The Impact of the Financial Crisis on Integration of Bond Markets in the European Union

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Abstract
The aim of the paper is to evaluate the impact of the financial crisis on the integration of bond markets in the European Union (EU). The initial indicator is the average yield of medium-term government bonds in individual EU countries. Consequently, the 2005 – 2011 time period has been divided into two periods - before the financial crisis and during the financial crisis, and after the financial crisis. Furthermore, we have used the one-factor analysis of variance ANOVA and then compared the mean values in the indicated periods. In order for ANOVA to be carried out, first the assumptions of normality and homogeneity of variances of survey data have to be tested. Here we apply Shapiro-Wilk test for testing the normality and Bartlett's test for testing the homogeneity of variances. The result of the procedure is a statement that the integration of bond markets in the EU has been deepened, despite the financial crisis.

Keywords: integration of bond market, financial crisis, European Union
JEL codes: F36, G15,

1. Introduction

The European integration process has led to the introduction of common currency, the euro. This step has contributed to the expected intensification of not only business relations, but also financial relations between the individual member countries of the European Monetary Union (EMU). However, together with the introduction of the common currency it is necessary to integrate financial markets as well.

Financial markets are markets, where the funds available are transferred from surplus units to deficit units, while these two groups mingle. Functioning financial markets form an inherent part of every economy and their effective functioning is the key factor of economic growth. In contrast, poor-functioning financial markets may significantly weaken the economy as the problems of the financial sector may as well expand to other economic sectors (Černohorský and Teplý, 2011).

The global financial crisis which broke out at the end of 2008 in the USA has led to a slowdown in the process of financial integration. Economic growth has stopped and many countries are not able to meet Maastricht Convergence Criteria. The problem of the global financial integration started with the emergence of financial institutions that were too large to go bankrupt.

On one hand, the integrated financial markets and the common currency may help protect the countries from the negative impacts of a financial crisis, since the countries are part of a unified and stable economic unit. However, on the other hand, a financial crisis may spread quite easily and quickly from one country to another, since barriers to the capital movements have been reduced.

The government bond markets are the main source of funding not only for central governments, but also for municipalities. These markets are also important because government bonds are considered as a benchmark for assessment of other securities. The integration of bond markets may bring two substantial advantages to the residents. The first advantage lies in the fact that the governments are able to significantly reduce their debt-service costs, because the integrated market allows the investors to geographically better resist entirely local economic shocks, which may lead to a lower liquidity premium, and as a consequence may reduce interest payments made by the governments. The second advantage is that the integration of bond markets contributes to increased transparency and homogeneity in the evaluation of bonds itself (Komárková and Komárek, 2008).

The aim of the paper is to examine, with the use of suitable methods, the impact of the financial crisis on the integration of bond markets in the European Union.

Our paper is based on scientific literature research and on theoretical delimitations of the integration process of financial markets as well as on the fundamental approaches to financial integration measurement. Further, we focus on theoretical definition of methodology used in the analysis of the integration of bond markets. The following part presents the results of the proposed methodology applied to average yields of medium-term government bonds in selected EU countries. Subsequently, the results are discussed and compared with other studies.

2. Theoretical background

2.1 Definition

There is a whole range of definitions on the process of financial integration in the economic literature. A wording of the definition by Baele et al. (2004) from the European Central Bank has been a generally used definition of the integration of financial markets:

The market for a given set of financial instruments and/or services is fully integrated if all potential market participants with the same relevant characteristics:

- face a single set of rules when they decide to deal with those financial instruments and/or services;
- have equal access to the above-mentioned set of financial instruments and/or services;
- and are treated equally when they are active in the market.

According to Čermák (2006), this definition includes important characteristics. One of these characteristics is that it is not necessary for the financial structure and the infrastructure to be identical. Another important characteristic is that, even though the full integration has been achieved, there may still persist different inequalities between supply and demand or various market rigidities. On a fully integrated market there have to be set up the same conditions for competing subjects, and the subjects have to be treated in the same way.

Czech National Bank (2011) states that it is possible to speak about the achievement of full integration of financial markets only if financial assets with comparable risk factors and yields are evaluated by the markets in the same way, regardless of the country where the assets are traded. Fully integrated markets without any barriers (economic, legislative, etc.) permit to make use of arbitration opportunities which lower the importance of local factors characteristic for given countries, and subsequently, enable direct comparison of the prices of financial assets in individual markets.

