap, resulting with NMS surpassing the OMS in EII values.

Keywords: *consumption, crisis, Euler equation, European Union, financial integration*

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Introduction

Strong integration of national financial markets has always been one of the key goals of European economic integration. The last 30 years have seen the biggest steps towards higher levels of financial integration in the European

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Union (EU) – from the Single European Act of 1986, through the Maastricht Treaty of 1992 to the final birth of the single currency in 1999. The challenges brought forward by the recent global financial crisis and the subsequent European sovereign debt crisis pushed the process of financial integration in Europe even further.

The integration of new member states (NMS) into the European financial markets and the increase of capital mobility between NMS and old member states (OMS) were one of the biggest challenges of this process, but one that the EU has dealt with success. As confirmed by multiple empirical studies, there have been significant increases in the levels of financial integration of money, bond and stock markets between Eurozone countries and NMS (see Chinn and Ito, 2008; Babetskii, Komárek and Komárková, 2007; Globan, 2014; Syllignakis and Kouretas, 2010; Kučerova and Pomenkova, 2015). On the other hand, higher financial integration may have made the economies of NMS more vulnerable to external shocks and sudden stop episodes, as evidenced by Forbes and Warnock (2012), Calderón and Kubota (2013) and Globan (2015a; 2015b).

Researchers have long been debating on how to measure the degree of financial integration amongst countries. However, two main approaches have emerged in the literature. The first one focuses on the interdependence of domestic investment and savings (Feldstein and Horioka, 1980). Their model was a basis for the empirical research by many authors in the following years, e.g. Bayoumi and Rose (1993), Blanchard and Giavazzi (2002), etc.

The second and more direct approach is based on testing of the interest rate parity hypothesis between countries. If there is perfect capital mobility and countries are perfectly integrated, the rates of return on financial assets should be equal across all countries. The existence of the interest rate differential should imply the existence of capital controls and imperfect financial integration. This approach also yielded many empirical studies, e.g. Lemmen and Eijffinger (1993), Montiel (1994), Schmitt-Grohé and Uribe (2008).

Many alternative measures of financial integration are also present in the literature. They include measuring the volume of gross capital flows (Lane and Milesi-Ferretti, 2007), measuring the degree of monetary policy autonomy (Dowla and Chowdhury 1991), and applying various administrative measures (Quinn, 2003; Mody and Murshid, 2005).

However, the approach proposed by Obstfeld (1986; 1989) differs significantly from other measures of financial integration. His method of measuring financial integration was based on the Euler equation (EE) describing the optimal intertemporal path of consumption. In essence, investors access international capital markets with the intention of smoothing their personal consumption path over time. If two investors from two different countries have similar consumption functions, this leads to the conclusion that they both use the same capital market and that this market is equally accessible to both of them, which implies that the economies are financially integrated.

In his later work, Obstfeld (1994a; 1994b) expanded this model to risky assets, while Brennan and Solnik (1989) and Bayoumi and MacDonald (1995) confirmed that internationally diversified portfolios facilitate consumption smoothing. Furthermore, Lemmen and Eijffinger (1995) mathematically derived that financial integration could be measured also by testing whether the differences in real returns on financial markets (money, bond and stock markets) can be explained by the differences in consumption behaviour in respective countries.

A related strand of literature examined the degree of cross-border risk sharing in global financial flows and dealt with the "puzzlingly" low empirical levels of international risk sharing, despite the ongoing capital account liberalisation and financial globalisation processes. The low levels of cross-border risk sharing have been evident and empirically proven through the low correlation between the ratio of domestic to foreign consumption and the real exchange rate as the ratio of domestic to foreign price levels (see Backus and Smith 1993; Kollmann 1995; Ravn, 2001). Corsetti et al. (2012) showed that the counter-theoretical evidence becomes even stronger and the correlations become negative (indicating low levels of international risk-sharing and financial integration) when the correlations are examined dynamically over different frequencies of data.

Montiel (1994) summarized several advantages of the EE approach to financial integration measurement. Unlike the tests of nominal interest rate parity, the estimation of EEs does not require the comparison of rates of return on domestic and foreign assets. Such assets may often be incompatible and incomparable, resulting in the lower applicability of the test. Also, with the EE, the null hypothesis of a high degree of financial integration will not be rejected due to the lack of evidence of purchasing power parity, as is the case when testing the real interest rate parity. Moreover, unlike the interest rate parity tests, EEs are estimated on real consumption data, which makes this method effectively a test of economic integration of real activity as well. Furthermore, the advantage of this method over the Feldstein-Horioka type of regressions is that it does not depend on some indirect causes of correlation between savings and investment. The focus of this method is to test the core of financial integration – could the residents of different countries trade with the same types of assets under the same conditions.

Despite the stated advantages and a strong theoretical foundation, empirical studies using the EE approach have been very scarce (Obstfeld, 1986; 1989;

1994a; Lemmen and Eijffinger, 1995) in an overall very large body of literature. This paper aims to fill this gap.

The main purpose of this study is to measure financial integration levels in 28 EU member states by estimating EEs on risk-free and risky types of financial assets in several types of markets (bond, stock and money market). The paper aims to answer several questions concerning financial integration in the EU: does the integration level of NMS and OMS with the Eurozone differ significantly? Which specific countries are the most financially integrated ones, and which display low integration levels? Has the recent financial and economic crisis impacted the levels of financial integration in the EU? Which types of financial markets display high levels of integration, and which are still weakly integrated? To answer these questions, we construct an *Euler integration index* (EII) which summarizes the results of EE estimations and measures the level of financial integration for each country and each financial market in a given EU country.

This study expands on the work of Lemmen and Eijffinger (1995) in several ways. Although their paper provided an excellent theoretical derivation for the EE estimations concerning risky assets, the contribution of our study vis-à-vis the Lemmen and Eijffinger's (1995) paper is reflected in the empirical sphere. One of the bigger issues of the empirical part of their paper is that they did not have the time series long enough to carry out reliable estimations, as they run OLS regressions on yearly data in three sub-periods between 1961 and 1992. Our analysis is based on quarterly data from 1995 to 2014, which gives us enough degrees of freedom for robust estimations. Furthermore, in our paper, the autocorrelation-induced biased estimates are prevented using the Newey-West estimator. The lag lengths are also clearly determined based on the Akaike information criterion.

The further contribution of this paper arises from the fact that it includes a larger sample of countries, namely the NMS, which entered the EU during the 2000s. Moreover, our calculations of real returns are based on the real *ex ante* expected inflation estimates, derived from European Commission's Consumer Surveys, thus avoiding the potentially erroneous assumption that the *ex post* inflation data is good enough proxy for expected inflation. Finally, to our knowledge, this is the first study dealing with the effects of the crisis on financial integration levels in the EU using EEs.

The rest of the paper is structured as follows. The first section derives the theoretical basis of the model. Data and methodology are explained in the second section, while the third reports the results of EE estimations. The last section concludes the paper.

1. Theoretical Model

1.1. Risk-free Assets

To measure the level of financial integration in the EU member states, we first theoretically derive the Obstfeld's (1986, 1989) model of EE tests provided that only risk-free assets (bonds) are traded.

The well-known EE is given by

$$E_t\left[R_{t+1}\vartheta_{t+1}\right]=1 \quad (1)$$

where R_{t+1} is the real return on the traded asset between periods t and $t+1$, and ϑ_{t+1} is the marginal rate of intertemporal substitution of future and current consumption of any consumer in the market, while E_t is conditional expectation at time t.

Consider two countries (home and foreign, denoted with an asterisk) and assume that the traded asset is a bond that pays a nominal interest rate i_{t+1}, which is known in period t. Then, the real return on this asset is given by

$$R_{t+1}=(1+i_{t+1})\frac{P_t}{P_{t+1}} \quad (2)$$

where P_t is a domestic price index.

