THE SIGNIFICANCE OF COUNTRY-SPECIFIC AND COMMON RISK FACTORS FOR CEE GOVERNMENT BOND SPREADS CHANGES

Greta Juodžiukynienė*
Vilnius University, Lithuania

Abstract. *This paper provides an empirical assessment of the relationship between common European Union and country-specific risk factors of sovereign bond spreads for Central and Eastern European countries over the period of 2004-2014. The model, estimated using Pooled Mean Group techniques, that accounts for both common long-run determinants and cross-country heterogeneities in sovereign bond spreads, tends to suggest that country-specific and common factors are important in the long-run, but common European Union factors are the main determinants of bond spreads in the short-run, i.e., market volatility index series converges with changes of sovereign bond spreads and turns out to be the predominant factor in the short-run. Furthermore, countries with stronger fundamentals have a tendency for lower responsiveness to changes in global risk aversion.*
The decomposition of changes in spreads for the purpose to compare actual and estimated spreads specifies that during risk-on periods (when the increase of misalignment falls down) there is consistency for increasing of creditworthiness undervaluation.
Keywords: *Sovereign bond spreads; Central and Eastern Europe; Pooled mean group*

1. Introduction

The government bond spreads that countries remunerate for borrowing in financial markets measure not only their costs of additional capital flows but also produce a point of reference on their financial fragility and vulnerability. These features of government borrowing results have provided a great deal of empirical research in policy, business, and academic circles aimed at understanding the determinants.

The determinants of sovereign bond spreads have already been analysed quite broadly, but still there is few analysis related to sovereign bonds issued by Central and Eastern Europe (hereinafter abbreviated CEE). To overcome this deficiency and to contribute to a better comprehension of the development in this region, this study pays attention to the yield differences between long-term CEE bonds and the German government (the so-called German Bund) as the risk-free benchmark. An important consideration of this analysis is on the role of country-specific versus the common European Union factors.

* *Corresponding author:*
Faculty of Economics, Vilnius University, Saulėtekio Ave. 9-II, LT-10222, Vilnius
E-mail: greta@pociute.lt

To investigate the issue of country-specific and common factors, the period from January 2004 until December 2014 is analysed, which seems perfectly suited for this purpose. In the beginning of the researched time period, a number of CEE economies were making genuine progress towards improving macroeconomic fundamentals as well as implementing structural reforms. Then CEE governments faced shockwaves emanating largely from advanced economies, notably the 2008 credit crisis that started in the United States or the European sovereign debt crisis. Moreover, looking at the sample period should provide opportunities to gauge any advantage CEE economies might have realised from their policy efforts when faced with large external shockwaves. However, the sample period excludes times when analysed countries suffered home-grown difficulties or crises.

This paper estimates a model using Pooled Mean Group (PMG) techniques to determine the role of internal and external conditions on government bond spreads. This is basically a dynamic error correction model with heterogeneous cross-sectional coefficients in the short-run equations and homogeneous coefficients in the long-run relationship, with different short-run dynamics and adjustment towards the equilibrium. Furthermore, the model points to a set of variables that are important components of the internal and external constraints on government debt obligations. The objective of the paper is to explain the long-run determinants of CEE bond spreads against German government bonds along with some short-run dynamic behaviours.

The rest of the paper is organised as follows: Section 2 reviews the related academic literature on describing the determinants of government bond spreads; Section 3 describes the data employed in the estimation; Section 4 outlines a brief description of the basic theoretical model; Section 5 reports and discusses the estimation results of the model; Section 6 represents the comparison of actual and estimated spreads and finally Section 7 summarizes the main findings and discusses the implications of the overall results for CEE countries.

2. Related literature review

The empirical analysis examined the relationship between sovereign bond spreads and macroeconomic indicators, and the market perception of countries' risk of default on sovereign debt goes back to Edward (1984) research. Due to his implication, investor evaluation of a debtor country's creditworthiness depends on a set of domestic, international, macroeconomic, fiscal, and financial factors.

Further analysis finds some empirical regularities, especially in the case of specific countries or regions and for certain time perspectives, and they, by no means, settle the debate about significant determinants of sovereign bond spreads. The European sovereign debt crisis has clearly increased the interest in this subject.

For the purposes of this research, two paths of the literature related to empirical models of European government bond spreads are represented. The first one focuses on

the research of euro area government bond markets, while the second one focuses on emerging markets with certain points of the new EU countries.

In reference to the European Union bond market, most studies noted that spread dynamics is driven by two main components: common (global) risk among European Union countries and country-specific risk (taking into account liquidity risk). In some studies, credit risk components of spreads are usually associated with the country's internal macroeconomic and fiscal fundamentals. Conversely, the liquidity components are affiliated with international financial conditions along with describing investor risk preferences.

Several papers have analysed the effect of an international risk factor on government bond yield spreads. The role of common risk of European Union aversion is usually evaluated by some index of equity market volatility. Codogno et al. (2003), Favero et al. (2010) find that changes in external conditions acquire a higher value for countries with high government debt ratios. Haugh et al. (2009) summarizes that it extends the effect of the debt service ratio on bond yields.

According to Barrios et al. (2009), Manganelli and Wolswijk (2009), Sgherri and Zoli (2009), Baldacci and Kumar (2010), Gerlach et al. (2010), and von Hagen et al. (2011) the explanatory role of international factors for spread changes has risen since 2008. Markets try to reprice global risk and take preferences to more liquid and safe government bond markets (i.e., US Government Bonds or German Bunds). As a result, the differentials of risk premium broaden among the EMU countries. Beber et al. (2009) and Favero et al. (2010) found that the level of the aggregated risk factors also has a considerable influence on the effect of liquidity on government bonds. Regarding this, Obstfeld (2014) emphasizes that financial market globalisation has likely weakened the abilities of countries to moderate the domestic impact on financial and monetary forces. However, Baldacci and Kumar (2010) concluded that greater integration of government bond markets to the international market and a faster globalisation process allows more efficient pricing of sovereign risk and better facilitated price discovery.

The analysis of the spillover effect and financial contagion as well as the increasing co-movement of financial markets among European countries has been the subject of a large number of studies. According to the findings of Caceres et al. (2010), and De Grauwe et al. (201) financial contagion has increased during the current European debt crises and market volatility has spread from GIPSI economies to the European periphery. Moreover, the authors also detected evidence that financial markets have become more sensitive to a country's economic fundamentals during the crisis as compared to the pre-crisis period. Beirne at al. (2013) concluded that most of the level of sovereign risk and the rise during the crisis period usually can be explained by a country's own economic fundamentals and its underlying fundamental contagion, while regional contagion explains a much more modest magnitude of sovereign risk. Based on studies

by Giordano M. et al. (2013), and Favero (2013), the increased unexplainable part of bond spread dynamics since 2010 could be related to the appearance of a new systemic risk, i.e., the risk of a euro break-up, that is, the risk that one or more countries might exit from the EMU.

A range of previous papers has focused on the determinants of the pricing of sovereign risk. An early study of the factors driving government bond spreads was carried out by Edwards (1984), who concluded that domestic macroeconomic fundamentals were significant determinants, including factors, such as the public debt, the current account balance, inflation, and foreign reserves. Subsequent studies tended to concentrate on government bond yield spreads as the reference measure for sovereign risk, and also on analysing sovereign risk in emerging economies. According to Faini (2006), Hallerberg and Wolff (2008), Haugh (2009), and Bernoth et al. (2012) the budget balance and the stock of government debt have, on average, a significant influence on sovereign bond spreads. However, Costantini et al. (2014) noted that in the period from 2001 to 2012 government debt level was the most significant determinant of the sovereign spreads among euro area countries in the long-run, while the budget balance had the least impact. More accurately, investors carefully observe and assess the deterioration of expected debt positions of those economies exhibiting gaps in competitiveness on the mid or long term perspective. Nevertheless, based on the Battistini et al. (2013) study, the effect of common risk factors were not only different in magnitude but also had opposite effects on bond spreads.

Similarly, Csontó (2014) summarized that idiosyncratic fundamentals were significant determinants of sovereign bond spreads under normal market conditions, but during times of market stress, global financial conditions compound their impact. Csontó (2014) also noted that stronger domestic fundamentals could encourage reduction on the influence of an adverse global shockwave on international sovereign spreads. Moreover, J. von Hagen et al. (2011) found that bond yield spreads in the euro area before and during the last financial crisis can be largely explained by fundamentals, but the market has assessed fiscal imbalances as a much riskier dimension since the collapse of Lehman Brothers in September 2008. By contrast, Caceres et al (2010) noted that in the beginning of the crisis, the growth in global risk aversion was a significant factor for changes of the euro area sovereign spreads, while subsequently country-specific factors became more significant for investors. Moreover, Ebner (2009) concluded that the importance and the weight of influence of country-specific factors varies across countries but external risk aversion is the single most important explanatory factor of spreads.