Financial markets are integrated when the law of one price holds. This states that assets generating identical cash flows command the same return, regardless of the domicile of the issuer and of the asset holder (Adam et al., 2002).

As Vodová (2009) notes, different revenues of identical assets are caused mainly by legislative barriers, economic barriers (information asymmetry) or other barriers (different language, different preferences of consumers, insufficient mobility of borrowers etc.).

2. 2 Approaches to measuring financial integration

In the following part we will briefly introduce basic approaches to measuring the degree of financial integration.

2.2.1 Analysis of synchronization

Analysis of synchronization is the first step to form the concept of financial integration. It is based on the correlation analysis in standard or dynamic (rollover) form. This analysis indicates the force of a linear relationship between two variables. Its value, however, may not be sufficient for the evaluation of this relationship, particularly in those cases where the assumption of normality is incorrect. The correlation coefficients, being aggregated statistics, cannot substitute for individual evaluation of the data (Babetskii et al., 2007).

2.2.2 β – convergence

β – convergence is used to determine the approximation rate of asset returns in financial markets. In order to quantify β – convergence, it is possible to apply regression (in time series or using the panel dataset method) according to the following formula:

$$\Delta R_{i,t} = \alpha_i + \beta R_{i,t-1} + \sum_{l=1}^{L} \gamma_l \, \Delta R_{i,t-l} + \varepsilon_{i,t} \,, \quad (1)$$

where $R_{i,t}$ represents the distribution rate of specific assets between a country *i* in time *t* with respect to the reference territory, Δ is the reference operator, α_i is a specific constant for the given country, $\varepsilon_{i,t}$ is white noise disturbance. Lag length *L* is based on Schwarz Criterion, maximal length is set to 4, because we have applied weekly data and financial markets memory is relatively short. *β* coefficient is a direct criterion of the rate of global market convergence. Convergence occurs in case that *β* coefficient is negative. The higher the absolute value of *β* coefficient is, the higher the rate of convergence is. In order to analyse, whether the rate of convergence is higher in one period than in another one, it is possible to decompose *β* into

$$\beta = \beta_1 I + (1 - I)\beta_2, \quad (2)$$

where *I* is a dummy variable which assumes the value of 1. Although β – convergence measures the rate of convergence, it does in no way indicate to what extent markets have already been integrated. For this purpose, *σ* – convergence is used.

2.2.3 σ – convergence

σ – convergence is used as a complement to *β* – convergence in order to determine the level of markets integration. For its quantification the calculation of (cross-sectional) standard deviation (σ) is applied according to the formula:

$$\sigma_t = \sqrt{\left(\frac{1}{N-1}\right) \sum_{i=1}^{N} [\log(y_{it}) - \log(\bar{y}_t)]^2}, \quad (3)$$

where y_{it} symbol stands for the return of asset *i* in time *t*, $\bar{y}_t$ symbol is the mean value of a data set in time *t*. Index *i* represents individual countries (*i = 1, 2, …, N*). By definition, *σ* assumes only positive values. A lower value of *σ* means that a higher level of convergence has been achieved. From a theoretical point of view, the full integration level is achieved when the standard deviation assumes zero value, whereas very high values of *σ* mean that a very low degree of integration has been achieved (Babetskii et al., 2007).

2.2.4 Measuring integration based on events

In case of integration measurement based on events, it is possible to use, similarly as in case of *β* – convergence, standard regression analysis given by the relation:

$$\Delta R_t = \alpha_t + \gamma_t \Delta R_{b,t} + \varepsilon_t, \quad (4)$$

or the panel estimation method in form of the equation:

$$\Delta R_{i,t} = \alpha_{i,t} + \gamma_{i,t} \Delta R_{b,t} + \varepsilon_{i,t}, \quad (5)$$

where $R_{i,t}$ stands for the return of asset *i* in time *t*, while in concrete application there is a difference between a given country's asset returns within two points in time on the part of a dependent variable ($\Delta R_{i,t}$), and on the part of the dummy variable there is a difference among the returns of a benchmark asset ($\Delta R_{b,t}$), where b symbol represents a benchmark country, Δ is the difference operator, $\alpha_{i,t}$ is a constant and the expression $\varepsilon_{i,t}$ denotes specific shock for individual countries. During the growth of this integration type it is required that α converges to zero, γ to one and the proportion of variation dependent ($\Delta R_{i,t}$) on common factor ($\Delta R_{b,t}$) increases towards one (Komárková and Komárek, 2008).

