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Financial integration before and after the crisis: Euler equations (re)visit European Union

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Abstract

This paper offers one of the rare applications of various 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). In order 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 known 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, while the crisis considerably decreased the gap, resulting even with NMS surpassing the OMS in *EII* values.

Key words

consumption, crisis, Euler equation, European Union, financial integration

JEL classification

E21, E44, F15, F36

1. 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 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 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 et al. 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).

How to measure the degree of financial integration amongst countries has long been a subject of debate amongst researchers. 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; Kolmann 1995; Ravn 2001). Corsetti et al. (2012) even showed that when the correlations are examined dynamically over different frequencies of data, the counter-theoretical evidence becomes even stronger and the correlations become negative, indicating low levels of international risk-sharing and financial integration.

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 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 performed OLS estimations 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 second section derives the theoretical basis of the model. Data and methodology are explained in the third section, while the fourth reports the results of EE estimations. Section five concludes the paper.

2. Theoretical model

2.1. Risk-free assets

In order 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

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

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

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

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

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

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

Let the marginal rate of intertemporal substitution be defined as

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

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

$$\psi_{t+1} = \frac{P_t}{P_{t+1}}\vartheta_{t+1} - \frac{P_t^*}{P_{t+1}^*}\frac{X_t}{X_{t+1}}\vartheta_{t+1}^*. \tag{5}$$

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

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

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

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

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.

2.2. 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[1], it follows that

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

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: 21), (13) can be written as

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

where *cov* denotes unconditional covariance.

Taking natural logarithms from both sides of the equation[2] leads to

$$E_t[r_{t+1}] - \alpha E_t[c_{t+1} - c_t] + \log\beta + \log\theta = E_t[r^*_{t+1}] - \alpha^* E_t[c^*_{t+1} - c^*_t] + \log\beta^* + \log\theta^* \tag{15}$$

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1 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.

2 Note that $\log(a + b) = \log a + \log(1 + b/a)$.

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

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

where $E_t[\Delta c_{t+1}]$ 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

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

where δ_0 is a constant containing thetas and betas from (16), and ω_t is 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

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

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

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

3. Data and methodology

3.1. 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 (see Appendix).

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, 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 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 corresponding 3-month rates from Eurostat.

All variables are of quarterly frequencies. In order to examine whether the recent crisis impacted the levels of financial integration in EU member states, all models 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 (see Appendix for details on each country). The "pre-crisis period" includes the data with the same starting points, but it ends on 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 substantial loss of observations. Data sources and time spans for all observed variables, together with their descriptive statistics, are given in Appendix.

3.2. 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 $r_{j,t} = \ln(i_{j,t} - \pi^e_{j,t} + 100)$, where $i_{j,t}$ is the nominal return of a particular financial market, $\pi^e_{j,t}$ 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 in order 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 paper cited there). Therefore, instead of erroneously assuming the validity of rational expectations (and approximating π^e_t 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 only from 2009:Q2, while the Croatian data start from 2005:Q3. This conditioned the impossibility to estimate risky assets models for the pre-crisis period for those countries.

4. 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).[3] 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).

4.1. 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 $\gamma_0$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 $\alpha = 0.5$.[4] Table 1 carries out the results for all 28 EU countries, divided into OMS and NMS. The results indicate whether the null hypothesis of perfect financial integration, as defined in (11), could be rejected for each given country.

[Table 1]

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 are able to trade the same asset on the same terms as the residents of Eurozone as a whole, indicating perfect financial integration between them.

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[3] Tables 1-4 report exactly 32 cases where the error terms assumptions were met. Even if the HAC option was used for those equations, the results would not change dramatically. A different decision in the significance test would be obtained in 5 out of 32 equations (15.6%). However, the authors chose to refrain from that beacuse 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).

[4] 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.

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 suggestion that the crisis could have reduced the level of integration amongst EU member states.

In 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 individual significances 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)).

4.2. 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.[5]

[Table 2]

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 amongst these eight there is an equal number of OMSs and NMSs 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 amongst the perfectly

[5] 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 start in 2005:Q2, leaving not enough data at hand.

integrated countries are those that will later suffer from the sovereign debt crisis, needing a bailout from the Troika (Greece, Portugal and Cyprus).

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

4.3. 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 sub-section, are reported in Table 3. It should come to 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.