Let X_t be a nominal exchange rate between the domestic and foreign currency. Then, the real return on the domestic bond can be written as

$$R_{t+1}=(1+i_{t+1})\frac{P_t^*}{P_{t+1}^*}\frac{X_t}{X_{t+1}} \quad (3)$$

where P_t^* is a price index in the foreign country.

Let the marginal rate of intertemporal substitution be defined as

$$\vartheta_{t+1}=\beta\frac{U_c(C_{t+1})}{U_c(C_t)} \quad (4)$$

for a discount factor $\beta<1$, domestic aggregate consumption C_t, and the utility function $U(C)$.

Then, the difference between price-adjusted marginal rates of substitution in home and foreign countries can be written as

$$\psi_{t+1}=\frac{P_t}{P_{t+1}}\vartheta_{t+1}-\frac{P_t^*}{P_{t+1}^*}\frac{X_t}{X_{t+1}}\vartheta_{t+1}^* \quad (5)$$

Two assumptions are made in this model. First, the consumers in both countries are characterized by the same endowments and preferences towards consumption, with same discount factors $(\beta = \beta^*)$. Second, we assume that the utility functions for both domestic and foreign consumers take the form of

$$U(C) = \frac{C^{1-\alpha} - 1}{1-\alpha}, \quad \alpha \geq 0 \tag{6}$$

with α as a relative risk-aversion coefficient, same in both countries. The marginal utility of consumption for this function is given by $C^{-\alpha}$.

These assumptions imply that the marginal rates of substitution in two countries should also be the same, which implies

$$E_t\left[\psi_{t+1}\right] = 0 \tag{7}$$

Taking into consideration the aforementioned assumptions, the marginal rate of intertemporal substitution defined in (4) can be written as

$$\vartheta_{t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha} \tag{8}$$

and analogously for the foreign country

$$\vartheta^*_{t+1} = \beta\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha} \tag{9}$$

This implies that the restriction given in (7) can be tested empirically, by testing whether any information known at time *t* can help predict the values of ψ in time *t* + 1 or later. Perfect financial integration implies that ψ_t should be orthogonal to the values of ψ_{t-1}, ψ_{t-2}, etc.

Thus, we test the following equation

$$\psi_t = \gamma_0 + \sum_{i=1}^{N} \gamma_i \psi_{t-i} + \varepsilon_t \tag{10}$$

If the countries are perfectly financially integrated, one should not reject the null hypothesis

$$H_0 : \gamma_0 = 0 \wedge \gamma_i = 0, \quad i = 1, \ldots, N \tag{11}$$

As noted by Obstfeld (1989), by testing this hypothesis, we test whether people in different countries equate *ex ante* marginal rates of substitution of present for future units of home currency through intertemporal trading, thus testing whether the degree of financial integration between the home and foreign country is perfect. In essence, we test whether the residents in different countries are able to trade the same asset on the same terms. In addition, due to the model assumptions, we test jointly for both financial integration and market completeness.

1.2. Risky Assets

In case of risk-free assets, the model, as presented in the previous section, assumes identical real returns on domestic and foreign assets. In reality, however, this condition is often violated, which is why we turn to the model designed by Lemmen and Eijffinger (1995), which allows for differences in real returns on domestic and foreign risky assets. Assuming that both domestic and foreign consumers are characterized by the same utility function,[2] it follows that

$$E_t\left[R_{t+1}\vartheta_{t+1}\right]=E_t\left[R^*_{t+1}\vartheta^*_{t+1}\right] \tag{12}$$

Then, combining (8) and (9) with (12), but without the condition that $\beta=\beta^*$ and $\alpha=\alpha^*$, yields

$$E_t\left[R_{t+1}\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha}\right]=E_t\left[R^*_{t+1}\beta^*\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha^*}\right] \tag{13}$$

Following Aiyagari (1993, p. 21), (13) can be written as

$$E_t\left[R_{t+1}\right]*E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha}\right]+cov\left[R_{t+1},\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha}\right]=E_t\left[R^*_{t+1}\right]* \\ E_t\left[\beta^*\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha^*}\right]+cov[R^*_{t+1},\beta^*\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha^*}] \tag{14}$$

where *cov* denotes the unconditional covariance.

Taking natural logarithms from both sides of the equation[3] leads to

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[2] Similar to Lemmen and Eijffinger (1995), it should be noted that the assumption is made that countries trade a set of Arrow-Debreu securities and that all state-contingent securities are actually traded at time t. It is also assumed that the set of securities is complete, i.e. that there are exactly as many securities as there are states of nature. In this model agents hold only domestic assets, i.e. domestic agents hold assets issued by the home country, while foreign agents hold assets issued by the foreign country, as the assumption of complete markets makes it possible to ignore the situation where agents do not hold only domestic assets. As a result of the complete markets assumption, the constraint defined in (12) is the only one imposed here. Without this rather strong assumption, agents would have a portfolio choice between home and foreign bonds.

[3] Note that $log\left(\mathrm{a}+\mathrm{b}\right)=log\,\mathrm{a}+log\left(1+\mathrm{b/a}\right)$.

$$E_t\left[r_{t+1}\right]-\alpha E_t\left[c_{t+1}-c_t\right]+\log\beta+\log\theta=E_t\left[r^*_{t+1}\right]-\alpha^* E_t\,[\,c^*_{t+1}-c^*_t\,]+\log\beta^*+\log\theta^* \quad (15)$$

where $$\theta=\left(1+\frac{cov\left[R_{t+1},\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha}\right]}{E_t\left[R_{t+1}\right]*E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\alpha}\right]}\right),\quad \theta^*=\left(1+\frac{cov[R^*_{t+1},\beta^*\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha^*}]}{E_t\left[R^*_{t+1}\right]*E_t\left[\beta^*\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\alpha^*}\right]}\right)$$

and lower-case variables denote natural logarithms of R_{t+1}, R^*_{t+1}, C_{t+1}, C_t, C^*_{t+1} and C^*_t respectively.

Rearranging (15) yields

$$E_t\left[r_{t+1}\right]-E_t\left[r^*_{t+1}\right]=\log\theta^*-\log\theta+\log\beta^*-\log\beta+\alpha E_t\left[\Delta c_{t+1}\right]-\alpha^* E_t[\Delta c^*_{t+1}] \quad (16)$$

where $E_t\left[\Delta c_{t+1}\right]$ and $E_t[\Delta c^*_{t+1}]$ are expected consumption growth rates in the home and foreign country, respectively, while the left-hand side of the equation represents the difference between expected real returns on the traded domestic and foreign asset.

By substituting expectations with realisations, (16) becomes testable, yielding the following regression equation

$$r_{t+1}-r^*_{t+1}=\delta_0+\alpha\left[\Delta c_{t+1}\right]-\alpha^*[\Delta c^*_{t+1}]+\omega_t \quad (17)$$

where δ_0 is a constant containing thetas and betas from (16), and ω_t an error term.

As in (10), perfect financial integration implies that no information known at time t can help predict the values of the real return differential in time $t+1$ between the domestic and foreign country, $r_{t+1}-r^*_{t+1}$.

Thus, we test the following equation

$$r_{t+1}-r^*_{t+1}=\delta_0+\alpha\left[\Delta c_{t+1}\right]-\alpha^*\left[\Delta c^*_{t+1}\right]+\sum_{i=1}^{N}\delta_i\Delta c_{t+1-i}-\sum_{j=1}^{N}\delta^*_j\Delta c^*_{t+1-j}+\mu_t \quad (18)$$

Note that here the risk aversions α and α^* are determined endogenously, unlike in the model with risk-free assets, where they were set arbitrarily.