To capture the liquidity risk component M. Costantini (2014), Barrios et al. (2009), Sgherri and Zoli (2009) used the bid-ask spread on ten-year sovereign bonds as the liquidity risk measurement indicator and concluded that liquidity risk has important weights on sovereign spreads changes.

Based on the study of J. von Hagen et al. (2012), at the beginning of the European Monetary Union market the liquidity premiums in the euro area were reduced (i.e., quite low) and investors paid less attention to deficit and debt service payments as the indicator of fiscal soundness. During the financial crisis, the cost of loose fiscal policy rose considerably resulting in market discipline becoming stronger. It should be noted that they released the German position with the finance crisis, i.e., this economy gained a safe-haven status in international financial markets – a position it did not hold before. Consistent with L. Pozzi et al. (2012) J. von Hagen et al. (2011), Pagano et al. (2004), and Favero et al. (2005), liquidity risk also played a role in driving spreads in the euro area, especially after the introduction of the euro, and further weakened with time. Moreover, Codogno et al. (2003) and Sgherri and Zoli (2009) noted that the liquidity risk component clarified exclusively a small part of sovereign spread changes.

However, both in academic debates and in the context of policy-making, no clear consensus has arisen due to liquidity risk evaluation. Barrios et al. (2009), Beber et al. (2009), Haugh et al. (2009), Manganelli and Wolswijk (2009), Favero et al. (2010), found that the liquidity factor is quite important in describing the euro area sovereign spreads. With respect to international risk aversion, Attinasi et al. (2010) showed that this factor significantly helped to explain the variation of sovereign bond spreads during the financial crisis.

There is very little systematic evidence to date regarding the determinants of Central and Eastern European Countries (CEE) bonds. Among current studies, Luengnaruemitchai and Schadler (2007) analysed whether or not investors underestimated the riskiness of holding sovereign bonds issued by CEE compared with other emerging markets sovereign bonds. They noted that for CEE the residuals were systematically negative during the period from mid-2002 to the end of 2006. This indicates that before the global financial turbulence, market participants were systematically requiring lower yields to hold CEE sovereign bonds than those determined by the econometric analysis.

The most important single-country time series study for European transition economies was performed by Ebner (2009), who concluded that the external risk aversion, captured in this case by market volatility, as opposed to macroeconomic variables, was more important in explaining spreads. Moreover, similarly to the Ebner (2009) study, Nickel et al (2009) analysis concluded that variables, that are traditionally used as determinants of bond spreads in the euro area, appeared to explain much less when applied to CEE. However, both papers used pre-crisis data. Accordingly, this paper adds to the existing work by attempting to quantify how the pricing of risk in CEE by market participants has been altered by the crisis.

A significant function in explaining bond spreads is sometimes chalked up to political factors as in the analysis by Baldacci et al. (2008). A panel of 30 emerging market economies (including some CEE countries) concluded that, apart from macroeconomic

policies, liquidity, and the degree of financial deepening, the interaction between fiscal and political factors were the most important determinants of country risk premium.

This study contributes to the literature in several ways. Firstly, it tries to assess similarities by the few existing CEE studies held in recent years in crises conditions. Secondly, it looks at whether there is a common driving factor that could implement the findings of EM and EMU studies carried out so far.

3. Variables used for estimation

The empirical estimation is performed for nine new EU member states from last expansion, i.e., Lithuania, Latvia, Poland, Slovakia, Czech Republic, Slovenia, Bulgaria, Hungary and Romania. Due to low debt level and different debt structure, Estonia is not included in the analysis. The main reason for Croatia exclusion is the lack of statistical information. The panel dataset contains quarterly data of the nine mentioned countries during the period of 2004:1–2014:12. Appendix 1 contains the description of the whole dataset, i.e., each indicator descriptive statistics as well as skewness and kurtosis information. Moreover, the pair wise correlation results are given in the Appendix 2.

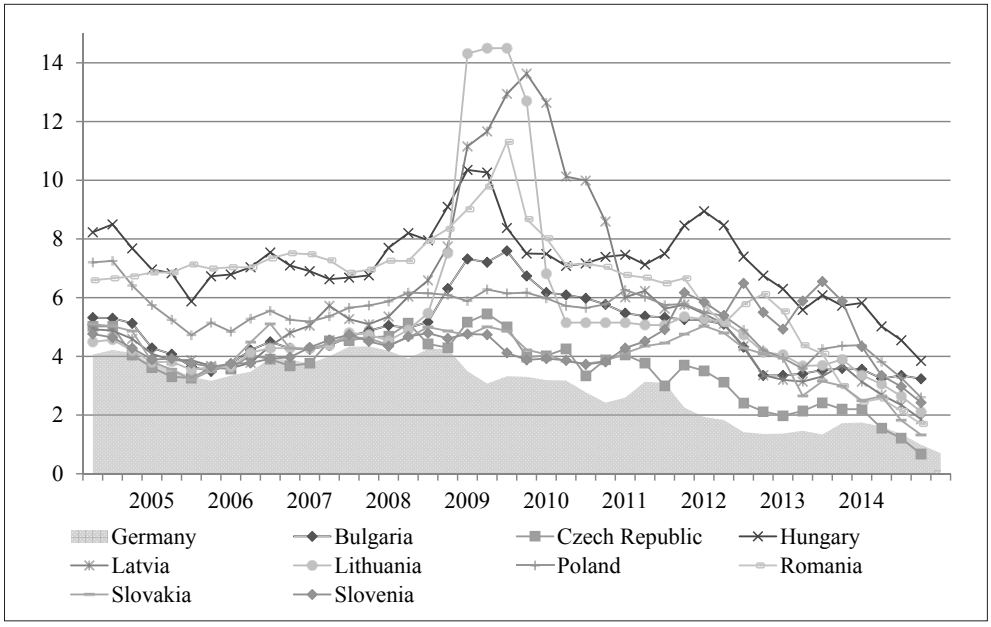

FIGURE 1. **The changes of long-term government bond yields of CEE countries and Germany in 2004–2014**
Source: ECB

The data presented in the Figure 1 shows the changes of long-term government bond yields for nine CEE countries relative to Germany over the period of January 2004 to December 2014.

Noted that apart from Poland, the bond markets of particular CEE countries are relatively small in the international context. However, pooling them together creates the fifth largest government bond market in continental Europe. In general, the bond markets of particular CEE countries that are analysing, although to a different degree, had a sufficiently stable trend of long-term government bond yields from 2004 to mid-2007. The main pillar of such development may be related to the affirmative international liquidity conditions herewith low investors' risk aversion as well as the favourable and effective economic development at domestic level.

From the middle of 2007, the long-term government bond yields of CEE countries started increasing and particularly accelerated from the second half of 2008. Moreover, some countries like Lithuania, Latvia, Romania and Hungary achieved their historical maximum levels. While these countries faced a significant enlargement in borrowing costs, the yields of Germany of the long-term government bond began to steadily fall. Furthermore, Slovenia, Slovakia, Czech Republic and Poland can be singled out as a separate group from the other analysed countries because during the financial turmoil period their yields remained sufficiently stable. In the mid-2013, the long-term government bond yields experienced a downward trend for all CEE countries.

The dependent variable (y_{it}) is given by quarterly average spreads computed from quarterly yield (aggregated form monthly data) on harmonised long-term government bond relative to the long-term Germany Bund yield. In detail, bond spreads are estimated as the difference between the yield to maturity[1] of a certain CEE country 10-year government bond and the yield to maturity of the respective 10-year German government bond.

$$y_{it} = z - z^*, \tag{1}$$

where z = CEE government bond yield and z^* = German government bond yield

Germany was chosen as the benchmark country because the Bund is considered the benchmark bond in the respective bond market (for details see Dunne et al. (2007) and Constantini (2014)). In other words, the return on a risky bond equals the return on a riskless bond plus a risk premium. In the remainder of the paper, subscript i refers to the cross-sectional dimension (country) and subscript t refers to the time dimension (month).

The explanatory variables that are involved in the analysis of CEE bond spreads were selected based on the convergence criteria, which are required for all European Union member states and on the existing literature on spread determinants as already

[1] Long term government bond yields are calculated by the ECB on the basis of individual yields taken from Reuters, who derive them from prices using the standard ISMA (International Securities Market Association) method. National rates are weighted by the nominal amounts outstanding in the maturity band. Bond yields are calculated as percentage expression of monthly averages (non seasonally adjusted data). They refer to central government bond yields on the secondary market, gross of tax, with a residual maturity of around 10 years.

mentioned above. Whereas the outlook of this paper is mostly empirical, variables for which available data exist and are easily obtainable is taken into account.