[Table 3]

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.

4.4. 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, due to the fact that 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 sub-sections.

[Table 4]

Due to a relatively low 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.

4.5. Summarising the results

In order to summarise the results and facilitate a more comprehensive view into 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) have been rejected or not for the three risky asset models.[6] *EII* for country *i* consists of two components and is defined as:

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

where *N* is a 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 the null hypotheses of $\delta_i = 0$ and $\delta_j^* = 0$ are tested separately. Thus:

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

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

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 each EE estimated in previous sub-sections. 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).

In order to test for the robustness of obtained results and to make sure that the inclusion of the component *SEPARATE* does not skew the values of *EII* 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. Results of robustness checks are reported in the next sub-section.

Table 5 reports the summary of all EE estimations with calculated *EII*s for the two periods.

[Table 5]

Fig. 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.

[Fig. 1]

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.

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

The notion of an adverse impact of the crisis on the integration levels in 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. Fig. 2 displays the values of the *EII* in two 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.

[Fig. 2]

The *EII* averages reveal that, out of all analysed financial markets in the EU, and the OMS especially, the highest levels of integration are present in the stock markets, regardless of the time period analysed (Fig. 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. Fig. 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 the levels of integration. In the NMS, the *EII* averages decreased from 0.83 to 0.45, and in 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 (Fig. 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 by 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.

4.6. Robustness checks

In order 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 for the first scenario, while for the second they are available upon request due to the limited space available. Results confirm the previously obtained results, 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.

[Table 6]

5. Conclusion

The empirical literature on the measurement of financial integration has grown significantly over the last two decades, but only 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 on two periods: one ending just before the onset of the global financial crisis, the other including the crisis and post-crisis period. 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 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 high 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 markets level, 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.

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 et al. (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).

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 markets 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.

[Appendix]

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Table 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 (see Appendix 1). The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Table 2 Euler equation tests of financial integration for the government bond market: $r_{t+1,bond} - r^*_{t+1,bond} = \delta_0 + \alpha[\Delta c_{t+1}] - \alpha^*[\Delta c^*_{t+1}] + \sum_{i=1}^{N} \delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N} \delta^*_j \Delta c^*_{t+1-j} + \mu_t$

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 (see Appendix 1). The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Table 3 Euler equation tests of financial integration for the stock market: $r_{t+1,stock} - r^*_{t+1,stock} = \delta_0 + \alpha[\Delta c_{t+1}] - \alpha^*[\Delta c^*_{t+1}] + \sum_{i=1}^{N} \delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N} \delta^*_j \Delta c^*_{t+1-j} + \mu_t$

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 (see Appendix 1). The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Table 4 Euler equation tests of financial integration for the money market: $r_{t+1,money} - r^*_{t+1,money} = \delta_0 + \alpha[\Delta c_{t+1}] - \alpha^*[\Delta c^*_{t+1}] + \sum_{i=1}^{N} \delta_i \Delta c_{t+1-i} - \sum_{j=1}^{N} \delta^*_j \Delta c^*_{t+1-j} + \mu_t$

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 (see Appendix 1). The "pre-crisis period" includes the data with the same starting points, but it ends on 2008:Q2.