If the countries are perfectly financially integrated, one should not reject the null hypothesis

$$H_0:\delta_i=0\wedge\delta^*_j=0,\ \ i=1,\ldots,N;\ \ j=1,\ldots,N \quad (19)$$

2. Data and Methodology

2.1. Data

In this study, we estimate the Obstfeld's (1986; 1989) model with risk-free assets defined in (10) and three variations of the Lemmen and Eijffinger's (1995) financial market integration test concerning risky assets (18), including the bond, stock and money markets. Thus, the following variables are utilised: real household consumption in levels, C_t; real household consumption growth rates (log--differences) Δc_t; real government bond yields, $r_{t,bond}$; real stock market returns, $r_{t,stock}$; and real money market interest rates, $r_{t,money}$. These variables are gathered for each EU member state, depending on data availability.[4]

Since each of the four estimated models also comprises foreign market equivalents of the mentioned variables (see (18)), the Eurozone was selected as the benchmark "foreign country" to all EU member states. This means that the employed estimations test the level of financial integration between the EU member states and the Eurozone. Therefore, the observed dataset also includes the following time series: the Eurozone (EA) real household consumption in levels, C_t^*; EA real household consumption growth rates, Δc_t^*; EA real government bond yields, $r_{t,bond}^*$; real stock market returns, $r_{t,stock}^*$; and the EA real money market interest rates, $r_{t,money}^*$.

Household consumption data was taken from Eurostat in the form of a non-seasonally adjusted index (2005 = 100). Thus, the consumption time series were seasonally adjusted using the ARIMA X12 method. Given that the index is based on constant prices and exchange rates, variables P_t, P_t^* and X_t from (5) were not needed to calculate required marginal rates of substitution.

For the government bond yields we used the EMU convergence criterion 10--year government bond yields, obtained from Eurostat and IMF databases. The data on the stock market indices was obtained from the IMF's International Financial Statistics Database, with the returns calculated by taking year-on-year log-differences of the index for each given quarter. The Eurozone stock market was represented by the EuroStoxx 50 index, obtained from the ECB Statistical Data Warehouse. Finally, for the money market rates we used the corresponding 3-month rates from Eurostat.

All variables are of quarterly frequencies. To examine whether the recent crisis impacted the levels of financial integration in EU member states, all models

[4] The full descriptive statistics with data spans for each variable are left out of the manuscript due to space issues, but are available in the working paper version of the paper (Globan and Sorić, 2017).

were estimated using the data that spans throughout the whole available period, as well as on the data that covers the pre-crisis period only. The “whole period” includes the data from 1995:Q1 (risk-free assets) and from 1997:Q1 (risky assets), and ending with 2014:Q2, all subject to data availability. The “pre-crisis period” includes the data with the same starting points, but it ends in 2008:Q2, just before the start of the global financial crisis. The time span of the data varies across countries due to availability issues. However, the objective was to use as much data as possible for each given country, as the approach that would unify the starting periods for all 28 countries would result in a substantial loss of observations.

2.2. Obtaining the Real Financial Market Returns

All three types of real financial market returns are expressed in logarithmic values. The rationale for this is given in the theoretical model derived in the previous section (see (16)). The logarithmic values of stock, bond and money market real returns are obtained as $r_{j,t} = \ln(i_{j,t} - \pi_{j,t}^{e} + 100)$, where $i_{j,t}$ is the nominal return of a particular financial market, $\pi_{j,t}^{e}$ stands for inflation expectations, and $j = \{bond, stock, money\}$ denotes the financial market of interest. It is evident that the three series are “rebased” by adding 100 to avoid negative values, for which logarithms could not be calculated.

The issue of particular interest here is the calculation of the inflation expectations variable. Several empirical studies have confirmed that the rational expectations hypothesis (at least in terms of inflation sentiment) is heavily flawed (see e.g. Sorić and Čižmešija (2013) and the papers cited there). Therefore, instead of erroneously assuming the validity of rational expectations (and approximating π_t^e with actual inflation realisations), inflation expectations are gathered from the Consumer Surveys (CS). CS are nowadays regularly conducted each month in all EU member states, using a fully harmonized methodology. Amongst other important economic issues, the following question is also raised each month through the CS:

Q6 By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will …
a) increase more rapidly, b) increase at the same rate, c) increase at a slower rate, d) stay about the same, e) fall, f) don’t know.

Having adequately long series of consumers’ responses to Q6 at hand, one can employ several alternative quantification procedures to obtain a numerical indicator of expected inflation: e.g. the Carlson-Parkin approach, or the nonlinear regression approach. Nardo (2003) provides a nice review of the mentioned approaches and heavily criticizes them because of their over-restrictive assumptions. To circumvent that issue, this study employs the Theil (1952) and Batchelor (1986) approach. This method has been proven to generate lower inflation forecasting errors when the responses distribution is skewed and non-normal (Terai, 2009).

One particular problem with the utilisation of CS data in this study is that two of the EU member states do not conduct them on a regular basis (Denmark and Luxembourg) which is why for these countries the real returns could not be calculated and risky assets models could not be estimated. On the other hand, Ireland has a consistent CS database from 2009:Q2 only, while the Croatian data starts from 2005:Q3. This conditioned the impossibility to estimate risky assets models for the pre-crisis period for those countries.

3. Results

Four separate EE tests were estimated using OLS. In cases where diagnostic tests indicated the presence of serial correlation and/or heteroscedasticity of residuals, the Newey-West estimator was used (denoted as HAC in Tables 1 – 4).[5] The results of diagnostic tests are available upon request. The optimal number of lags for each equation was determined by minimizing the Akaike information criterion (AIC).

3.1. Risk-free Assets

We start by estimating (10) for risk-free assets and testing the null hypothesis specified in (11) by testing for the joint significance of γ_0 and γ_i. In addition, following Lemmen and Eijffinger (1995), to gain more insight into individual significances of the constant and parameters next to the lagged marginal rate of substitution differentials, these tests have also been done separately and are reported in Table 1.

It is assumed initially that $\alpha = 0.5$.[6] Table 1 carries out the results for all 28 EU countries, divided into OMS and NMS. The results indicate whether the null

[5] Tables 1 – 4 report exactly 32 cases where the error terms assumptions were met. Even if the HAC option has been used for those equations, the results would not have changed dramatically. A different decision in the significance tests would have been obtained in 5 out of 32 equations (15.6%). However, the authors chose to refrain from that because using robust standard errors with no autocorrelation and/or heteroskedasticity can lead to significant losses in efficiency (especially when dealing with limited sample sizes, such as those in the present study).

[6] Equations were estimated using other values of α, namely $\alpha = 1$ and $\alpha = 2$, but the results do not change significantly. These estimations are available upon request.

hypothesis of perfect financial integration, as defined in (11), could be rejected for each given country.

T a b l e 1

Euler Equation Tests of Financial Integration for Risk-free Assets:

$$\psi_t = \gamma_0 + \sum_{i=1}^{N} \gamma_i \psi_{t-i} + \varepsilon_t . (\alpha = 0.5)$$