The explanatory variables are divided into two groups according to their probability of explaining country differences in country-specific fundamentals (X_{it}), such as fiscal and external conditions, nominal convergence, economy openness and money market conditions, and global factors that are expressed as a common factor (C_{it}) related to the financial market conditions in the European Union.

The pair wise correlation is used for the primary analysis to determine the contemporaneous relationship between spreads and their prospective determinants (see in Appendix 2). The correlation matrices focus attention on the heterogeneity of particular country sensitivity to country-specific fundamentals and the common factors. According to such attributes, the PMG model in the short-run should assess the heterogeneous adjustment to the equilibrium levels.

More precisely, the empirical analysis involving the following country-specific variables and common factors as explanatory variables is summarised in the following table.

TABLE 1. **Predicted impact of independent variables on spreads**

Indicators	Predicted impact on spread	Explanation of indicators
Country-specific variables		
Debt-to-GDP ratio	+	The ratio of a country's national debt to its gross domestic product;
Government budget balance	–	The ratios of a country's government budget balance to its gross domestic product;
Government debt service measure	+	The ratio between a country's outstanding amount of general government interest payments on public debt to its gross domestic product;
Fiscal space measure	–	The ratio of a country's national debt to its total tax revenues;
Trade openness	–	The ratio between sum of a country's imports and exports to its gross domestic product;
Inflation rate	+	The measure the changes in prices of consumer goods and services acquired, used or paid for by households;
GNI per capita	–	The gross national income divided by the midyear population (in euro);
Market liquidity measure	–	The difference between a country's domestic short-term money market rates and 3-months euro area money market rates (EURIBOR);
Common variable		
Volatility index	–	Volatility in the euro area equity market measured by EURO STOXX 50 volatility index

Source: author's calculations

As a measure of a country's fiscal balance sustainability and creditworthiness, the ratios of government budget balance to GDP and ratio of debt to GDP were chosen. These two fiscal variables correspond to the main sources of information for investors to explain expectations on a country's fiscal position and the association to the default risk. According to Ferrucci (2003), J. von Hagen (2011), and Ebner (2009), these two indicators are expected to have a strong relationship on spreads. If the country gets closer to the bottom limit set through the Stability and Growth Pact, it casts doubt of the probability of the non-fulfilled country's debt commitments and increases the risk of default on sovereign debt. In regard to Akitoby et al. (2008), and Alexopoulou et al. (2009), and as pairwise correlations at the country level show there are highly negative correlations with the fiscal balance-to-GDP ratio for Lithuania and Slovenia and a strong positive relationship between spreads and the government debt-to-GDP ratio for Bulgaria, Hungary, Latvia, Poland, Slovakia, and Slovenia.

The measure to assess liquidity influence on yield differentials is government debt service indicator, expressed as the ratio between the outstanding amount of general government interest payments on public debt and GDP. Alexopoulou et al. (2009) presumed that markets should make an immediate response to changes in interest payments made on public debt, rather than to changes in the principal. Strong and positive pairwise correlation results are a confirmation of such relationship, especially in the case of Czech Republic, Hungary, Latvia, and Slovenia.

Following Aizenman et al. (2012) and De Grauwe and Ji (2012), other alternative measures of a country's fiscal fragility is fiscal space defined as the ratio of debt-to-total tax revenues. This measure of debt sustainability takes into account the government's ability to raise taxes, i.e., a country with low debt can encounter difficulties in meeting debt service obligations just like a country with massive debt if it takes a long time to generate the revenues necessary to make debt payments. The strong negative pairwise correlation results confirm this explanation for all analysed countries except Lithuania and Romania.

The degree of openness to trade and financial flows is used to analyse the impact of countries' external solvency to spread differentials. In this analysis, the trade openness is calculated as the ratio between sum of imports and exports and GDP. As Ferrucci (2003) noted, a low degree of openness can encourage that the required expected trade surpluses to meet future foreign debt repayments may not materialize. Moreover, country openness is significant in explaining the emerging economies' cost of borrowing as the punishment for sovereign default and there is a higher, in terms of capital, reversion in an open rather than a closed economy. The supposed negative relationship of pairwise correlation is determined for Lithuania, Poland, Slovakia, and Slovenia.

One more country-specific indicator included in the other explanatory variables is the actual realised inflation rates. As Constantini et al. (2014) noted, even negligible

differences in inflation rates can make changes in relative price levels, either taking into account bond prices. Furthermore, the authors emphasize that cumulated inflation differentials have persistently diverged among EMU countries form the initiation of the monetary union. Theses persistent inflation differentials were analysed by Estrada et al. (2012) and concluded that such benign phenomenon can be influenced by a structural convergence process according to a Balassa-Samuelson type of argument and the source of enduring and damaging losses of competitiveness. Consequently, the increase in the inflation rate should put upward pressure on government bond yields. Whenever the rise in inflation is perceived by investors as having a structural rather than transitory source, higher inflation may well coexist with lower long-term interest rate differentials (Alexopoulou et al. (2009)).

The gross national income per capita was included in the calculation for the purpose of evaluating the influence of real convergence, i.e., the process to get closer to the euro area living standards that have characterized the period of the CEE countries since joining the European Union. According to Alexopoulou et al. (2009), it is supposed that spreads tighten in the context of improved real convergence. The negative sign of correlation is determined for all analysed countries except Romania and Poland.

The difference between domestic short-term money market rates and euro area short-term money market rates (Euribor) is used as the indicator to assess money market conditions as well as the measure of domestic money market liquidity. Precisely, Euribor is the average interest rate at which a selection of banks provide one another with short-term loans in euros. From Euribor rates for 8 maturities, ranging between 1 week to 12 months (until November 1st 2013 there were 15 Euribor rates), in this analysis the 3 months EURIBOR rate is chosen. Furthermore, the overnight rate (maturity of 1 day) for CEE countries that are members of euro area is taken as Eonia interest rate (these data was provided by European Money Markets Institute).

The difference between these two indicators should be small when the market is liquid but it tends to get larger in absolute terms when market participants start nervous or more risk averse as during the current subprime crisis. Such conditions determine a deterioration of liquidity conditions and this may negatively affect the corresponding spreads. In addition, Koukouritakis and Michelis (2008) through analysis of the expectations theory, specify that long-term government bond yields of the new EU countries can be expressed as a function of short-term rates. According to pairwise correlation results, the positive relationship is measures for Romania, Slovakia and Slovenia.

The analysed literature considers the international risk aversion as one determinant of sovereign bond yield spreads. Thus, in this analysis as the common European Union factor is included the market are volatility index (VIX) as the variable capturing market sentiment to risk. Attinasi et al. (2010) finds that the stationarity of the time-varying degree of international risk aversion indicates the influence for short-run variations (even

in the financial crisis terms) in sovereign yield spreads but no fluctuation for long-run period. Overall, higher volatility of VIX leads to wider government spreads. Empirically, the pairwise correlation confirms a positive relationship for Bulgaria, Czech Republic, Hungary, Latvia, Lithuania, Poland, and Romania.

4. Model descriptive

In order to assess the yield of CEE countries compared to equivalent bonds issued by the euro area union member states, a model is needed that is accommodating enough to involve the adjustment trend to equilibrium values from medium to long-run (that can be identified as convergence process) and heterogeneous short-run dynamics at country-level. Thus, yield differentials calculated as the difference from the euro area average and are explained by their own lags as well as by the lags of domestic fundamentals and a global, i.e., the European Union common factor.

Due to the tendency that European Union countries hold their economies to the same financial standards (via convergence process), increasing regional cooperation, trade and technology transfer, most of the EU countries assimilate in the long-run. However, idiosyncratic factors influence short-run heterogeneity among them. A potentially better solution to deal with this situation is to investigate a panel framework and allow short-run heterogeneity in conjunction with long-run homogeneity.

In the analysed literature, there are number of dynamic panel techniques, but for purposes of the paper, the pooled mean group estimator (PMG) developed by Pesaran, Shin and Smith (1999a) seems to be the most eligible approach. PMG is an intermediate procedure that constrains the long-run coefficients to be the sufficiently homogeneous but the short-run coefficients and error variance can vary across countries (Pesaran et al., 1999a). Moreover, pooling data allows to provide more variability, less collinearity, more degree of freedom and more efficiency (more analysis about the gains of using panel data see Baltagi (2013). According to Csonto (2014), particular country regressions are inclined to underestimate the role of fundamentals in explaining spreads, while the PMG estimator allows for the variation in time of country – specific fundamentals, which is usually much lower than that of sovereign spreads.