Table 5 Euler integration indices across EU countries and financial markets

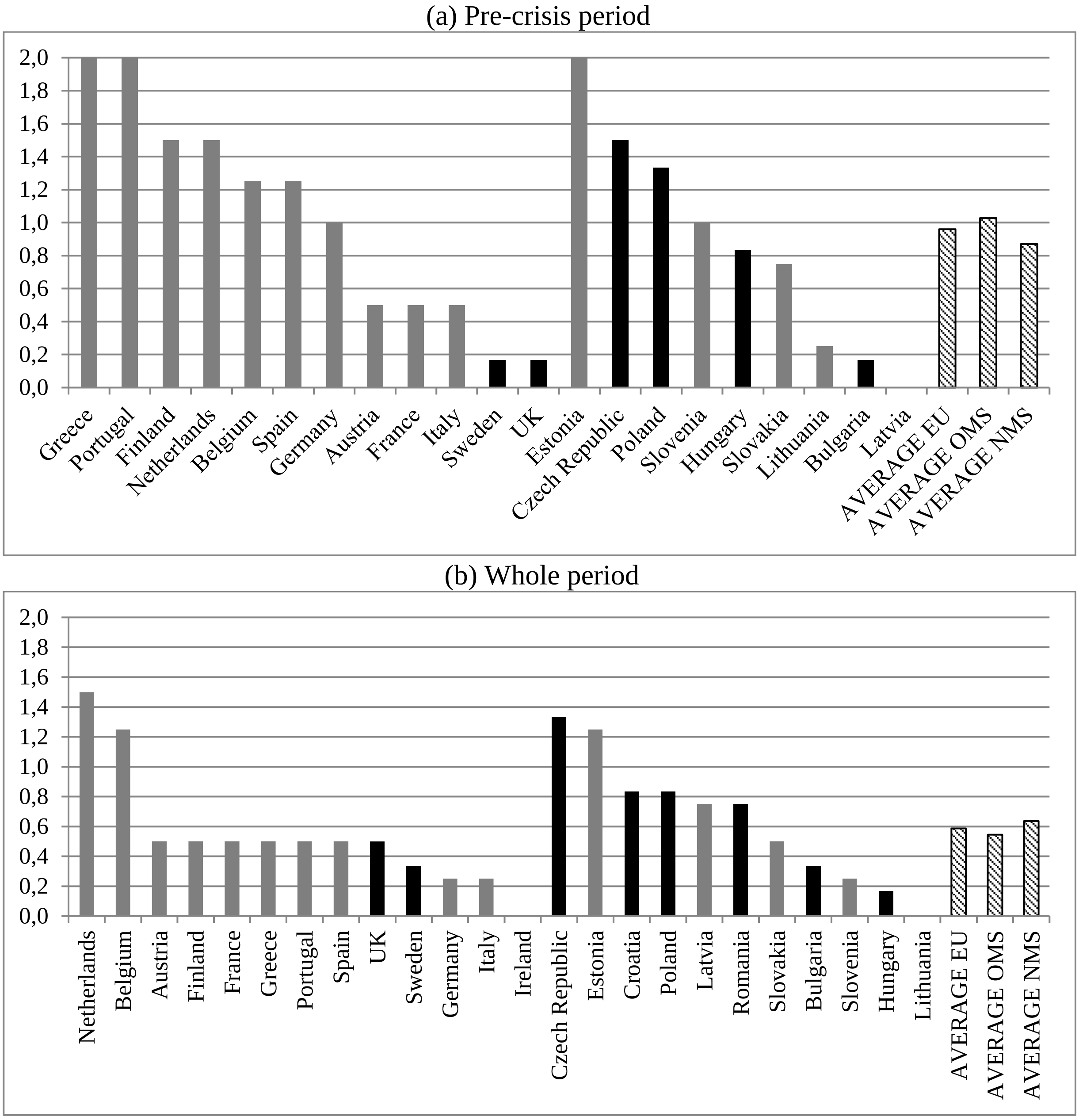
Country	(a) Pre-crisis period				(b) Whole period			
	Bond	Stock	Money	*EII*	Bond	Stock	Money	*EII*
OMS								
Austria	0.5	0.5	n/a	***0.50***	0.5	0.5	n/a	***0.50***
Belgium	0.5	2	n/a	***1.25***	0.5	2	n/a	***1.25***
Finland	2	1	n/a	***1.50***	0.5	0.5	n/a	***0.50***
France	0.5	0.5	n/a	***0.50***	0.5	0.5	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.

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.



Notes: non-eurozone countries are coloured black.