Country	(a) Pre-crisis period					(b) Whole period				
	Lags (N)	Est.	γ_0 and $\gamma_i = 0$	$\gamma_0 = 0$	$\gamma_i = 0$	Lags (N)	Est.	γ_0 and $\gamma_i = 0$	$\gamma_0 = 0$	$\gamma_i = 0$
			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat
OMS										
Austria	2	HAC	33.080*	1.121	32.381*	2	HAC	28.532*	0.667	26.420*
Belgium	1	HAC	0.937	0.321	0.926	3	HAC	16.927*	0.828	13.789*
Denmark	4		1.933	–0.155	2.405	1	HAC	2.833	0.001	2.665
Finland	1		4.961*	–3.047*	0.414	1	HAC	6.406*	5.414*	0.529
France	1		3.292*	–0.221	6.581*	1		4.006*	–2.047*	5.393*
Germany	4		6.498*	3.319*	2.844*	3		5.526*	0.632	6.513*
Greece	1		11.105*	–4.449*	2.373	2		2.984*	0.571	3.929*
Ireland	1	HAC	16.477*	15.064*	7.169*	4		4.948*	–0.671	4.339*
Italy	1		2.080	1.659	0.627	1		5.399*	2.848*	0.347
Luxembourg	4	HAC	31.683*	4.967*	11.893*	4	HAC	48.818*	8.727*	14.229*
Netherlands	3		2.699*	–0.600	2.863	3		3.009*	–0.374	3.528*
Portugal	3		2.395	–1.095	1.891	4		10.698*	–0.109	13.372*
Spain	1		29.591*	–7.203*	9.120*	4		5.466*	–1.199	4.338*
Sweden	2		10.547*	–2.236*	15.336*	3	HAC	4.434*	7.593*	36.625*
UK	1	HAC	25.088*	10.865*	0.429	3		8.901*	–1.519	5.145*
NMS										
Bulgaria	1	HAC	15.540*	1.119	11.990*	4	HAC	58.892*	0.502	35.384*
Croatia	1	HAC	5.343	3.638	0.097	2	HAC	7.944*	0.768	7.854*
Cyprus	4	HAC	92.421*	19.600*	45.187*	1	HAC	9.741*	2.386	9.720*
Czech Republic	2		2.269	–0.580	3.069	2		2.958*	–0.740	3.879*
Estonia	1		7.591*	–3.690*	0.540	3		5.086*	–1.152	3.980*
Hungary	1	HAC	3.436	1.653	2.170	1		1.954	–0.513	3.694
Latvia	1	HAC	15.301*	12.923*	1.119	3		3.635*	–0.593	3.932*
Lithuania	2	HAC	42.166*	23.298*	25.806*	3		4.318*	–1.330	3.740*
Malta	2	HAC	22.399*	2.411	15.705*	4	HAC	27.740*	8.416*	25.061*
Poland	2		7.433*	–4.522*	5.787*	2		10.734*	–5.618*	7.015*
Romania	4		7.858*	–3.418*	3.743*	4		3.310*	–2.289*	1.885
Slovakia	1	HAC	4.575	4.315*	2.451	1	HAC	5.013	4.481*	2.400
Slovenia	1	HAC	29.633*	15.281*	13.150*	1		3.303*	–1.757	4.718*

Notes: * denotes that the coefficient is significantly different from zero at the 5% significance level. In cases where the Newey-West estimator was used (denoted as HAC above), χ^2 tests were performed instead of t- and F-tests, respectively. The optimal number of lags was determined by minimizing the AIC. The "whole period" includes the data from 1995:Q1 until 2014:Q2, subject to data availability. The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Source: Authors' calculations.

It is evident that the number of countries for which we cannot reject the null hypothesis of perfect financial integration (PFI) increases substantially if only the pre-crisis period is observed. Table 1a reveals that there are eight countries for which we cannot reject PFI in the pre-crisis period (Belgium, Denmark, Italy, Portugal, Croatia, Czech Republic, Hungary, and Slovakia). This test essentially indicates that the residents in these countries can trade the same asset on the same terms as the residents of Eurozone as a whole, indicating perfect financial integration between them.

However, if we estimate the model for the whole period, the number of countries for which PFI is indicated drops to three – Denmark, Hungary and Slovakia (Table 1b). This is the first indication that the crisis might have reduced the level of integration amongst EU member states.

Over the next three subsections, we deal with EE tests allowing for these differences, essentially allowing for the trading of risky assets in three different financial markets – bond, stock and money markets. Equation (18) is estimated by testing for the joint significance of δ_i and δ_j^*. Again, following Lemmen and Eijffinger (1995), to gain more insight into the individual significance of the domestic and foreign parameters next to the respective lagged domestic and foreign consumption growth rates, these tests have also been done separately and are reported in Tables 2 – 4. We test the null hypothesis that no information known at time *t* can help predict the future values of real return differentials between the domestic and Eurozone assets (see (19)).

3.2. Government Bond Market

First, we estimate EEs to test the financial integration in the long-term government bond markets across the EU. Table 2 displays the estimation results, indicating whether the null hypothesis of perfect financial integration could be rejected for each given country.[7]

Again, the number of countries for which we could not reject PFI varies significantly, depending on the time span of estimation. In the pre-crisis period (Table 2a), PFI is indicated in eight countries – Finland, Greece, the Netherlands, Portugal, Cyprus, Estonia, Malta and Poland. The fact that there is an equal number of OMSs and NMSs amongst these eight countries is a sign of good integration of government bond markets of the new member states into European financial flows in the pre-crisis period. What is interesting to note is that countries that will later suffer from the sovereign debt crisis, needing a bailout from the Troika (Greece, Portugal and Cyprus), are amongst the perfectly integrated countries.

However, when the crisis period is included (Table 2b), the total number of PFI rejections increases significantly (from 15 to 24) and the number of countries for which perfect integration is indicated drops to two (the Netherlands and the Czech Republic). This drop in the level of integration in the bond markets is

[7] It should be noted that the integration of Romanian government bond market could not be tested for the pre-crisis period because the Romanian government bond nominal returns series starts in 2005:Q2, leaving not enough data at hand.

not unexpected given the divergence of government bond yield spreads in the EU post-2008.

Table 2

Euler Equation Tests of Financial Integration for the Government Bond Market:

$$r_{t+1,bond} - r^{*}_{t+1,bond} = \delta_0 + \alpha\left[\Delta c_{t+1}\right] - \alpha^{*}\left[\Delta c^{*}_{t+1}\right] + \sum_{i=1}^{N}\delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N}\delta^{*}_j \Delta c^{*}_{t+1-j} + \mu_t$$

Country	(a) Pre-crisis period					(b) Whole period				
	Lags (N)	Est.	δ_i and $\delta^{*}_j = 0$	$\delta_i = 0$	$\delta^{*}_j = 0$	Lags (N)	Est.	δ_i and $\delta^{*}_j = 0$	$\delta_i = 0$	$\delta^{*}_j = 0$
			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat
OMS										
Austria	3	HAC	16.845*	3.306	13.553*	4	HAC	70.573*	4.887	57.862*
Belgium	1	HAC	7.570*	7.570*	2.082	4	HAC	45.784*	1.280	12.255*
Finland	1	HAC	1.333	1.229	0.624	2	HAC	11.323*	0.601	10.833*
France	4	HAC	104.62*	4.664	19.311*	4	HAC	165.91*	4.615	75.722*
Germany	3	HAC	16.807*	3.987	3.615	4	HAC	212.64*	139.63*	173.99*
Greece	1	HAC	0.241	0.072	0.159	3	HAC	169.57*	10.459*	3.268
Ireland	n/a	n/a	n/a	n/a	n/a	4	HAC	176.51*	21.021*	102.61*
Italy	4	HAC	44.781*	7.114	34.718*	4	HAC	95.151*	15.797*	41.965*
Netherlands	3	HAC	8.801	3.651	3.118	1	HAC	2.418	0.014	1.316
Portugal	1	HAC	0.766	0.713	0.049	1	HAC	13.236*	3.081	4.416*
Spain	1	HAC	8.679*	7.289*	3.449	4	HAC	146.07*	19.536*	0.731
Sweden	2	HAC	13.597*	13.046*	0.931	2	HAC	22.061*	16.490*	18.278*
UK	4	HAC	96.733*	31.525*	10.216*	2	HAC	16.009*	0.214	14.132*
NMS										
Bulgaria	4	HAC	223.92*	4.646	134.972*	1	HAC	6.928*	4.009*	0.252
Croatia	n/a	n/a	n/a	n/a	n/a	3	HAC	36.665*	31.663*	2.547
Cyprus	1	HAC	0.382	0.345	0.022	4	HAC	47.604*	7.889	35.006*
Czech Republic	2	HAC	12.929*	10.113*	4.052	1	HAC	3.978	0.896	3.910*
Estonia	1	HAC	2.882	2.878	0.508	2	HAC	170.56*	151.98*	4.698
Hungary	3	HAC	42.886*	19.422*	5.371	3	HAC	63.189*	39.122*	11.816*
Latvia	4	HAC	119.87*	15.860*	31.084*	4	HAC	115.08*	79.168*	18.504*
Lithuania	1	HAC	7.012*	0.400	6.848*	2	HAC	38.015*	16.609*	14.626*
Malta	1	HAC	0.333	0.005	0.291	4	HAC	64.508*	27.972*	8.984
Poland	1	HAC	5.921	0.033	4.923*	2	HAC	23.685*	11.858*	5.749
Romania	n/a	n/a	n/a	n/a	n/a	3	HAC	96.886*	14.163*	5.323
Slovakia	2	HAC	12.940*	4.866	4.386	3	HAC	24.649*	0.782	7.864*
Slovenia	4		42.261*	0.560	2.821	4	HAC	282.28*	7.598	42.979*

Notes: * denotes that the coefficient is significantly different from zero at the 5% significance level. In cases where the Newey-West estimator was used (denoted as HAC above), χ^2 tests were performed instead of t- and F-tests, respectively. The optimal number of lags was determined by minimizing the AIC. Denmark and Luxembourg were not included due to lack of data on expected inflation. The "whole period" includes the data from 1997:Q1 until 2014:Q2, subject to data availability. The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Source: Authors' calculations.