The starting point to describe the model of this empirical analysis for the determinants of sovereign yields spreads is the autoregressive distributive lag $ARDL(p, q_1 ... q_n)$ dynamic panel specification:

$$\ln y_{it} = \sum_{j=1}^{p} \lambda_{ij} \ln y_{i,t-j} + \sum_{j=0}^{q} \delta_{1ij} \ln X_{i,t-j} - \sum_{j=0}^{q} \delta_{2ij} \ln C_{t-j} + \mu_i + \varepsilon_{it} \qquad (2)$$

where the groups of countries $i = 1, 2, ..., N$; the number of periods $t = 1, 2, ..., N$; y is the explained variable, i.e., the average spreads computed from yields on government bonds for nine CEE countries relative to the average of the euro area government bond yields. X_{it} is a $k_1 \times 1$ vector of explanatory variables of fundamentals and δ_{1ij} are

the $k_1 \times 1$ coefficients vector and respectively C_t is a $k_2 \times 1$ vector of explanatory common European Union variables and δ_{2ij} are the $k_2 \times 1$ coefficient vectors. λ_{ij} are scalars; coefficients μ_i capture the fixed effects, which varies across CEE countries.

In the ARDL model estimated by Pesaran et al. (1999a), the primary was determined by the optimum lag length of explanatory variables at country approach. The ARDL model can be re-parameterized by writing it in first differences as follows:

$$\Delta \ln y_{it} = \phi_i\left(\ln y_{i,t-1} - \gamma_{1i}' \ln X_{it} - \gamma_{2i}' \ln C_t\right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta \ln y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{1ij}^* \Delta \ln X_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij}^* \Delta \ln C_{t-j} + \mu_i + \varepsilon_{it} \quad (3)$$

where $\phi_i = -\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right)$,

$\gamma_{1i} = \frac{\sum_{j=0}^{q} \delta_{1ij}}{1-\sum_{j=1}^{p} \lambda_{ij}}$,

$\gamma_{2i} = \frac{\sum_{j=0}^{q} \delta_{2ij}}{1-\sum_{j=1}^{p} \lambda_{ij}}$,

$\lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im}$ for $j = 1, 2, \ldots, p-1$ and

$\delta_{ij}^* = -\sum_{m=j+1}^{p} \delta_{im}$ for $j = 1, 2, \ldots, q-1$.

Noted that ϕ_i is the error correction coefficient or the speed of adjustment to equilibrium values, can differ across countries. The error correction coefficients have to be different from zero if exist the long-run relationship between variables, i.e. $\phi_i \neq 0$ for all *i*.

Moreover, involving homogeneity restrictions in the long-run coefficients when $\gamma_{1i} = \gamma_1$ and $\gamma_{2i} = \gamma_2$ the equation can be transformed as follows:

$$\Delta \ln y_{it} = \phi_i\left(\ln y_{i,t-1} - \gamma_1' \ln X_i - \gamma_2' \ln C_t\right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta \ln y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{1ij}^* \Delta \ln X_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij}^* \Delta \ln C_{t-j} + \mu_i + \varepsilon_{it}\,. \quad (4)$$

According to Pesaran et al. (1999b), for the simplest case of restrictions when $p = 1$ and $q = 1$, the completed model used for calculations can be rewritten as follows:

$$\Delta \ln y_{it} = \phi_i\left(\ln y_{i,t-1} - \gamma_1' \ln X_{it} - \gamma_2' \ln C_t\right) + \delta_{1i}^* \Delta \ln X_{it} + \delta_{2i}^* \Delta \ln C_t + \mu_i + \varepsilon_{it}. \quad (5)$$

First of all, in the estimation, the stationary of the variables were investigated. After the calculation of Dickey-Fuller unit root test applied to the residuals there were rejected the null hypothesis that data panel has the unit roots for each fundamental and common explanatory variable, so coefficients are estimated consistently (p-value = 0,0197).

The error correction-based cointegration test for panel data developed by Westerlund (2008) accepted the null hypothesis of no cointegration relationship among analysed variables. Finally, to assess the multicollinearity issue, the collinearity diagnostics

measure was made to estimate how much variables are related to each other and how this affects the stability and variance of the PMG estimates (these calculation results are given in the Appendix 3). Thus, the results of VIF's coefficient (less than 10) do not indicate signs of multicollinearity.

Moreover, the test for autocorrelation in panel-data models derived by Wooldridge (2002, 282–283) was executed and the calculation results rejected the existence of autocorrelation.

The results of Greene (2012), Maddala and Lahiri (2006), Davidson and MacKinnon (1993) derived calculation methods that allow estimation in the presence of autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels, are presented in the Appendix 4.

5. Empirical results

The results of the short-run and long-run determinants given by the pooled mean group estimation for CEE countries is presented in Table 2. The equation 5 is estimated on the whole sample for nine CEE countries to the period from January 2004 until December 2008. The given results are calculated for variables in first differences. Due to the results of the model calculation, the analysis of long-run determinants is realized as the common for all CEE countries and the short-run determinants are separated for individual countries.

The main features of long-run determinants of government bond spreads are that most of the significant parameters is concerned to market variables like the euro area equity volatility (VIX) and market liquidity measure as both reflected by the significant positive coefficients, as well as debt burden expressed by debt-to-GDP ratio (the significant positive coefficient), country's trade openness parameter (positive coefficient) and the ratio between the outstanding amount of general government interest payments on public debt and GDP (negative coefficient). As noted, the long-run relationships would be applicable if the error correction coefficients are different from zero for each country. The error correction value for Czech Republic, Hungary, and Latvia is below - 0.1 and indicates that at constant long-run coefficients on independent variables government bond spreads would be relatively less affected in the long-run by changes determinants than in the short-run. However, error correction coefficients for Bulgaria, Lithuania, Poland, Romania, Slovakia, and Slovenia are higher than the specified level.

In the analysis of short-run determinants the trade openness turns out to be one of the key factors in understanding bond spreads. The tendency that the higher is trade integration, the lower is risk premium is significant for all analysed countries except Poland (significance occurs with positive sign) and Slovakia. This implication indicates that consolidation of market trade has assisted with facilitating the access to finance on the government bond markets for CEE economies. Moreover, the high degree of

openness tends to reduce bond spreads because developed close trade relations and expected trade surpluses ensure the reliability of the issuer of debt. In the case of Poland, the positive coefficient suggesting that the ability to participate as the equivalent trade partner and higher accession to capital flows reinforces sovereign risk.

TABLE 2. **Pool Mean Group Estimation Results**

	Short-run coefficients									*Long-run coef.(all panel)*
	Bulgaria	**Czech Republic**	**Hungary**	**Latvia**	**Lithuania**	**Poland**	**Romania**	**Slovakia**	**Slovenia**	
d.Inflation	-1,76*	2,3**	-0,24	-2,68***	-4,48***	3,26***	-0,09	2,77***	0,69	*-0,14*
d.GovDebt-to-GDP	2,64***	-1,71*	-1,25	2,77***	-0,68	0,15	-0,85	-0,95	0,61	*1,65****
d.FiscalBalance	-0,86	-0,21	1,1	-1,2	-0,41	-2,64***	-0,27**	-0,59	-0,31	*-0,77*
d.OIPoD-to-GDP[a]	-1	0,82	1,37	-0,9	-0,28	-0,3	-1,13	-1,38	-2,27**	*-1,41**
d.MarketLiq	1,06	-1,31	1,04	2,43**	2,98***	-0,44	1,52	0,95	-0,21	*0,24*
d.GNI_perCapita	-2,27**	-1,63*	0,73*	-0,49	0,1	-3,04***	-0,08	-0,36	-2,1**	*-0,8**
d.FiscalSpace	1,37	-2,39***	-1,2*	0,57	0,08	1,49	-0,48***	-1,03**	-0,26	*0,15*
d.TradeOpeness	0,14**	-1,69***	0,44	-1,95**	-1,78**	1,66*	-1,71*	-0,92	-1,6*	*-1,41*
d.VIX	1,08	-2,84***	-0,57**	-2,69***	-3,51***	0,32	-0,98	-0,39**	0,5	*8,53****
_constant	-1,59	-2,28**	0,17	-1,18	-1,09	-0,9	-0,49	-1,31	-0,45	
error correction	-0,482***	-0,053***	-0,048***	-0,064***	-0,256***	-0,361***	-0,274***	-0,233**	-0,202**	

Note:

*** indicates significance at 1%, ** indicates significance at 5% and * indicates significance at 10%

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Source: author's calculations

Another important variable, though more country-specific in its significance, is the inflation rate. A more pronounced increase could indicate a larger widening of spreads in Latvia, Lithuania, Poland, and Slovakia and it also carries significance in most of the other countries. Furthermore, the positive coefficient for Poland, Slovakia, and Bulgaria could be explained by the fact that financial markets pay attention to convergence criteria related to the inflation target and the monetary policy stance accordingly of the central bank as very important determinants for government bond spreads (more detailed see in Alexopoulou et al .(2009)).