3. Data

Throughout this paper we have been using the data of the International Monetary Fund, specifically on the development of the average yield of medium-term government bonds in individual EU countries. Default data are listed in the Table below.

The analysis included all EU countries except for those lacking in statistical data.

Table 1: Average yields of medium-term government bonds in individual EU countries in 2005 – 2011, in % p.a.

country	2005	2006	2007	2008	2009	2010	2011
Austria	3.39	3.80	4.30	4.36	3.94	3.23	3.32
Belgium	3.43	3.82	4.33	4.42	3.90	3.46	4.23
Bulgaria	3.87	4.18	4.54	5.38	7.22	6.00	5.36
Cyprus	5.16	4.13	4.48	4.60	4.60	4.60	5.79
Czech republic	3.61	3.68	4.65	4.30	3.98	3.89	3.70
Denmark	3.40	3.81	4.29	4.28	3.59	2.93	2.73
Estonia	3.98	4.30	5.63	8.16	7.78	5.97	5.91
Finland	3.35	3.78	4.29	4.29	3.74	3.01	3.01
France	3.41	3.80	4.30	4.23	3.65	3.12	3.32
Germany	3.35	3.76	4.22	3.98	3.22	2.74	2.61
Greece	3.59	4.07	4.50	4.80	5.17	9.09	15.75
Hungary	6.60	7.12	6.74	8.24	9.12	7.28	7.64
Ireland	3.33	3.77	4.31	4.53	5.23	5.74	9.60
Italy	3.56	4.05	4.49	4.68	4.31	4.04	5.42
Latvia	3.88	4.13	5.28	6.43	12.35	10.34	5.91
Lithuania	3.70	4.08	4.55	5.61	14.00	5.57	5.16
Luxemburg	2.41	3.30	4.46	4.61	4.23	3.17	2.92
Malta	4.56	4.32	4.72	4.81	4.54	4.19	4.49
Netherlands	3.37	3.78	4.29	4.23	3.69	2.99	2.99
Poland	5.22	5.23	5.48	6.07	6.12	5.78	5.96
Portugal	3.44	3.92	4.42	4.52	4.21	5.40	10.24
Romania	7.01	7.23	7.14	7.70	9.69	7.34	6.65
Slovakia	3.52	4.41	4.49	4.72	4.71	3.87	4.42
Slovenia	3.81	3.85	4.53	4.61	4.38	3.83	4.97
Spain	3.39	3.79	4.31	4.37	3.98	4.25	5.44
Sweden	3.38	3.71	4.17	3.89	3.25	2.89	2.61
United Kingdom	4.46	4.37	5.04	4.58	3.65	3.61	3.12
Eurozone	3.44	3.86	4.33	4.36	4.03	3.78	4.31

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

For the purpose of analysis, the interest-rate values were divided into two periods. The first examined the period is from 2005 to 2007 (before the global financial crisis) and the second examined period is from 2008 to 2011 (during and after the global financial crisis). Data have primarily been divided into these periods so that we could determine the impact of the global financial crisis on financial integration.

4. Methodology

4.1 Proposal of methodology for financial integration evaluation

In the paper we have decided to use the statistical method of one-factor analysis of variance (ANOVA), which allows us to compare the mean values of several populations. The principle of this method lies in the decomposition of the total sum of deviation squares from the arithmetic mean, calculated from all the measured values on the number of components that belong to the expected sources of variability. These components are mutually compared, and based on their relationships it is possible to make conclusions, whether the total variance was primarily caused due to the differences in the mean values, or as a result of random effects (Kubanová, 2004).

Thus, ANOVA tests the null hypothesis that all random variables Y_i have the same mean values of $\mu_{i.}$. If the null hypothesis is rejected, it is necessary to reveal which samples differ significantly from each other, and thus had caused the rejection of the hypothesis. For this purpose we will use the Scheffé's or Tukey method, because the number of observations in each group is the same.