Figure 1 Euler integration index, by countries

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

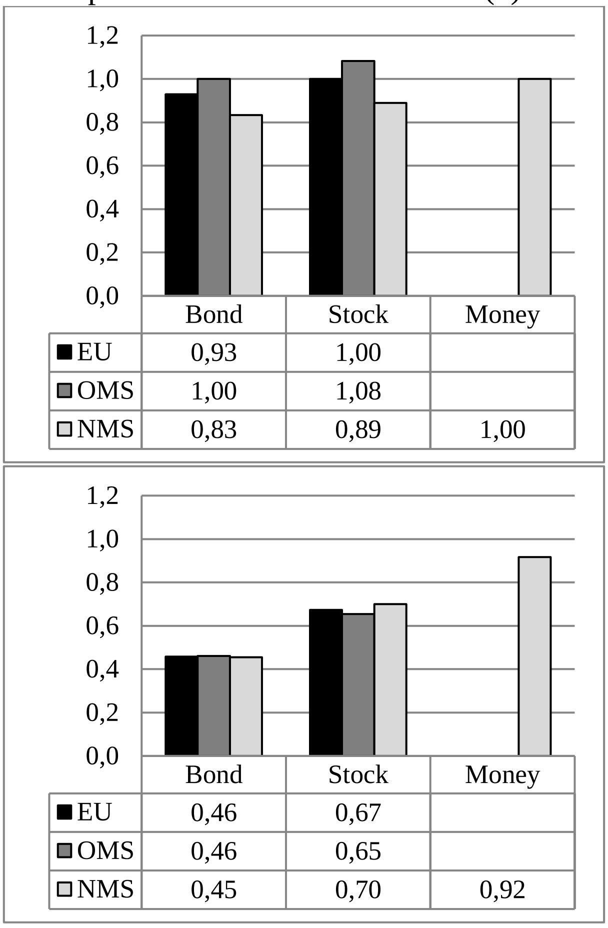


Figure 2 Euler integration index, by financial markets

Appendix 1a Descriptive statistics of the analysed variables (NMS)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat, IMF	IMF	Eurostat
Bulgaria	min	55.4120	-0.2602	4.5832	4.5146	4.5626
	max	121.2913	0.1452	4.6251	4.5650	4.6113
	mean	93.4155	0.0073	4.5994	4.5487	4.5864
	st. dev.	19.5597	0.0490	0.0112	0.0117	0.0123
	Time span	1995Q1-2014Q3	1995Q2-2014Q3	2001Q3-2015Q1	2001Q4-2015Q1	2001Q3-2015Q1
Croatia	min	67.1313	-0.0454	4.6095	4.5545	4.5828
	max	112.4274	0.1317	4.6531	4.5870	4.6632
	mean	93.5994	0.0057	4.6291	4.5732	4.6105
	st. dev.	13.3364	0.0217	0.0107	0.0072	0.0207
	Time span	1997Q1-2014Q2	1997Q2-2014Q2	2006Q1-2015Q1	2005Q3-2015Q1	2005Q3-2015Q1
Cyprus	min	66.2620	-0.0720	4.6213	n/a	n/a
	max	128.2884	0.0548	4.6775		
	mean	97.6421	0.0064	4.6388		
	st. dev.	17.6324	0.0242	0.0144		
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q2-2015Q1		
Czech rep.	min	72.3127	-0.0294	4.5904	4.5527	4.5837
	max	110.9947	0.1010	4.6424	4.5941	4.6230
	mean	96.6845	0.0056	4.6199	4.5813	4.6032
	st. dev.	11.8202	0.0153	0.0118	0.0095	0.0112
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q1-2015Q1	2001Q1-2015Q1	2001Q1-2015Q1
Estonia	min	54.5495	-0.0463	4.6079	4.5387	n/a
	max	121.8465	0.0579	4.6790	4.5901	
	mean	90.4470	0.0100	4.6297	4.5670	
	st. dev.	21.0788	0.0202	0.0176	0.0101	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q2-2010Q4	2001Q2-2015Q1	

Note: *n/a* stands for "not available".

Appendix 1b Descriptive statistics of the analysed variables (NMS) (continued)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	IMF	Eurostat
Hungary	min	70.4697	-0.0417	4.5491	4.4581	4.5540
	max	104.3363	0.0528	4.6259	4.5476	4.6306
	mean	89.0662	0.0032	4.5877	4.5125	4.5946
	st. dev.	10.6174	0.0173	0.0192	0.0211	0.0179
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q1-2015Q1	2001Q1-2015Q1	1997Q1-2015Q1
Latvia	min	55.4808	-0.1097	4.5791	4.5350	n/a
	max	133.2362	0.0857	4.7192	4.6009	
	mean	91.7479	0.0104	4.6184	4.5622	
	st. dev.	22.9481	0.0307	0.0333	0.0147	
	Time span	1995Q1-2014Q1	1995Q2-2014Q1	2001Q3-2015Q1	2001Q3-2015Q1	
Lithuania	min	54.4349	-0.0904	4.5970	4.5601	n/a
	max	124.9625	0.0958	4.7213	4.6044	
	mean	89.6282	0.0105	4.6371	4.5842	
	st. dev.	21.1647	0.0283	0.0264	0.0141	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q3-2014Q4	2002Q1-2015Q1	
Malta	min	90.0159	-0.0415	4.6073	n/a	n/a
	max	123.0555	0.1001	4.6418		
	mean	105.5962	0.0051	4.6231		
	st. dev.	9.3014	0.0225	0.0071		
	Time span	2000Q1-2014Q2	2000Q2-2014Q2	2002Q4-2015Q1		
Poland	min	66.8789	-0.0248	4.6086	4.5480	4.6048
	max	130.7175	0.0781	4.6685	4.5882	4.7022
	mean	100.7501	0.0097	4.6349	4.5789	4.6306
	st. dev.	19.1856	0.0144	0.0115	0.0077	0.0197
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q3-2015Q1	2001Q3-2015Q1	2001Q3-2015Q1