Moreover, there is a strong confirmation that bond spreads are influenced by improvements in real convergence, which explains aspects of the transitory dynamics of the spreads for Poland, Slovenia, and Bulgaria, and are statistically significant at the 10% level for Czech Republic and Hungary.

Other country-specific indicators related to the fiscal variables play a conditionally influential role in explaining government bond spreads. More precisely, the government debt-to-GDP ratio has a positive significant sign for Bulgaria and Latvia, the fiscal balance-

to-GDP ratio is significant with a negative sign for Poland and to a lower extent for Bulgaria. Additionally, the ratio between the outstanding amount of general government interest payments on public debt and GDP was an uninformative indicator explaining the dynamics of government bond spreads and is statistically significant at a 5% level only for Slovenia.

Furthermore, country fiscal fragility measure called fiscal space, as reflected in the ratio of debt-to-total tax revenues, plays an important role in driving the short-run dynamics of spreads. The coefficients are negative and significant for Czech Republic, Romania, Slovakia, and to a lesser extent, Hungary.

The common risk factor as captured by the volatility in the euro area equity market seems to have an important value in understanding bond spreads. Following the PMG results, the rise in the global risk aversion drives wider fluctuation of government bond spreads in CEE countries. The coefficient of VIX is negative and significant for Lithuania, Czech Republic, Latvia, and, to a lesser extent, for Hungary and Slovakia. These estimated negative coefficients contradict theoretically predicted impact on spreads (Table 2). Alexopoulou et al.(2009) made the assumption that such tendencies of negative sign may have two different explanations. On one hand, it can be related to possible investors' discrimination regarding bonds issued by a particular country when some countries are assessed as more risky than others. On the other hand, the short-term feature along with the inconclusive impact in the long-run specification suggests the idea that particular countries' spreads may have a distinct resilience to common external factors in both the long and the short-run.

6. Comparison of Actual and Estimated Spreads

The portmanteau Q-test results for serial independence of estimated PMG model residuals performed up to 20 lags is presented in the Table 3. The null hypothesis of no serial correlation up to 20th order in the disturbance process is accepted for all analysed nine CEE countries, implying that the residual series are serial independent in the context of the main explanatory model of spreads.

TABLE 3. **The test of PMG residual autocorrelation**

Country	Portmanteau (Q) statistics	Prob > chi2(20)
Bulgaria	89,062	0,000
Czech Republic	39,974	0,005
Hungary	67,693	0,000
Latvia	44,370	0,001
Lithuania	60,693	0,000
Poland	69,561	0,000
Romania	50,249	0,000
Slovakia	36,435	0,014
Slovenia	35,122	0,020

Source: author's calculations

To study the misalignment in the valuation of CEE sovereign debt, there is defined as the differences of actual and fitted spreads for each country, using the long-term coefficients received form the calculation of pool mean group estimation (see results in Table 2). This analysis helps to assess whether CEE bond prices were in line with their fundamentals over the analysis period and whether PMG predictions of misalignments synchronize with fluctuations in market conditions. According to Csonto (2014), it is assumed in advance that misalignments have a negative sign in the risk-on periods, because bond spreads may be tighter than it would be proposed by fundamentals. On the other hand, risk-off periods may suppose more cases with positive misalignment associated with a more cautious investors' pricing behaviour.

TABLE 4. **Decomposition of Changes in the Residual**

Sing of the residual			Contribution to change in spreads	
Previous period		Current period	Increase in misalignment	Correction in misalignment
+	>	+	$e_t - e_0$	0
+	<	+	0	$e_t - e_0$
−	>	−	0	$e_t - e_0$
−	<	−	$e_t - e_0$	0
+		−	$-e_0$	e_t
−		+	$-e_0$	e_t

Source: based on Csonto (2014)

Another part of the estimated spreads analysis is focused on the task to identify whether country-specific or common factors have a greater influence on the substantial declines or increases of spreads and what is the distribution of this influence through time. The decomposition of changes is used in the spread because variation of residual can indicate either an increase in the absolute value of the residual (increase in misalignment), a decrease in the absolute value of the residual (correction in misalignment) or their combination. The main calculation principals of decomposition in changes of spread are given in the Table 4 (see figures in Appendix 5) and are based on principals of Csonto (2014) analysis. For instance, there is a meaningful difference if residual vary from a higher to a lower positive value that is related to the situation when the debt is undervalue or it become over-valuated when the residual changes the sign from positive to negative.

TABLE 5. **Pool Mean Group Estimation: Decomposition of Changes in the Residual**

	2004Q1 - 2007Q2	2007Q3 - 2008Q4	2009Q1 - 2010Q4	2011Q1 - 2011Q4	2012Q1 - 2014Q4
Fitted spread	2,076	4,880	4,686	4,356	2,255
Common	2,343	5,509	5,290	4,918	2,546
Country -specific	-0,268	-0,629	-0,604	-0,562	-0,291
Residual	-0,365	-2,781	0,315	-0,916	0,784
Correction of misalignment	0,048	0,221	0,560	-0,088	0,072
Increase of misalignment	0,022	-1,265	0,296	-0,437	0,021

Source: author's calculations

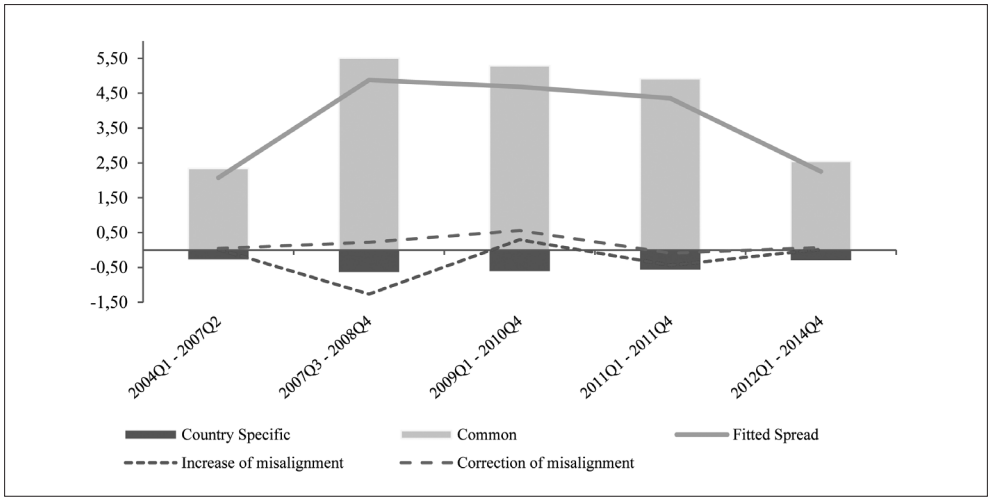

FIGURE 2. **Pool Mean Group Estimation: Decomposition of Changes in the Residual**
Source: author's calculations

For the analysis of the results, five main sub-periods are identified that represent changes in the data related to the actual market experience in the recent decade. Figure 2 plots the observed spreads and the fitted spreads resulting after the decomposition of changes in the residual.

- *Pre-crisis period (till 2007)*. During this period, market pricing behaviour differs across the countries i.e., Hungary, Poland and Romania have positive sign of misalignment that suggests a more cautious market pricing preferences. As the Figure 2 shows, the greater part of model-based spreads is explained by common factors than country-specific indicators. Moreover, for the remaining countries negative misalignment (residual) should indicate that bond spreads were tighter than would be proposed by fundamentals.
- *From the beginning of crises in the middle of 2007 till late 2008.* Since when the U.S. economy had officially slipped into a recession in 2007, the negative misalignment decreases to the lowest point in 2008 for all analysed countries. This possibly indicates the reaction of financial markets either in response to observable factors, such as changes in sovereign risk among neighbouring countries, rapidly shrinking capital flows, worsening macroeconomic imbalances or due to unobservables, such as soaring global risk aversion during the crises period. The economy expansion tumbled and the CEE countries encountered difficulties in maintaining steady and necessary external flows of capital, as well as accumulated domestic imbalances in many countries.