To ensure that the ANOVA technique can be used, it is necessary to meet the assumptions of normality and homogeneity of variances in populations. In this paper we will use the Shapiro-Wilk test for testing the normality and Bartlett's test for testing the homogeneity of variances. Both tests are, based on Kubanová (2004), specified below.

4.1.1 Shapiro–Wilk test for normality

By means of this test we test the null hypothesis (H_0): H_0: X has N (μ, σ) probability distributions against the alternative hypothesis H_1: X does not have N (μ, σ) of probability distributions.

The test criterion is given by:

$$SW = \frac{\left(\sum_{i=1}^{m} a_i(n)(X_{(n-i+1)} - X_{(i)})\right)^2}{\sum_{i=1}^{n}(X_i - \bar{X})^2}, \qquad (6)$$

where $a_i(n)$ are tabulated constants, $m = n / 2$, if n is even and $m = (n - 1) / 2$, if n is an odd number, $X_{(n-i+1)}$ and $X_{(i)}$ are the order statistics of a random sample $X_1, \ldots, X_n$ created through its arrangement into a non-decreasing sequence.

The test principle lies in the fact that we estimate σ by the random variable $S* = \sum_{i=1}^{n} a_i X_i$ and its estimate is compared with an estimate based on the random variable $\sum_{i=1}^{n}(X_i - \bar{X})^2$.

4.1.2 Bartlett's test

This test verifies the hypothesis that all samples come from populations with equal variance of σ^2. We are testing the null hypothesis: H_0: $\sigma_1^2 = \sigma_2^2 = \ldots = \sigma_k^2$ against the alternative hypothesis H_1: $\sigma_i^2 \neq \sigma_j^2$ for at least one index pair i, j. The test criterion is given by:

$$B = \frac{1}{C}\left[(n-k)lnS^2 - \sum_{i=1}^{k}(n_i - 1)ln\bar{S}_i^2\right], \qquad (7)$$

where C is an auxiliary factor, $\bar{S}_i^2$ symbol denotes unbiased estimates of variances σ_i^2 in individual samples and S^2 is the composite sample variance. If at least one of these assumptions is not met, then the one-factor ANOVA technique cannot be applied and we have to use its non-parametric equivalent, which is called the Kruskal-Wallis test.

4.1.3 Kruskal–Wallis test

This test is used for testing the hypothesis that all samples come from the same population, hence all distribution functions (F_i, $i = 1, \ldots, k$) are identical. Then the null hypothesis can be formulated in the following way: H_0: $F_1(x) = F_2(x) = \ldots = F_k(x)$ against the alternative hypothesis H_1: $F_i(x) \neq F_j(x)$ for at least one index pair $i \neq j$. The test criterion is given by:

$$Q = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(n+1), \qquad (8)$$

where k is the number of levels of the traced factor, $n = n_1 + n_2 + \ldots + n_k$ is the total sample size, n_i is the number of observations in sample i and R_i is the sum of element ranks taken from the i-th sample.

Upon the rejection of the null hypothesis it is necessary to find out which samples differ significantly from each other and had caused the rejection of the hypothesis. This can be found out by means of multiple comparisons of mean ranks for all groups.

Significance level (Type I error rate α) has been set at 0.05 in the paper, which means that we obtain 95% confidence level for the correct decision.

5. Empirical results

5.1 One-factor analysis of variance for government bond average yields

The examined period will be divided into two periods so that we can explore the impact of the global financial crisis on the integration of bond markets. The first period thus comprises years 2005 to 2007, and the second period comprises years 2008 to 2011.

5.1.1 ANOVA for government bond yields (the first period)

In order for ANOVA to be carried out, at first we had to test for the assumptions of normality and homogeneity of variances in survey data. Results of the normality test are presented in the following table.