3.3. Stock Market

We then turn to the measurement of financial integration of the stock markets across EU countries. The results of EE estimations, based on the same hypothesis as in the previous subsection, are reported in Table 3. It should come as no surprise that once again there are substantial differences in the number of null hypothesis rejections between the two periods. Stock markets of seven countries, out of 21 for which the model could be estimated, indicate PFI in the pre-crisis period (Table 3a), four of which were amongst the PFI countries in the bond markets as well – Greece, Portugal, Estonia and Poland. In addition, PFI could not be rejected for Belgium, Spain and the Czech Republic.

T a b l e 3

Euler Equation Tests of Financial Integration for the Stock Market:

$$r_{t+1,stock} - r^*_{t+1,stock} = \delta_0 + \alpha\left[\Delta c_{t+1}\right] - \alpha^*\left[\Delta c^*_{t+1}\right] + \sum_{i=1}^{N} \delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N} \delta^*_j \Delta c^*_{t+1-j} + \mu_t$$

Country	(a) Pre-crisis period					(b) Whole period				
	Lags (N)	Est.	δ_i and $\delta^*_j=0$	$\delta_i=0$	$\delta^*_j=0$	Lags (N)	Est.	δ_i and $\delta^*_j=0$	$\delta_i=0$	$\delta^*_j=0$
			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat
OMS										
Austria	3	HAC	63.440*	6.062	42.932*	2	HAC	16.440*	10.998*	4.284
Belgium	2	HAC	7.189	1.469	3.653	1	HAC	3.911	0.046	3.462
Finland	4	HAC	25.302*	5.444	8.276	1	HAC	6.178*	0.762	6.110*
France	4	HAC	33.934*	3.437	18.424*	4	HAC	21.061*	3.416	18.202*
Germany	3	HAC	28.800*	5.400	5.465	3	HAC	12.751*	7.746	9.734*
Greece	4		1.487	2.838	0.232	4	HAC	62.464*	6.155	9.823*
Ireland	n/a	n/a	n/a	n/a	n/a	2	HAC	24.722*	9.890*	18.500*
Italy	4	HAC	47.543*	3.176	33.815*	3	HAC	21.405*	4.070	10.127*
Netherlands	3	HAC	13.386*	1.229	4.537	3	HAC	35.801*	2.818	7.557
Portugal	1	HAC	0.622	0.082	0.530	3	HAC	26.594*	4.896	13.264*
Spain	1	HAC	4.667	3.402	0.375	4	HAC	130.43*	36.864*	6.016
Sweden	2	HAC	19.002*	11.023*	7.236*	1	HAC	8.867*	1.308	1.529
UK	4	HAC	40.237*	7.815	10.018*	4	HAC	26.500*	5.162	12.764*
NMS										
Bulgaria	4	HAC	104.29*	23.519*	75.798*	4	HAC	61.147*	44.120*	35.505*
Croatia	n/a	n/a	n/a	n/a	n/a	4	HAC	122.11*	82.228*	24.235*
Czech Republic	1	HAC	1.807	1.217	1.465	1	HAC	3.211	0.680	3.205
Estonia	1	HAC	1.540	1.103	0.157	1	HAC	2.568	2.434	0.197
Hungary	3	HAC	63.112*	9.968*	4.403	4	HAC	23.790*	19.030*	5.203
Latvia	4	HAC	313.23*	22.438*	15.910*	1	HAC	5.086	3.989*	1.709
Lithuania	4	HAC	147.44*	44.447*	27.304*	2	HAC	28.947*	13.725*	25.367*
Poland	1	HAC	1.842	1.691	1.557	1	HAC	9.107*	4.368*	1.704
Slovakia	2	HAC	15.704*	2.146	13.010*	1	HAC	7.956*	0.443	6.219*
Slovenia	1	HAC	7.056*	1.679	3.785	4	HAC	87.727*	9.608*	54.038*

Notes: * denotes that the coefficient is significantly different from zero at the 5% significance level. In cases where the Newey-West estimator was used (denoted as HAC above), χ^2 tests were performed instead of t- and F-tests, respectively. The optimal number of lags was determined by minimizing the AIC. Denmark and Luxembourg were not included due to lack of data on expected inflation. Cyprus, Malta and Romania were not included due to lack of data on stock market indices. The "whole period" includes the data from 1997:Q1 until 2014:Q2, subject to data availability. The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Source: Authors' calculations.

On the other hand, the inclusion of the crisis period into the estimation (Table 3b) reduces the number of PFI countries to four – Belgium, the Czech Republic, Estonia and Latvia. This suggests that the crisis had a strong adverse impact on the integration levels not only of the bond markets, but of the stock markets as well.

3.4. Money Market

Finally, we estimate the EEs for the money markets. This time the number of countries for which the model could be estimated drops noticeably, since the Eurozone member states share the common Eurosystem money market and do not have their own national money market rates. Table 4 reports the results based on the testing of the same hypothesis as in previous two subsections.

Table 4

Euler Equation Tests of Financial Integration for the Money Market:

$$r_{t+1,money} - r^{*}_{t+1,money} = \delta_0 + \alpha\left[\Delta c_{t+1}\right] - \alpha^{*}\left[\Delta c^{*}_{t+1}\right] + \sum_{i=1}^{N}\delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N}\delta^{*}_j \Delta c^{*}_{t+1-j} + \mu_t$$

Country	(a) Pre-crisis period					(b) Whole period				
	Lags (N)	Est.	δ_i and $\delta^*_j = 0$	$\delta_i = 0$	$\delta^*_j = 0$	Lags (N)	Est.	δ_i and $\delta^*_j = 0$	$\delta_i = 0$	$\delta^*_j = 0$
			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat			F- or χ^2-stat	t- or χ^2-stat	F- or χ^2-stat
OMS										
Sweden	4	HAC	38.285*	16.488*	17.584*	3	HAC	63.684*	8.524*	42.481*
UK	1	HAC	9.084*	5.848*	5.699*	2	HAC	24.628*	4.765	7.841*
NMS										
Bulgaria	4	HAC	67.257*	13.990*	15.090*	3	HAC	15.204*	8.852*	1.894
Croatia	n/a	n/a	n/a	n/a	n/a	1	HAC	1.436	1.017	0.217
Czech Republic	1	HAC	2.969	2.891	0.108	1	HAC	7.106*	4.699*	1.246
Hungary	1	HAC	4.824	4.390*	0.788	3	HAC	43.861*	16.280*	15.563*
Poland	4	HAC	38.485*	6.177	38.485*	3	HAC	9.783	8.094*	3.714
Romania	3	HAC	37.588*	3.086	37.588*	1	HAC	7.614*	3.692	1.483

Notes: * denotes that the coefficient is significantly different from zero at the 5% significance level. The optimal number of lags was determined by minimizing the AIC. Only non-eurozone countries are included in the estimation, given that EMU member states share the common Eurosystem money market. The "whole period" includes the data from 1997:Q1 until 2014:Q2, subject to data availability. The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Source: Authors' calculations.