  The model-based spreads doubled compared with the previous period, while the increase of misalignment changed the sign from positive to negative value that associated with increasing of creditworthiness undervaluation. Moreover, the

rise of spreads was driven by both country-specific and common factors, but the improvement of global factors was greater in this analysed period.

- *From the beginning in 2009 till the 2011.* Bulgaria, Czech Republic, Poland and Slovakia had consistent decline of misalignments. This is possibly reflecting the fact that investors positively assess the economics adjustments to changing market conditions. Moreover, positive residuals of Latvia, Lithuania, Romania and Hungary may imply the appreciation that markets were placing lower risk premiums on perceived top performers or save havens within the context of CEE countries. The increase of misalignment values moved from a negative to a positive value during this period and indicates the reduction in the undervaluation of CEE spreads. These corrections represented mostly the enhancement of global market sentiment, with some influence of improving fundamentals and lessen vulnerabilities. It is notable importance of misalignment is the highest through all analysed time.
- *European debt crisis deepens over 2011.* The majority of CEE countries once again had negative misalignments. This may indicate that particular countries were successfully decoupling from the other European countries, especially the necessity of bailouts among PIIG countries. Noted that in the middle of 2011, after several years of financial turmoil in the European debt market, the permanent bailout fund designed to replace the European Financial Stability Facility and the European Financial Stabilisation Mechanism was brought forward. The exceptional situation of misalignment is for Hungary and Slovenia that had positive residuals as well as increased market distrust. This feature of Hungary may be explained due to solvency problems. As a result, In November of 2011, Hungary made an official request for assistance from the IMF but negotiations have not been resolved due to the economic conditions attached to the loan.
- *From 2012 till 2014, adaption to existing circumstances.* The last defined period indicates substantial reduction of spreads across CEE countries as well as a slight increase of correction of the misalignment. Due to PMG results, such changes were almost entirely influenced by an improvement in common factors. In addition, these changes can be associated with reduced worries about the European debt crises in the international market. In September 2012, ECB launched an unlimited but sterilized bond-buying program (known as Outright Monetary Transactions) when the central bank offset bond purchases by taking money out of circulation to avoid increasing the money supply. Improvement in market sentiment can also be related to coherent discussions and solutions for Greece debt crises. As a result, during this period, spreads had almost fallen back to the levels seen in early 2007.

  The analysis of changes in PMG model based spreads indicates that the sign of misalignment diverges during the last decade but is more or less similar in particular market conditions. Moreover, the magnitudes of misalignments also vary among the results of bond spreads.

7. Conclusions

The results of the PMG calculation on the initial sample of nine CEE countries identify that the government debt-to-GDP ratio, the equity market volatility in the euro area as well as the amount of general government interest payments on public debt and GDP ratio and real convergence measure are the main long-run determinants of spreads. However, the corresponding importance of common European Union factor is much more important in the short-run.

Comparing to the analysed literature on bond spreads, the results of estimations confirm that global risk aversion, captured in this case by the volatility index, is the single most important explanatory factor in the short-run perspective. However, countries (such as Czech Republic or Slovakia) with more balanced economic policy, especially during risk-on periods, turn for lower sensitivity to changes in global risk aversion, i.e., this suggests the idea that common factors have a different influence on the CEE countries and this distinction depends on the quality of fundamentals. As shown, the analysis at the country level, especially during the crises period, Bulgaria, Latvia, Hungary and Romania were more implied by fundamentals due to considerable financial imbalances. Nevertheless, although macroeconomic factors are statistically significant, their explanatory power is very limited for the analysed period.

The comparative analysis of the actual and estimated spreads, expressed as the decomposition of changes in spreads, specifies that during the risk-on periods (when the increase of misalignment falls down) there is a tendency for increasing of creditworthiness undervaluation. Moreover, due to the improvement of common factors significance during these anxious years, misalignment tends to increase in magnitude and drive actual spreads.

REFERENCES

Aizenman, J., Hutchison, M., Jinjarak, Y. (2011). What is the Risk of European Sovereign Debt Defaults? Fiscal Space, CDS Spreads and Market Pricing of Risk , NBER Working Papers, No. 17407.

Akitoby, B., Stratman, T. (2008). Fiscal policy and Financial Markets, Economic Journal, 118(533), pp.1971-85.

Alexopoulou, I., Bunda, I., Ferrando, A. (2009). Determinants of Government Bond Spreads in New EU Countries. Eastern European Economics, M.E. Sharpe, Inc., vol. 48(5), pages 5-37.

Attinasi, M.G., Checherita, C., Nickel, C. (2010). What explains the surge in euro area sovereign spreads during the Financial Crisis 2007–2009? Public Finance and Management 10, 595–645.

Baldacci, E., Gupta, S., Mati, A. (2008). Is it (Still) Mostly Fiscal? Determinants of Sovereign Spreads in Emerging Markets , IMF Working Paper no 08/259, November.

Baldacci, E., Kumar, M.S. (2010). Fiscal Deficits, Public Debt, and Sovereign Bond Yields. IMF Working Paper 10/184.

Baltagi, B.H. (2013). Econometric Analysis of Panel Data. 5th ed. Chichester, UK: Wiley.

Barrios, S., Iversen, P., Lewandowska, M., Setzer, R. (2009). Determinants of intra-euro area government bond spreads during the financial crisis. European Economic Paper. 388.

Battistini, N., Pagano, N, Simonelli, S. (2013). Systemic risk and home bias in the euro area. European Economy – Economic Papers 494.

Beber, A., Brandt, M. W., Kavajecz, K. A. (2009). Flight-to-quality or áight-to-liquidity? Evidence from the Euro-area bond market. Review of Financial Studies, vol. 22(3), pp. 925- 957.

Bernoth, K., J. von Hagen, Schuknecht, L. (2012). Sovereign risk premiums in the European government bond market Journal of International Money Finance, 31 (5), pp. 975–995.

Caceres, C., Vincenzo, G., Segoviano, M. (2010). Sovereign Spreads: Global risk Aversion, Contagion or Fundamentals?, IMF Working Paper No. WP/10/120 (Washington, International Monetary Fund).

Codogno, L., Favero C., Missale, A. (2003). Yield spreads on EMU government bonds. Economic Policy 18, 505–532.

Costantini, M., Fragetta, M, Melina, G. (2014). Determinants of sovereign bond spreads in the EMU: an optimal currency area perspective. European Economic Review, 70, pp. 337–349.

Csontó, B. (2014). Emerging market sovereign bond spreads and shifts in global market sentiment. Emerging Markets Review, 20, pp. 58–74.

Davidson, R., MacKinnon, J. G. (1993). Estimation and Inference in Econometrics. New York: Oxford University Press.

De Grauwe, P., Ji, Y. (2012). Self-Fulfilling Crises in the Eurozone: An Empirical Test , CEPS Working Document, June.

Dunne, P. G., Moore, M. J., Portes, R. (2007). Benchmark Status in Fixed- Income Asset Markets. Journal of Business Finance & Accounting, 1615-1634.

Ebner, A. (2009). An empirical analysis on the determinants of CEE government bond spreads. Emerging Markets Review 10, pp. 97–121.

Edwards, S. (1984). LDC Foreign Borrowing and Default Risk: an Empirical Investigation, 1976-80. American Economic Review, Vol. 74, N. 4, 726-34.

Estrada, A., Gal, J., Lopez-Salido, D., (2012). Patterns of convergence and divergence in the euro area. 13th Jacques Polak Annual Research Conference Proceeedings, Washington DC: International Monetery Fund.

Faini, A. (2006). Fiscal policy and interest rates in Europe. Economic Policy, 21 (47) pp. 443–489.

Favero, C., Pagano, M., von Thadden, E.L. (2005). Valuation, Liquidity and Risk in Government Bond Markets, IGIER – Università Bocconi Working Paper no. 281, January.

Favero, C.A., Pagano, M., von Thadden, E.-L. (2010). How does liquidity affect government bond yields? J. Financ. Quant. Anal., 2010, 45, 107–134.

Gerlach, S., Schulz, A., Wolff, G. (2010). Banking and sovereign risk in the euro area. CEPR Discussion Paper, No. 7833.

Giordano, M., Pericoli, P., Tommasino, A. (2013). Pure or wake-up-call contagion? Another look at the EMU sovereign debt crisis. International Finance, 16 (2), pp. 131–160.

Greene, W. H. (2012). Econometric Analysis. 7th ed. Upper Saddle River, NJ: Prentice Hall.

Hallerberg, M., Wolff, G. (2006). Fiscal institutions, fiscal policy and sovereign risk premia. Discussion Paper Series, Deutsche Bundesbank, Research Centre 35.