Table 2: Testing for the assumption of normality of government bond yields in the first period

country	p-values	country	p-values
Austria	0.891063	Latvia	0.321246
Belgium	0.853267	Lithuania	0.883392
Bulgaria	0.917762	Luxemburg	0.855050
Cyprus	0.650669	Malta	0.780440
Czech republic	0.115063	Netherland	0.880302
Denmark	0.913333	Poland	0.064836
Estonia	0.351205	Portugal	0.977497
Finland	0.906231	Romania	0.800247
France	0.863946	Slovakia	0.142015
Germany	0.936651	Slovenia	0.094436
Greece	0.939434	Spain	0.856445
Hungary	0.502637	Sweden	0.819092
Ireland	0.887613	United Kingdom	0.236950
Italy	0.940735		

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

As follows from the preceding table, the assumption of normality holds (all *p*-values are greater than α). Further, the assumption of homogeneity of variances can be then tested, the result of which is shown in the following table. It is obvious from the table that the assumption of homogeneity of variances holds as well (*p*-value is greater than the chosen significance level of α = 0.05. It means that it is possible to perform ANOVA, the result of which is assessed in the Table no. 4.

Table 3: Testing for the assumption of homogeneity of variances in government bond yields in the first period

	Bartlett	*p-value*
rate	15.58856	0.945599

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

Since the null hypothesis of a one-factor analysis of variance has been rejected (see the Table below), i.e. there is a difference among the average yields from government bonds in individual EU countries, it is necessary to find out which of the countries differ from each other to such an extent that had caused the rejection of the hypothesis.

Table 4: One-factor analysis of variance in government bond yields in the first period

	One-dimensional significance tests for rate		
	Sigma-restricted parameterisation		
Effect	Degrees of freedom	F	*p-value*
Abs. term	1	6013.155	0.000
Country	26	9.001	0.000
Error	54		

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

In order to detect the pairs of countries which caused the rejection of the ANOVA null hypothesis, Tukey test was used. The result of this test is shown in the table below. On the basis of the Tukey test's outcome we can say that the most differing yields from government bonds are in Hungary and Romania (marked with a frame in the table), the yields of which have been in all the three years analysed relatively much higher than in other EU countries. The rejection of the null hypothesis was also caused by the pair of countries, Luxembourg - Poland (marked with frame in the table), the government bond yields of which differ mutually as well.