Note: *n/a* stands for “not available”.

Appendix 1c Descriptive statistics of the analysed variables (NMS) (continued)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	IMF	Eurostat
Romania	min	52.1280	-0.2338	4.4908	n/a	4.4816
	max	139.2450	0.2542	4.6116		4.6395
	mean	101.1128	0.0140	4.5534		4.5598
	st. dev.	24.5201	0.0511	0.0262		0.0342
	Time span	1998Q1-2014Q2	1998Q2-2014Q2	2005Q2-2015Q1		2001Q3-2015Q1
Slovakia	min	66.4011	-0.0353	4.5674	4.4823	n/a
	max	122.6620	0.1015	4.6205	4.5779	
	mean	98.4756	0.0079	4.5870	4.5399	
	st. dev.	18.2659	0.0193	0.0123	0.0212	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	2001Q1-2015Q1	2001Q1-2015Q1	
Slovenia	min	72.8612	-0.0259	4.5798	4.5154	n/a
	max	114.5787	0.0519	4.6230	4.5774	
	mean	96.9685	0.0058	4.6003	4.5432	
	st. dev.	13.0499	0.0126	0.0118	0.0164	
	Time span	1995Q1-2014Q1	1995Q2-2014Q1	2002Q2-2015Q1	1997Q1-2015Q1	

Note: *n/a* stands for "not available".

Appendix 1d Descriptive statistics of the analysed variables (OMS)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	IMF	Eurostat
Austria	min	84.2725	-0.0260	4.5906	4.5791	n/a
	max	109.7338	0.0231	4.6503	4.5929	
	mean	98.5799	0.0036	4.6275	4.5891	
	st. dev.	7.9653	0.0086	0.0147	0.0045	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	
Belgium	min	83.9761	-0.0031	4.5961	4.5782	n/a
	max	111.1408	0.0094	4.6489	4.5921	
	mean	99.1938	0.0037	4.6276	4.5875	
	st. dev.	8.2492	0.0025	0.0128	0.0045	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	
Denmark	min	82.7842	-0.0189	n/a	n/a	n/a
	max	107.6445	0.0239			
	mean	97.2188	0.0033			
	st. dev.	7.7933	0.0084			
	Time span	1995Q1-2014Q2	1995Q2-2014Q2			
Finland	min	75.0211	-0.0273	4.5978	4.5754	n/a
	max	112.3811	0.0247	4.6569	4.5943	
	mean	96.3954	0.0053	4.6252	4.5876	
	st. dev.	11.7660	0.0080	0.0149	0.0058	
	Time span	1995Q1-2014Q1	1995Q2-2014Q1	1997Q1-2015Q1	1997Q1-2015Q1	
France	min	81.6244	-0.0078	4.5970	4.5812	n/a
	max	110.1530	0.0191	4.6500	4.5920	
	mean	97.6374	0.0039	4.6269	4.5888	
	st. dev.	9.1780	0.0050	0.0134	0.0051	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	

Note: *n/a* stands for “not available”.