Due to a relatively small number of countries entering the model, not many conclusions can be drawn from the estimation. However, the results may be suggesting that the crisis did not have as strong of an effect on the integration of money markets in the EU, as it did in the case of bond and stock markets. In the whole period PFI is indicated for Croatia, for which there is not enough data to estimate the pre-crisis model, and Poland, for which PFI was rejected in the pre-crisis period. On the other hand, the Czech Republic and Hungary are the two countries for which PFI was indicated pre-crisis, but not in the whole period.

3.5. Summarising the Results

To summarise the results and facilitate a more comprehensive view into the integration levels across the EU member states and across financial markets, an *Euler integration index* (*EII*) is constructed. The index measures the level of integration of each country by quantifying whether the null hypothesis defined in (19) has been rejected or not for the three risky asset models.[8] *EII* for country *i* consists of two components and is defined as:

$$EII_i = \frac{\sum_{j=1}^{N}\left(JOINT_{i,j} + SEPARATE_{i,j}\right)}{N}; \quad 1 < N \le 3 \tag{20}$$

where *N* is the number of markets for which Euler equations could be estimated for a given country.

$JOINT_i$ quantifies whether the hypothesis of the joint insignificance of δ_i and δ_j^* from (18) was rejected at the 5 percent level of significance or not. Thus:

$$JOINT_i = \begin{cases} 0, if\ \delta_i\ and\ \delta_j^* \neq 0 \\ 1, if\ \delta_i\ and\ \delta_j^* = 0 \end{cases} \tag{21}$$

On the other hand, $SEPARATE_i$ component is not based on joint tests, but rather on the null hypotheses of $\delta_i = 0$ and $\delta_j^* = 0,$ tested separately. Thus:

$$SEPARATE_i = \begin{cases} 0, if\ \delta_i \neq 0\ and\ \delta_j^* \neq 0 \\ 0.5, if\ \delta_i \neq 0\ and\ \delta_j^* = 0 \\ 0.5, if\ \delta_i = 0\ and\ \delta_j^* \neq 0 \\ 1, if\ \delta_i = 0\ and\ \delta_j^* = 0 \end{cases} \tag{22}$$

This means that the sum of *JOINT* and *SEPARATE* can take a value of 0, 0.5, 1, 1.5 or 2, depending on the number of rejections of null hypotheses within the each EE estimated in previous subsections. Similarly, *EII* was calculated for each market across EU member states by summarizing the values for each country and dividing them by the number of countries for which the EE could be estimated.

The reason for the inclusion of the component *SEPARATE* into *EII* is the fact that basing the index solely on testing the joint significance of parameters results in the index having very low variability, due to the binary nature of possible hypothesis testing outcomes. This would make any kind of differentiation between countries and markets extremely difficult. Consequently, not many conclusions could be extracted from such an index, which would defeat the purpose of the index itself. By including the tests for the individual significance of parameters, alongside the joint hypothesis testing, it is possible to obtain higher variability and more detailed gradation between the levels of financial integration across countries and financial markets. The similar approach was used also by Lemmen and Eijffinger (1995).

[8] The risk-free asset model was not included into EII calculation given the theoretical differences vis-à-vis the risky asset models.

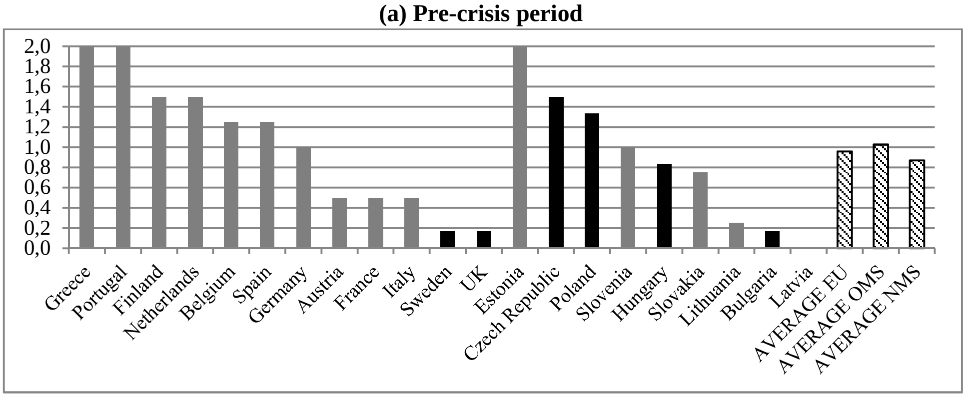
To test for the robustness of obtained results and to make sure that the inclusion of the *SEPARATE* component does not skew the *EII* values too far away from the assumptions of the theoretical model, different variants of (20) were used to calculate *EII*. Namely, instead of weighting *JOINT* and *SEPARATE* equally, the weight of *SEPARATE* was decreased from 1 to 0.5 and 0.25, respectively. The robustness check results are reported in the next subsection. Table 5 in the Appendix reports the summary of all EE estimations with calculated *EII*s for the two periods.

Figure 1a displays the *EII* for the pre-crisis period in OMS and NMS in descending order. It is evident that the most integrated countries amongst the OMS were Greece, Portugal, Finland, the Netherlands, Belgium, Spain and Germany, all with the *EII* above the EU average. On the other side of the spectrum, countries least integrated with the Eurozone were Sweden and UK. Not surprisingly, as these are the only two non-Eurozone members amongst the OMS analysed here.

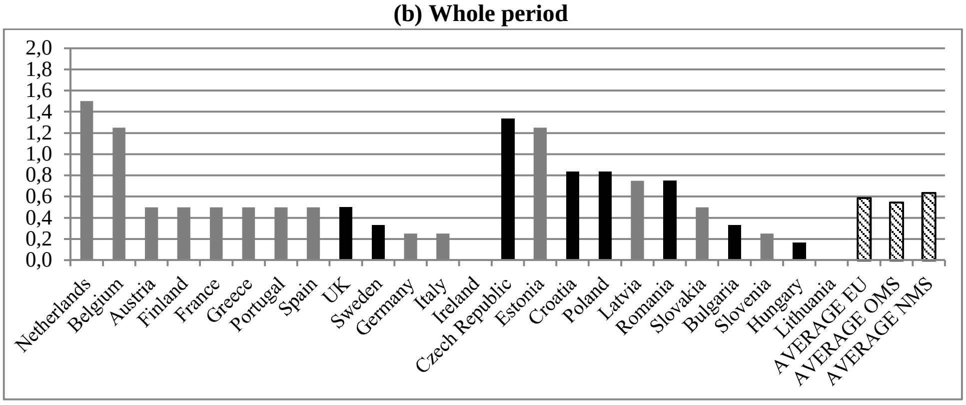
F i g u r e 1

Euler Integration Index, by Countries

(a) Pre-crisis period



(b) Whole period



Notes: Non-Eurozone countries are coloured black.

Source: Authors' calculations.

If we look at the NMS, the most integrated country in the pre-crisis period was Estonia. Non-Eurozone members follow, namely the Czech Republic and Poland. It is also evident that the aforementioned countries have an *EII* above not only the NMS average, but the OMS and EU average as well. On the other side, Lithuania, Bulgaria and Latvia were the least integrated countries amongst not only the NMS, but the EU as a whole. If we look at the group averages, the *EII* for the OMS is noticeably above the NMS average, with values of 1.03 and 0.87, respectively.

The results change significantly if the crisis period is included in the estimation (Figure 1b). The Netherlands and Belgium are now the two most integrated countries of the EU, while the pre-crisis leaders (Greece and Portugal) dropped significantly in *EII* value. This is not surprising, given the sovereign debt crisis that has hit these two countries. Similar movements are evident in almost all EU countries, with, perhaps surprisingly, Germany in the bottom half of the OMS group.[9]

The notion of an adverse impact of the crisis on the integration levels across the EU is supported by the fact that the *EII* averages decreased across the board: from 0.96 to 0.59 for the EU as a whole, from 1.03 to 0.54 for the OMS, and, finally, from 0.87 to 0.64 for the NMS. Evidently, the NMS' index is now even above the OMS' one, but the difference between the two has decreased substantially, indicating two findings: 1) the crisis had a stronger adverse impact on the integration of the OMS with the Eurozone, than of the NMS; 2) the integration levels of the NMS and OMS are converging, but to a lower level than in the pre--crisis period.