Table 5: Multiple comparisons of government bond yields in the first period

země	Aust-ria	Bel-gium	Bulga-ry	Cyp-rus	Czech R.	Dan-mark	Esto-nia	Fin-land	France	Germa-ny	Gree-ce	Hun-gary	Ire-land	Italy	Latvia	Lithua-nia	Luxem burg	Malta	Net-her-land	Poland	Portu-gal	Roma-nia	Slov-akia	Slove-nia	Spain	Swe-den	United King-dom
Austria		1.000	1.000	0.978	1.000	1.000	0.958	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.999	1.000	1.000	0.991	1.000	0.099	1.000	0.000	1.000	1.000	1.000	1.000	0.964
Belgium	1.000		1.000	0.986	1.000	1.000	0.972	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.995	1.000	0.119	1.000	0.000	1.000	1.000	1.000	1.000	0.977
Bulgary	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.958	1.000	1.000	0.559	1.000	0.000	1.000	1.000	1.000	1.000	1.000
Cyprus	0.978	0.986	1.000		0.999	0.979	1.000	0.969	0.980	0.954	1.000	0.001	0.967	1.000	1.000	1.000	0.410	1.000	0.972	0.988	0.996	0.000	1.000	1.000	0.978	0.939	1.000
Czech R.	1.000	1.000	1.000	0.999		1.000	0.996	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	0.228	1.000	0.000	1.000	1.000	1.000	1.000	0.997
Danmark	1.000	1.000	1.000	0.979	1.000		0.959	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.999	1.000	1.000	0.992	1.000	0.101	1.000	0.000	1.000	1.000	1.000	1.000	0.966
Estonia	0.958	0.972	1.000	1.000	0.996	0.959		0.944	0.961	0.922	0.999	0.001	0.942	0.999	1.000	1.000	0.338	1.000	0.948	0.995	0.990	0.000	1.000	1.000	0.958	0.901	1.000
Finland	1.000	1.000	1.000	0.969	1.000	1.000	0.944		1.000	1.000	1.000	0.000	1.000	1.000	0.998	1.000	1.000	0.987	1.000	0.086	1.000	0.000	1.000	1.000	1.000	1.000	0.952
France	1.000	1.000	1.000	0.980	1.000	1.000	0.961	1.000		1.000	1.000	0.000	1.000	1.000	0.999	1.000	1.000	0.992	1.000	0.104	1.000	0.000	1.000	1.000	1.000	1.000	0.967
Germany	1.000	1.000	1.000	0.954	1.000	1.000	0.922	1.000	1.000		1.000	0.000	1.000	1.000	0.997	1.000	1.000	0.979	1.000	0.071	1.000	0.000	1.000	1.000	1.000	1.000	0.932
Greece	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000		0.000	1.000	1.000	1.000	1.000	0.996	1.000	1.000	0.323	1.000	0.000	1.000	1.000	1.000	1.000	1.000
Hungary	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.000	1.000	0.000	0.000	0.000	0.000	0.001
Ireland	1.000	1.000	1.000	0.967	1.000	1.000	0.942	1.000	1.000	1.000	1.000	0.000		1.000	0.998	1.000	1.000	0.986	1.000	0.084	1.000	0.000	1.000	1.000	1.000	1.000	0.950
Italy	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	0.000	1.000		1.000	1.000	0.997	1.000	1.000	0.295	1.000	0.000	1.000	1.000	1.000	1.000	0.999
Latvia	0.999	1.000	1.000	1.000	1.000	0.999	1.000	0.998	0.999	0.997	1.000	0.000	0.998	1.000		1.000	0.686	1.000	0.999	0.904	1.000	0.000	1.000	1.000	0.999	0.995	1.000
Lithuania	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000		0.988	1.000	1.000	0.410	1.000	0.000	1.000	1.000	1.000	1.000	1.000
Luxemburg	1.000	1.000	0.958	0.410	0.999	1.000	0.338	1.000	1.000	1.000	0.996	0.000	1.000	0.997	0.686	0.988		0.506	1.000	0.005	1.000	0.000	0.981	0.995	1.000	1.000	0.358
Malta	0.991	0.995	1.000	1.000	1.000	0.992	1.000	0.987	0.992	0.979	1.000	0.000	0.986	1.000	1.000	1.000	0.506		0.988	0.972	0.999	0.000	1.000	1.000	0.991	0.970	1.000
Netherland	1.000	1.000	1.000	0.972	1.000	1.000	0.948	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.999	1.000	1.000	0.988		0.090	1.000	0.000	1.000	1.000	1.000	1.000	0.956
Poland	0.099	0.119	0.559	0.988	0.228	0.101	0.995	0.086	0.104	0.071	0.323	0.083	0.084	0.295	0.904	0.410	0.005	0.972	0.090		0.173	0.010	0.460	0.338	0.099	0.062	0.994
Portugal	1.000	1.000	1.000	0.996	1.000	1.000	0.990	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	0.173		0.000	1.000	1.000	1.000	1.000	0.992
Romania	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000		0.000	0.000	0.000	0.000	0.000
Slovakia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.981	1.000	1.000	0.460	1.000	0.000		1.000	1.000	1.000	1.000
Slovenia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.995	1.000	1.000	0.338	1.000	0.000	1.000		1.000	1.000	1.000
Spain	1.000	1.000	1.000	0.978	1.000	1.000	0.958	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.999	1.000	1.000	0.991	1.000	0.099	1.000	0.000	1.000	1.000		1.000	0.964
Sweden	1.000	1.000	1.000	0.939	1.000	1.000	0.901	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.995	1.000	1.000	0.970	1.000	0.062	1.000	0.000	1.000	1.000	1.000		0.913
United Kingdom	0.964	0.977	1.000	1.000	0.997	0.966	1.000	0.952	0.967	0.932	1.000	0.001	0.950	0.999	1.000	1.000	0.358	1.000	0.956	0.994	0.992	0.000	1.000	1.000	0.964	0.913	

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

5.1.2 ANOVA for government bond yields (the second period)

ANOVA could not be applied to the second period, since the assumption of normality of the survey data did not hold, as illustrated by the table below (*p*-values for Cyprus and Lithuania are smaller than α). Therefore, it was necessary to take advantage of the non-parametric equivalent of ANOVA called Kruskal-Wallis test, the null hypothesis of which was rejected (due to a very low *p*-value), and therefore it was necessary to perform multiple comparisons that helped reveal which pairs of countries differ from each other, causing thus the rejection of the null hypothesis. The results of the multiple comparisons are presented in Table 7 (in the header of the table it is possible to see the result of the Kruskal-Wallis test).