Haugh, D., Ollivaud, P., Turner, D. (2009). What drives sovereign risk premiums? An analysis of recent evidence from the euro-area. OECD Economics Department Working Papers, No. 718.

Koukouritakis, M., Michelis, l. (2008). The term structure of interest rates in the 12 newest EU countries , Applied Economics, Vol. 40:4, pp. 479-490.

Luengnaruemitchai, P., Schadler, S. (2007). Do Economist' and Financial Markets' Perspectives on the New Members of the EU Differ? IMF Working Paper No. WP/07/65 (Washington, International Monetary Fund).

Maddala, G. S., Lahiri, K. (2006). Introduction to Econometrics. 4th ed. New York: Wiley.

Manganelli, S., Wolswijk, G. (2009). What drives spreads in the Euro area government bond market? Economic Policy, 24, 191–240.

Nickel, C., Rother, P., Rülke, J. (2009). Fiscal Variables and Bond Spreads- Evidence from Eastern European Countries and Turkey , ECB Working Paper 11101.

Obstfeld, M. (2014). Trilemmas and tradeoffs: living with financial globalization. Paper Commissioned for the Asian Monetary Policy Forum, Singapore.

Pagano, M., von Thadden, E.L. (2004). The European Bond Markets under EMU , Oxford Review of Economic Policy, Vol. 20(4), pp. 531-554.

Pesaran, M. H, Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis, in (ed.) S. Strom, Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, chapter 11, Cambridge University Press.

Pesaran, M. H., Shin, Y., Smith, R.P. (1999). Pooled mean group estimation of dynamic heterogeneous panels, Journal of the American Statistical Association, Vol.94, pp.621-634.

Pozzi, L., Wolswijk, G. (2012). The time-varying integration of euro area government bond markets European Economic Review, 56 (1), pp. 36–53.

Sgherri, S., Zoli, E. (2009). Euro Area Sovereign Risk During the Crisis. IMF Working Paper, 09/222. International Monetary Fund, Washington DC.

von Hagen J., Schuknecht, L., Wolswijk, G. (2011). Government bond risk premiums in the EU revisited: The impact of the financial crisis. European Journal of Political Economy, 27 , pp. 36–43.

Westerlund, J. (2007). Testing for error correction in panel data. Oxford Bulletin of Economics and Statistics 69: 709–748.

Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press.

APPENDIX 1

Descriptive statistics by indicators

B.Spread

	Percentiles	Smallest		
1%	-0,077	-0,243		
5%	0,165	-0,163		
10%	0,29	-0,157	Obs	396
25%	0,762	-0,077	Sum of Wgt.	396
50%	1,91		Mean	2,34
		Largest	Std. Dev.	2,01
75%	3,482	10,44		
90%	4,383	11,177	Variance	4,039
95%	5,997	11,197	Skewness	1,552
99%	10,44	11,243	Kurtosis	6,538

Inflation

	Percentiles	Smallest		
1%	-1,8	-3,867		
5%	-0,1	-2,267		
10%	0,4	-1,833	Obs	396
25%	1,633	-1,8	Sum of Wgt.	396
50%	3,25		Mean	3,734
		Largest	Std. Dev.	3,139
75%	4,933	14,033		
90%	7,867	15,6	Variance	9,851
95%	9,067	16,233	Skewness	1,164
99%	14,033	17,533	Kurtosis	5,078

VIX

	Percentiles	Smallest		
1%	11,035	11,035		
5%	12,251	11,035		
10%	12,738	11,035	Obs	396
25%	13,63	11,035	Sum of Wgt.	396
50%	16,444		Mean	19,612
		Largest	Std. Dev.	9,025
75%	22,55	58,596		
90%	29,94	58,596	Variance	81,452
95%	33,016	58,596	Skewness	2,374
99%	58,596	58,596	Kurtosis	9,721

GovDebt-to-GDP

	Percentiles	Smallest		
1%	9,809	8,151		
5%	12,387	8,403		
10%	14,332	8,777	Obs	396
25%	21,795	9,809	Sum of Wgt.	396
50%	36,455		Mean	37,237
		Largest	Std. Dev.	18,661
75%	46,94	82,711		
90%	64,889	82,76	Variance	348,222
95%	78,187	82,86	Skewness	0,645
99%	82,711	83,957	Kurtosis	2,851

FiscalBalance

	Percentiles	Smallest		
1%	-18,465	-39,374		
5%	-10,624	-22,417		
10%	-8,498	-18,853	Obs	396
25%	-5,512	-18,465	Sum of Wgt.	396
50%	-3,092		Mean	-3,3
		Largest	Std. Dev.	4,759
75%	-0,838	10,075		
90%	1,764	10,16	Variance	22,651
95%	3,333	11,578	Skewness	-1,343
99%	10,075	12,467	Kurtosis	12,131

OIPoD-to-GDP

	Percentiles	Smallest		
1%	0,304	0,129		
5%	0,568	0,275		
10%	0,687	0,301	Obs	396
25%	1,013	0,304	Sum of Wgt.	396
50%	1,526		Mean	1,785
		Largest	Std. Dev.	1,093
75%	2,111	4,882		
90%	3,802	4,92	Variance	1,195
95%	4,237	5,066	Skewness	1,192
99%	4,882	5,144	Kurtosis	3,811

MarketLiq

	Percentiles	Smallest		
1%	-0,334	-0,334		
5%	0,213	-0,334		
10%	0,246	-0,334	Obs	396
25%	0,558	-0,334	Sum of Wgt.	396
50%	0,728		Mean	0,711
		Largest	Std. Dev.	0,317
75%	0,882	1,305		
90%	1,064	1,305	Variance	0,1
95%	1,169	1,305	Skewness	-0,779
99%	1,305	1,305	Kurtosis	4,261

GNI_perCapita

	Percentiles	Smallest		
1%	197,002	142,815		
5%	255,296	168,331		
10%	324,031	194,612	Obs	396
25%	478,431	197,002	Sum of Wgt.	396
50%	673,504		Mean	676,54
		Largest	Std. Dev.	289,466
75%	804,949	1508,292		
90%	1015,264	1545,296	Variance	83790,66
95%	1367,189	1548,877	Skewness	0,878
99%	1508,292	1589,445	Kurtosis	4,046

FiscalSpace

	Percentiles	Smallest		
1%	13,598	12,88		
5%	14,968	13,433		
10%	17,151	13,479	Obs	396
25%	20,704	13,598	Sum of Wgt.	396
50%	25,259		Mean	33,95
		Largest	Std. Dev.	19,481
75%	42,097	107,132		
90%	63,135	109,691	Variance	379,503
95%	76,498	110,943	Skewness	1,502
99%	107,132	112,913	Kurtosis	5