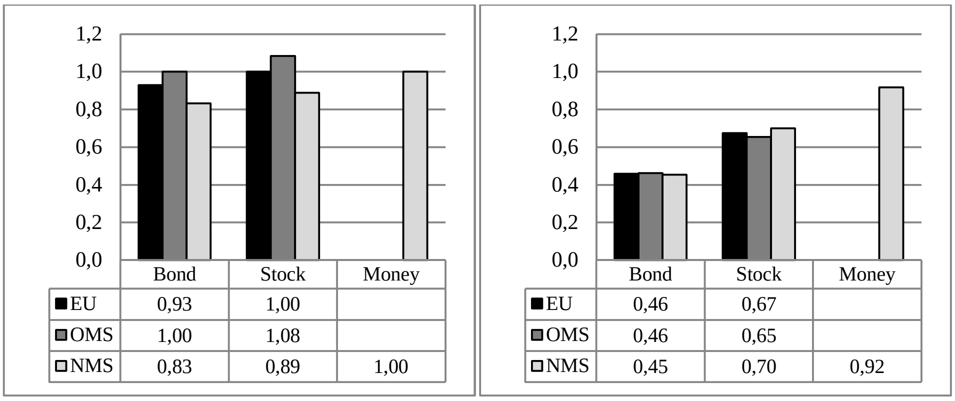
The analysis now turns from the integration levels by countries to the integration levels by financial markets. Figure 2 displays the *EII* values in both periods for the bond, stock and money markets. Estimations for the money markets contain only the NMS, as it makes little sense to calculate the index only for two OMS countries (UK and Sweden). Nevertheless, the corresponding values are visible in Table 5 in the Appendix.

[9] One of the reasons for this finding could possibly be found in the nature of the Euler equation tests and the choice of the benchmark country – in this case the Eurozone. Specifically, Euler tests reject the null hypothesis of perfect financial integration in countries from both sides of the spectrum vis-à-vis the Eurozone average. For instance, on the side of countries performing the worst during the crisis, analysed variables started to deviate from the Eurozone average in a way that the consumption growth decreased much more than in the Eurozone as a whole, while real returns on government bonds increased much faster than the Eurozone average due to higher risk premiums. However, on the side of countries performing the best during the crisis, the real returns also started to deviate from the Eurozone average, but in the opposite direction (lower risk premiums and higher consumption growth than the Eurozone average). In both cases, the Euler tests will reject perfect financial integration, resulting in the EII values that could be surprising at a first glance, like the one regarding Germany.

F i g u r e 2

Euler Integration Index, by Financial Markets

(a) Pre-crisis period **(b) Whole period**



Source: Authors' calculations.

The *EII* averages reveal that, out of all analysed financial markets in the EU, the OMS especially, the highest levels of integration are present in the stock markets, regardless of the period analysed (Figure 2b). However, the integration of the stock markets in the NMS was well below the OMS level in the pre-crisis period, reflecting the often shallow and weakly developed non-banking financial sectors in these countries, especially when compared to the OMS. However, the noticeable difference in the integration levels of stock markets between the NMS and OMS disappears when the crisis period is included in the estimation, indicating that stock markets of NMS showed higher integration-wise resilience to the financial and economic turmoil that ensued.

Further analysis suggests that the crisis severely decreased the integration levels of both the bond and the stock markets across the board. Figure 2b reveals that the *EII* averages for the stock markets dropped both in the NMS (from 0.89 to 0.70) and the OMS (from 1.08 to 0.65). However, the impact was much stronger in the government bond market which suffered substantial decreases in integration levels. For the NMS, the *EII* averages decreased from 0.83 to 0.45, and for the OMS they more than halved, plunging from 1.00 to 0.46. The fact that it was the government bond market that suffered the hardest blow integration-wise should come as no surprise, bearing in mind the sovereign debt crisis that recently hit the Eurozone. And the finding that the integration drop was bigger in the OMS than in the NMS probably reflects the fact that the sovereign crisis centred on the OMS from the periphery of the Eurozone. Estimations for the whole period again reveal the downward convergence of integration levels of the bond markets between the NMS and OMS.

In contrast, the money markets in the NMS proved stable and fairly resilient to the crisis, as the integration index averages dropped from 1.00 in the pre-crisis period to 0.92 in the whole period (Figure 2). This could reflect the fact that many of the biggest banks in the NMS are subsidiaries of Eurozone-based parent banks, thus having easier access to liquidity during crisis periods, resulting in increasingly integrated money markets.

Overall, Euler integration indices calculated for the financial markets confirm the earlier finding – the level of integration in the NMS was lower than in the OMS in the pre-crisis period. However, the differences between them have decreased due to the crisis, converging on a lower level than in the pre-crisis period.

3.6. Robustness Checks

To provide a robustness check, different variants of Euler integration index calculation were employed. Instead of weighting *JOINT* and *SEPARATE* equally (each with the weight of 1), the weight of *SEPARATE* was decreased from 1 to 0.5 and 0.25, respectively. The results are presented in Table 6 in the Appendix for the first scenario, while for the second one they are available upon request due to space limitations. Results confirm the previously obtained conclusions, as the ordering of countries within the two groups of countries does not change significantly, nor do the values of *EII* across financial markets alter the previously stated conclusions.

Conclusion

The empirical literature on the measurement of financial integration has grown significantly over the last two decades, but only a few authors utilised the many advantages of the Euler equation approach to that end. Building on the work of Obstfeld (1986; 1989; 1994a; 1994b) and Lemmen and Eijffinger (1995), this paper aimed to fill this gap in the literature and expand the research to various questions not yet addressed.

In that respect, this study measures financial integration levels between 28 EU member states and the Eurozone by estimating Euler equations on risk-free and risky assets in three types of financial markets (bond, stock and money market), taking into account several methodological issues not addressed in previous studies. By doing so, we constructed a new index (*Euler integration index*, EII), measuring financial integration across EU countries and financial markets.

The empirical analysis yielded several key findings. Euler equations were estimated for two periods: one ending just before the onset of the global financial crisis, the other including the crisis and post-crisis period as well. The results indicated a severe decrease in financial integration in the second period in both the NMS and the OMS, just like in the EU as a whole. However, the differences between the integration levels between the NMS and OMS have decreased significantly, indicating the convergence of integration levels, but to a lower level than in the pre-crisis period.

On the country level, the Netherlands and Belgium proved to be the two countries most highly integrated with the Eurozone, a finding not disrupted even if the crisis period is included in the estimation. Amongst the NMS, only Estonia, the Czech Republic and Poland have maintained high relative values of the *EII* throughout both periods, indicating their respective elevated levels of integration with the Eurozone. This could serve as an indication of preparedness of the Czech Republic and Poland to join the monetary union. On the other hand, Sweden and UK, the two non-Eurozone members amongst the OMS, showed relatively low integration levels with the Eurozone.

On the market type level, the results differed substantially, depending on the country group analysed. For the OMS, stock markets displayed highest integration levels amongst all analysed market types throughout both periods. On the other hand, the analysis revealed a relatively low integration level of stock markets in the NMS, with the *EII* at a noticeably lower level than in OMS in the pre-crisis period. This finding points to the need for the policy makers in these economies to make further efforts in stimulating the capital market development, deepening the non-banking financial sector and decreasing the bank-dependency of the economy.