Table 6: Testing for the assumption of normality of government bond yields in the second period

Country	*p*-values	Country	*p*-values
Austria	0.441850	Latvia	0.385742
Belgium	0.792009	Lithuania	**0.005317**
Bulgaria	0.184758	Luxemburg	0.418768
Cyprus	**0.001241**	Malta	0.868648
Czech republic	0.840931	Netherland	0.272611
Denmark	0.615145	Poland	0.609812
Estonia	0.128915	Portugal	0.066738
Finland	0.271311	Romania	0.452383
France	0.693670	Slovakia	0.195019
Germany	0.455840	Slovenia	0.932753
Greece	0.269596	Spain	0.224140
Hungary	0.774746	Sweden	0.799939
Ireland	0.150349	United Kingdom	0.509265
Italy	0.704273		

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

Table 7: Multiple comparisons of government bond yields in the second period

Country	Aust-ria	Bel-gium	Bulga-ry	Cyp-rus	Czech R.	Dan-mark	Esto-nia	Fin-land	France	Germa-ny	Gree-ce	Hun-gary	Ire-land	Italy	Latvia	Lithua-nia	Luxem burg	Malta	her-land	Poland	Portu-gal	Roma-nia	Slov-akia	Slove-nia	Spain	Swe-den	King-dom
Austria		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.765	1.000	1.000	0.872	1.000	1.000	1.000	1.000	1.000	1.000	0.899	1.000	1.000	1.000	1.000	1.000
Belgium	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bulgary	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	0.794	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000
Cyprus	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Czech R.	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Danmark	1.000	1.000	1.000	1.000	1.000		0.396	1.000	1.000	1.000	0.809	0.150	1.000	1.000	0.174	1.000	1.000	1.000	1.000	0.905	1.000	0.178	1.000	1.000	1.000	1.000	1.000
Estonia	1.000	1.000	1.000	1.000	1.000	0.396		0.794	0.856	0.171	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.531	1.000	1.000	1.000	1.000	1.000	1.000	0.160	1.000
Finland	1.000	1.000	1.000	1.000	1.000	1.000	0.794		1.000	1.000	1.000	0.317	1.000	1.000	0.365	1.000	1.000	1.000	1.000	1.000	1.000	0.373	1.000	1.000	1.000	1.000	1.000
France	1.000	1.000	1.000	1.000	1.000	1.000	0.856	1.000		1.000	1.000	0.344	1.000	1.000	0.396	1.000	1.000	1.000	1.000	1.000	1.000	0.404	1.000	1.000	1.000	1.000	1.000
Germany	1.000	1.000	0.794	1.000	1.000	1.000	0.171	1.000	1.000		0.365	0.061	1.000	1.000	0.072	0.585	1.000	1.000	1.000	0.412	1.000	0.073	1.000	1.000	1.000	1.000	1.000
Greece	1.000	1.000	1.000	1.000	1.000	0.809	1.000	1.000	1.000	0.365		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.344	1.000
Hungary	0.765	1.000	1.000	1.000	1.000	0.150	1.000	0.317	0.344	0.061	1.000		1.000	1.000	1.000	1.000	1.000	1.000	0.206	1.000	1.000	1.000	1.000	1.000	1.000	**0.044**	0.750
Ireland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Italy	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Latvia	0.872	1.000	1.000	1.000	1.000	0.174	1.000	0.365	0.396	0.072	1.000	1.000	1.000	1.000		1.000	1.000	1.000	0.239	1.000	1.000	1.000	1.000	1.000	1.000	0.067	0.856
Lithuania	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.585	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.553	1.000
Luxemburg	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Malta	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Netherland	1.000	1.000	1.000	1.000	1.000	1.000	0.531	1.000	1.000	1.000	1.000	0.206	1.000	1.000	0.239	1.000	1.000	1.000		1.000	1.000	0.243	1.000	1.000	1.000	1.000	1.000
Poland	1.000	1.000	1.000	1.000	1.000	0.905	1.000	1.000	1.000	0.412	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	0.388	1.000
Portugal	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000
Romania	0.899	1.000	1.000	1.000	1.000	0.178	1.000	0.373	0.404	0.073	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.243	1.000	1.000		1.000	1.000	1.000	0.069	0.872
Slovakia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000
Slovenia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Spain	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Sweden	1.000	1.000	0.750	1.000	1.000	1.000	0.160	1.000	1.000	1.000	0.344	**0.044**	1.000	1.000	0.067	0.553	1.000	1.000	1.000	0.388	1.000	0.069	1.000	1.000	1.000		1.000
United Kingdom	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	0.856	1.000	1.000	1.000	1.000	1.000	1.000	0.872	1.000	1.000	1.000	1.000	