Appendix 1e Descriptive statistics of the analysed variables (OMS) (continued)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	IMF	Eurostat
Germany	min	91.4166	-0.0074	4.5978	4.5836	n/a
	max	109.2851	0.0141	4.6491	4.5984	
	mean	100.4621	0.0024	4.6281	4.5927	
	st. dev.	4.8865	0.0047	0.0140	0.0035	
	Time span	1995Q1-2014Q1	1995Q2-2014Q1	1997Q1-2015Q1	1997Q1-2015Q1	
Greece	min	80.9577	-0.0545	4.5997	4.5412	n/a
	max	113.9284	0.0406	4.8128	4.5919	
	mean	96.2637	0.0004	4.6441	4.5694	
	st. dev.	10.0135	0.0188	0.0475	0.0105	
	Time span	2000Q1-2014Q2	2000Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	
Ireland	min	60.2875	-0.0276	4.6145	4.5839	n/a
	max	115.2121	0.0473	4.7316	4.6753	
	mean	94.4012	0.0079	4.6724	4.6228	
	st. dev.	15.4223	0.0151	0.0376	0.0229	
	Time span	1997Q1-2014Q1	1997Q2-2014Q1	2009Q2-2015Q1	2009Q2-2015Q1	
Italy	min	84.3522	-0.0146	4.6083	4.5728	n/a
	max	102.4751	0.0174	4.6574	4.5955	
	mean	96.1377	0.0017	4.6309	4.5852	
	st. dev.	5.3518	0.0054	0.0077	0.0056	
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	
Luxembourg	min	70.4321	-0.0226	n/a	n/a	n/a
	max	117.8962	0.0430			
	mean	96.9468	0.0068			
	st. dev.	13.3548	0.0099			
	Time span	1995Q1-2014Q1	1995Q2-2014Q1			

Note: *n/a* stands for "not available".

Appendix 1f Descriptive statistics of the analysed variables (OMS) (continued)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	IMF	Eurostat
Netherlands	min	78.3579	-0.0099	4.5940	4.5722	n/a
	max	108.6673	0.0141	4.6479	4.5922	
	mean	97.9763	0.0038	4.6225	4.5849	
	st. dev.	9.0821	0.0054	0.0131	0.0053	
	Time span	2000Q1-2014Q1	2000Q2-2014Q1	1997Q1-2015Q1	1997Q1-2015Q1	
Portugal	min	75.2263	-0.0406	4.6093	4.5688	n/a
	max	106.7504	0.0221	4.7059	4.5913	
	mean	94.6928	0.0033	4.6328	4.5798	
	st. dev.	8.6921	0.0120	0.0202	0.0057	
	Time span	2000Q1-2014Q1	2000Q2-2014Q1	1997Q1-2015Q1	1997Q1-2015Q1	
Spain	min	68.2981	-0.0194	4.6076	4.5710	n/a
	max	110.2850	0.0260	4.6509	4.5964	
	mean	93.0572	0.0054	4.6272	4.5825	
	st. dev.	13.7975	0.0091	0.0103	0.0063	
	Time span	2000Q1-2014Q2	2000Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	
Sweden	min	80.6782	-0.0155	4.6014	4.5767	4.5588
	max	116.7191	0.0264	4.6614	4.5977	4.6107
	mean	98.7645	0.0046	4.6273	4.5894	4.5868
	st. dev.	10.4374	0.0075	0.0143	0.0055	0.0141
	Time span	2000Q1-2014Q2	2000Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	1997Q1-2015Q1
UK	min	68.3410	-0.0101	4.5973	4.5823	4.5633
	max	106.8786	0.0202	4.6606	4.5958	4.6350
	mean	92.7962	0.0059	4.6307	4.5893	4.5966
	st. dev.	11.9975	0.0059	0.0162	0.0037	0.0239
	Time span	2000Q1-2014Q2	2000Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	1997Q1-2015Q1

Note: *n/a* stands for "not available".

Appendix 1g Descriptive statistics of the analysed variables (eurozone)

Country	Variable	C_t	Δc_t	$r_{t,bond}$	$r_{t,stock}$	$r_{t,money}$
	Source	Eurostat	Eurostat	Eurostat	ECB	Eurostat
Eurozone	min	82.9829	-0.0069	4.6025	4.5793	4.5859
	max	106.2541	0.0108	4.6507	4.5936	4.6381
	mean	97.5593	0.0032	4.6290	4.5880	4.6130
	st. dev.	7.5229	0.0035	0.0100	0.0041	0.0155
	Time span	1995Q1-2014Q2	1995Q2-2014Q2	1997Q1-2015Q1	1997Q1-2015Q1	1997Q1-2015Q1