The results suggested that the integration of government bond markets took the biggest hit during the crisis. *EII* values for these markets decreased in both the OMS and the NMS, and the scope of its decline was staggering. This finding reflected the severity of the recent Eurozone sovereign debt crisis. However, the OMS bond markets were more affected by the crisis, reflecting the fact that the sovereign crisis centred on the OMS from the periphery of the Eurozone. The only type of financial market that proved fairly resilient to the crisis regarding the integration level was the money market.

The results of this paper are in line with the previous findings found in the literature on the adverse effects of the recent crisis on the financial integration levels amongst EU countries that used different measures of financial integration than those utilised in this study (e.g. Syllignakis and Kouretas, 2010; Globan, 2014). Furthermore, the finding of relatively high integration levels of the stock markets in certain new member states (namely, the Czech Republic and Poland) is in line with the findings of Babetskii, Komárek and Komárková (2007) and Syllignakis and Kouretas (2010). Moreover, the lagging behind of the new EU member states vis-à-vis the more developed old member states in terms of financial integration in the pre-crisis period corresponds to the findings of Lane and Milesi-Ferretti (2007) and Égert and Kočenda (2011).

It should be noted that this study has its limitations and that the interpretation of results should be taken with caution. The theory behind the empirical estimation imposed some strong assumptions, i.e. the completeness of markets, which may make rejections of hypotheses difficult to interpret. For instance, if the hypothesis of perfect financial integration is rejected, this does not necessarily need to be a sign of low capital mobility and capital controls, but it could be a sign of asset market incompleteness. For future research, a potentially more rigorous way of testing for perfect financial integration would be to relax the assumption of market completeness and adjust the model to solve the portfolio choice problem in a way that allows for the investors to hold both domestic and foreign bonds at the same time.

The results obtained in this study strongly suggest that the recent crisis has decreased the overall level of financial integration amongst EU countries. It is therefore of great importance to make policy efforts both on the national and supranational level to boost the financial integration in the EU and make it sustainable in the long run. European Commission's recently set objective to achieve the banking and the capital market unions seems like a step in the right direction. These types of financial market unions would help diversify the sources of corporate financing, particularly for small and medium enterprises, and reduce the dependence of economies on bank-based financing, especially in the NMS. All this should help promote a more stable and sustainable economic growth. Furthermore, higher financial integration would improve risk sharing in the EU, which helps smoothing the business cycles and mitigates the impact of negative shocks (like the recent sovereign debt crisis) on private consumption.

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Appendix

Table 5

Euler Integration Indices across EU Countries and Financial Markets

Country	**(a) Pre-crisis period**				**(b) Whole period**			
	Bond	**Stock**	**Money**	***EII***	**Bond**	**Stock**	**Money**	***EII***
OMS								
Austria	0.5	0.5	n/a	***0.50***	0.5	0.5	n/a	***0.50***
Belgium	0.5	2	n/a	***1.25***	0.5	2	n/a	***1.25***
Finland	2	1	n/a	***1.50***	0.5	0.5	n/a	***0.50***
France	0.5	0.5	n/a	***0.50***	0.5	0.5	n/a	***0.50***
Germany	1	1	n/a	***1.00***	0	0.5	n/a	***0.25***
Greece	2	2	n/a	***2.00***	0.5	0.5	n/a	***0.50***
Ireland	n/a	n/a	n/a	–	0	0	n/a	***0.00***
Italy	0.5	0.5	n/a	***0.50***	0	0.5	n/a	***0.25***
Netherlands	2	1	n/a	***1.50***	2	1	n/a	***1.50***
Portugal	2	2	n/a	***2.00***	0.5	0.5	n/a	***0.50***
Spain	0.5	2	n/a	***1.25***	0.5	0.5	n/a	***0.50***
Sweden	0.5	0	0	***0.17***	0	1	0	***0.33***
UK	0	0.5	0	***0.17***	0.5	0.5	0.5	***0.50***
EII OMS	***1.00***	***1.08***	***0.00***		***0.46***	***0.65***	***0.25***	
NMS								
Bulgaria	0.5	0	0	***0.17***	0.5	0	0.5	***0.33***
Croatia	n/a	n/a	n/a	–	0.5	0	2	***0.83***
Czech Republic	0.5	2	2	***1.50***	1.5	2	0.5	***1.33***
Estonia	2	2	n/a	***2.00***	0.5	2	n/a	***1.25***
Hungary	0.5	0.5	1.5	***0.83***	0	0.5	0	***0.17***
Latvia	0	0	n/a	***0.00***	0	1.5	n/a	***0.75***
Lithuania	0.5	0	n/a	***0.25***	0	0	n/a	***0.00***
Poland	1.5	2	0.5	***1.33***	0.5	0.5	1.5	***0.83***
Romania	n/a	n/a	n/a	–	0.5	n/a	1	***0.75***
Slovakia	1	0.5	n/a	***0.75***	0.5	0.5	n/a	***0.50***
Slovenia	1	1	n/a	***1.00***	0.5	0	n/a	***0.25***
EII NMS	***0.83***	***0.89***	***1.00***		***0.45***	***0.70***	***0.92***	

Note: EII was calculated only for countries for which at least two markets could be estimated.

Source: Authors' calculations.

Table 6

Euler Integration Indices across EU Countries and Financial Markets, Weighting of Component *SEPARATE* = 0.5

Country	(a) Pre-crisis period				(b) Whole period			
	Bond	**Stock**	**Money**	***EII***	**Bond**	**Stock**	**Money**	***EII***
				OMS				
Austria	0.25	0.25	n/a	***0.25***	0.25	0.25	n/a	***0.25***
Belgium	0.25	1.5	n/a	***0.88***	0.25	1.5	n/a	***0.88***
Finland	1.5	0.5	n/a	***1.00***	0.25	0.25	n/a	***0.25***
France	0.25	0.25	n/a	***0.25***	0.25	0.25	n/a	***0.25***
Germany	0.5	0.5	n/a	***0.50***	0	0.25	n/a	***0.13***
Greece	1.5	1.5	n/a	***1.50***	0.25	0.25	n/a	***0.25***
Ireland	n/a	n/a	n/a	–	0	0	n/a	***0.00***
Italy	0.25	0.25	n/a	***0.25***	0	0.25	n/a	***0.13***
Netherlands	1.5	0.5	n/a	***1.00***	1.5	0.5	n/a	***1.00***
Portugal	1.5	1.5	n/a	***1.50***	0.25	0.25	n/a	***0.25***
Spain	0.25	1.5	n/a	***0.88***	0.25	0.25	n/a	***0.25***
Sweden	0.25	0	0	***0.08***	0	0.5	0	***0.17***
UK	0	0.25	0	***0.08***	0.25	0.25	0.25	***0.25***
EII OMS	***0.67***	***0.71***	***0.00***		***0.27***	***0.37***	***0.13***	
				NMS				
Bulgaria	0.25	0	0	***0.08***	0.25	0	0.25	***0.17***
Croatia	n/a	n/a	n/a	–	0.25	0	1.5	***0.58***
Czech Republic	0.25	1.5	1.5	***1.08***	1.25	1.5	0.25	***1.00***
Estonia	1.5	1.5	n/a	***1.50***	0.25	1.5	n/a	***0.88***
Hungary	0.25	0.25	1.25	***0.58***	0	0.25	0	***0.08***
Latvia	0	0	n/a	***0.00***	0	1.25	n/a	***0.63***
Lithuania	0.25	0	n/a	***0.13***	0	0	n/a	***0.00***
Poland	1.25	1.5	0.25	***1.00***	0.25	0.25	1.25	***0.58***
Romania	n/a	n/a	n/a	–	0.25	n/a	0.5	***0.38***
Slovakia	0.5	0.25	n/a	***0.38***	0.25	0.25	n/a	***0.25***
Slovenia	0.5	0.5	n/a	***0.50***	0.25	0	n/a	***0.13***
EII NMS	***0.53***	***0.61***	***0.75***		***0.27***	***0.50***	***0.63***	

Note: EII was calculated only for countries for which at least two markets could be estimated.

Source: Authors' calculations.