Source: Author`s calculation based on INTERNATIONAL MONETARY FUND. International Financial Statistics: Yearbook 2012. Washington, D.C.: International Monetary Fund, 2012.

As can be seen in the above table, there has been a greater difference in the yields of government bonds only within the pair of countries, Sweden – Hungary (marked with a frame in the table).

6. Results and Discussion

If we compare the Table 7 and the Table 5, it can be summarized that the financial integration, despite the onset of the financial crisis, has deepened. Government bond markets of the EU countries were almost fully integrated in the second period.

Based on the calculations the outcome is that, despite the financial crisis, the integration of the bond markets has deepened, and government bond markets of the EU countries were almost fully integrated in the period following the crisis.

If we compare our results with the results of studies carried out in the years when the single currency of the euro had already been introduced for a few years, however, the studies do not deal with the impact of the financial crisis, then the same conclusions can be seen in e.g. Baele et al. (2004) who state that the measures of integration indicate that, since the introduction of the euro, the degree of integration in the euro area government bond market has been very high. With the introduction of the single currency and a common monetary policy, government bond yields converged swiftly in all countries. Moreover, yields became increasingly driven by common news, and less by purely local risk factors.

Our results correspond with the results arrived at by Adam et al. (2002) who states that in the government bond market (maturity of 10 years) there are signs of increased convergence and convergence after January 1999. However, the largest part of the reduction of interest rate differentials took place already before the end of 1997. There is also evidence that convergence in the Euro zone is stronger than convergence in the EU as a whole. Overall, convergence is almost achieved in this market.

Berber and Jansen study (2006) confirms our results as well by stating that our test produces strong evidence of greater comovement across the board for both stock markets and government bond markets.

In contrast, Abad et al. assert that financial markets are only partially integrated. For their part, the markets of the countries that decided to stay out of the Monetary Union present a higher vulnerability to external risk factors.

According to Czech National Bank (2011), the impact of the financial crisis on the integration of the individual parts of the financial markets is evident. In the pre-crisis period there was a rapid adjustment of prices in all markets observed in the study, and in new EU member countries the integration level was lower. With the beginning of the crisis the emergence of divergent development until nearly mid-2009 is evident, when the situation in the financial markets began to quieten down for the time being. In the period since the outbreak of the financial crisis the prevailing incidence of asymmetric shocks has been evident, which is associated with higher volatility of the markets.

7. Conclusion

The aim of the paper has been to determine the impact of the financial crisis on the integration of bond markets within EU countries. In order to measure the integration level it is possible to use several methods. In this paper we have used the statistical method of one-factor analysis of variance (ANOVA). By means of this method we are able to compare the mean values of several populations, when the total sum of squares of deviations from the arithmetic mean can be decomposed into several components related to the expected sources of variability. These components can be then mutually compared and on their basis, it is possible to draw the conclusions on the reasons for the emergence of the total variance - whether the significance of the difference between the mean values prevails or whether it has been caused by random effects.

We have based our study on the International Monetary Fund data on the development of the average yields of medium-term government bonds in individual EU countries in 2005-2011. We have excluded the countries for which data were not available in the whole time series.

The performance of ANOVA has demonstrated that the financial integration, despite the outbreak of the financial crisis, has deepened. Government bond markets of the EU countries were almost fully integrated in the second period, i.e. within 2008-2011.

In conclusion we can therefore state that, contrary to the assumptions, the financial crisis had a positive effect on the integration of bond markets.

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