APPENDIX 2

Pair wise correlation results

Bulgaria	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,561*	1									
Inflation	-0,694*	-0,54*	1								
VIX	0,064	0,54*	0,196	1							
GovDebt-to-GDP,	-0,577*	0,465*	0,089	-0,465*	1						
FiscalBalance	-0,281	-0,379*	0,281	-0,307*	0,177	1					
OIPoD-to-GDP[a]	-0,834*	-0,601	0,392*	-0,352*	0,861*	0,331*	1				
MarketLiq	-0,065	0,173	-0,294	-0,351*	0,164	0,167	0,199	1			
GNI_perCapita	0,92*	0,591*	-0,665*	0,171	-0,52*	-0,544*	-0,811*	-0,116	1		
FiscalSpace	0,331*	-0,377*	0,187	0,625*	-0,888*	-0,053	-0,707*	-0,291	0,324*	1	
TradeOpeness	0,648*	-0,031	-0,164	-0,185	-0,448*	0,291	-0,494*	-0,196	0,406*	0,295	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Czech Republic	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,291	1									
Inflation	-0,235	0,036	1								
VIX	0,064	0,565*	0,234	1							
GovDebt-to-GDP,	0,904*	0,283	-0,342*	-0,14	1						
FiscalBalance	-0,012	-0,271	0,195	-0,25	-0,06	1					
OIPoD-to-GDP[a]	0,74*	0,466*	-0,376*	-0,047	0,838*	-0,266	1				
MarketLiq	-0,065	0,216	-0,334*	-0,351*	0,218	-0,255	0,397*	1			
GNI_perCapita	0,821*	-0,41*	-0,035	0,344*	0,649*	-0,266	0,551*	-0,146	1		
FiscalSpace	-0,855*	-0,403*	0,377*	0,063	-0,937*	0,172	-0,899*	-0,295	-0,606*	1	
TradeOpeness	0,801*	-0,064	-0,107	-0,315*	0,774*	0,104	0,619*	-0,114	0,512*	-0,67*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Hungary	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,366*	1									
Inflation	-0,575*	-0,08	1								
VIX	0,064	0,536*	0,059	1							
GovDebt-to-GDP,	0,874*	0,53*	-0,509*	0,268	1						
FiscalBalance	0,583*	0,204	-0,093	0,028	0,394*	1					
OIPoD-to-GDP[a]	0,185	0,524*	-0,018	0,133	0,294	0,03	1				
MarketLiq	-0,065	0,228	0,168	-0,351*	0,114	-0,05	0,426*	1			
GNI_perCapita	-0,374*	-0,35*	0,388*	0,229	-0,386*	-0,23	-0,37*	-0,369*	1		
FiscalSpace	-0,582*	-0,52*	0,317*	-0,174	-0,814*	-0,15	-0,495*	-0,238	0,472*	1	
TradeOpeness	0,799*	0,26	-0,314*	0,057	0,724*	0,412*	0,241	-0,176	-0,304*	-0,642*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Latvia	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,257	1									
Inflation	-0,564*	-0,397*	1								
VIX	0,064	0,546*	0,241	1							
GovDebt-to-GDP,	0,844*	0,462*	-0,775*	0,059	1						
FiscalBalance	-0,128	-0,492*	0,116	-0,464*	-0,194	1					
OIPoD-to-GDP[a]	0,736*	0,608*	-0,742*	0,181	0,938*	-0,272	1				
MarketLiq	-0,065	0,224	-0,513*	-0,351*	0,223	0,114	0,311*	1			
GNI_perCapita	0,711	-0,371*	-0,064	0,462*	0,437*	-0,41*	0,423*	-0,395*	1		
FiscalSpace	-0,75*	-0,536*	0,75*	-0,209	-0,93*	0,225	-0,923*	-0,234	-0,392*	1	
TradeOpeness	0,743*	-0,171	-0,545*	-0,339*	0,743*	0,161	0,566*	0,193	0,186	-0,578*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Lithuania	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,28	1									
Inflation	-0,234	0,027	1								
VIX	0,064	0,573*	0,499*	1							
GovDebt-to-GDP,	0,877*	0,173	-0,547*	-0,146	1						
FiscalBalance	-0,295	-0,553*	-0,075	-0,482*	-0,288	1					
OIPoD-to-GDP[a]	0,792*	0,296	-0,487*	-0,021	0,951*	-0,438*	1				
MarketLiq	-0,065	0,175	-0,493*	-0,351*	0,253	-0,058	0,374*	1			
GNI_perCapita	-0,723*	-0,446*	0,057	0,353*	0,541*	-0,581*	0,552*	-0,196	1		
FiscalSpace	-0,724*	-0,273	0,676*	0,17	-0,928*	0,261	-0,921*	-0,431*	-0,378*	1	
TradeOpeness	0,86*	-0,104*	-0,222	-0,235	0,836*	-0,109	0,725*	0,015	0,469*	-0,666*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Poland	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,427*	1									
Inflation	-0,289	0,431*	1								
VIX	0,064	0,318*	0,467*	1							
GovDebt-to-GDP,	0,657*	0,642*	-0,166	-0,06	1						
FiscalBalance	-0,048	-0,336*	-0,138	-0,26	-0,203	1					
OIPoD-to-GDP[a]	-0,139	0,253	0,119	0,069	0,307*	-0,266	1				
MarketLiq	-0,065	0,293	0,064	-0,351*	0,454*	-0,06	0,318*	1			
GNI_perCapita	-0,83*	0,294	-0,138	0,166	0,507*	-0,292	-0,115	-0,195	1		
FiscalSpace	-0,615*	-0,679*	0,127	0,223	-0,886*	0,28	-0,272	-0,56*	-0,389*	1	
TradeOpeness	0,807*	0,285	-0,248	-0,082	0,535*	0,354*	-0,151	-0,062	0,568*	-0,489*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Romania	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	-0,23	1									
Inflation	-0,815*	0,264	1								
VIX	0,064	0,505*	0,02	1							
GovDebt-to-GDP,	0,85*	-0,26	-0,578*	-0,179	1						
FiscalBalance	-0,155	-0,502*	0,111	-0,583*	0,01	1					
OIPoD-to-GDP[a]	0,394*	-0,016	-0,248	-0,162	0,586*	0,121	1				
MarketLiq	-0,065	0,386*	0,094	-0,351*	0,224	0,076	0,396*	1			
GNI_perCapita	0,612*	0,087	-0,572*	0,487*	0,172	-0,529*	-0,03	-0,32*	1		
FiscalSpace	-0,677*	0,02	0,387*	0,119	-0,922*	0,024	-0,661*	-0,398*	-0,005	1	
TradeOpeness	0,064	-0,411*	0,02	-0,461*	0,301*	0,503*	0,467*	0,218	-0,275	-0,288	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Slovakia	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,546*	1									
Inflation	-0,591*	0,093	1								
VIX	0,064	0,252	-0,019	1							
GovDebt-to-GDP,	0,73*	0,494*	-0,223	-0,353*	1						
FiscalBalance	-0,195	-0,221	0,359*	-0,285	0,055	1					
OIPoD-to-GDP[a]	-0,013	0,013	0,146	-0,238	0,246	0,269	1				
MarketLiq	-0,065	0,329*	0,072	-0,351*	0,247	-0,195	0,246	1			
GNI_perCapita	0,898*	-0,502*	-0,564*	0,198	0,578*	-0,491*	-0,262	-0,114	1		
FiscalSpace	-0,633*	-0,544*	0,149	0,351*	-0,936*	-0,025	-0,362*	-0,41*	-0,436*	1	
TradeOpeness	0,628*	0,255	-0,212	-0,285	0,498*	0,112	0,012	-0,18	0,534*	-0,345*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

Slovenia	qtr	B.Spread	Inflation	VIX	GovDebt-to-GDP,	Fiscal Balance	OIPoD-to-GDP	Market Liq	GNI_per Capita	Fiscal Space	Trade Openess
qtr	1										
B.Spread	0,756*	1									
Inflation	-0,475*	-0,277	1								
VIX	0,064	0,005	0,07	1							
GovDebt-to-GDP,	0,87*	0,679*	-0,6*	-0,256	1						
FiscalBalance	-0,445*	-0,416*	0,363*	-0,009	-0,462*	1					
OIPoD-to-GDP[a]	0,733*	0,597*	-0,57*	-0,367*	0,967*	-0,408*	1				
MarketLiq	-0,065	0,259	-0,153	-0,351*	-0,023	-0,107	-0,007	1			
GNI_perCapita	0,909*	-0,692*	-0,463*	0,202	0,699*	-0,429*	0,531*	0,045	1		
FiscalSpace	-0,856*	-0,742*	0,656*	0,209	-0,921*	0,493*	-0,869*	-0,249	-0,787*	1	
TradeOpeness	0,717*	0,532*	-0,024	-0,209	0,624*	-0,211	0,552*	-0,231	0,534*	-0,531*	1

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

APPENDIX 3

Collinearity Diagnostics

Variable	VIF	SQRT VIF	Tolerance
id	1,39	1,18	0,7174
qtr	1,95	1,39	0,514
B.Spread	1,93	1,39	0,5189
Inflation	1,86	1,36	0,5372
VIX	1,65	1,28	0,6068
GovDebt-to-GDP	1,38	1,37	0,0879
FiscalBalance	1,37	1,17	0,7285
OIPoD-to-GDP[a]	7,06	2,66	0,1417
MarketLiq	1,45	1,2	0,6913
GNI_perCapita	2,02	1,42	0,4942
FiscalSpace	4,05	2,01	0,247
TradeOpeness	1,52	1,23	0,6563
Mean VIF	2,3025		

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

APPENDIX 4

Cross-sectional time-series FGLS regression

Coefficients: generalized least squares
Panels: heteroskedastic
Correlation: no autocorrelation

Estimated covariances	=	9	Number of obs	=	396
Estimated autocorrelations	=	0	Number of groups	=	9
Estimated coefficients	=	10	Time periods	=	44
			Wald chi2(10)	=	390,35
			Prob > chi2	=	0,000

SpreadBondGER	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Inflation	0,014	0,028	0,480	0,630	-0,042	0,069
VIX	0,071	0,008	8,580	0,000	0,055	0,087
GovDebt-to-GDP	0,055	0,011	5,110	0,000	0,034	0,077
FiscalBalance	-0,064	0,017	-3,850	0,000	-0,096	-0,031
OIPoD-to-GDP[a]	0,416	0,134	3,110	0,002	0,154	0,679
MarketLiq	1,518	0,233	6,510	0,000	1,061	1,975
GNI_perCapita	-0,001	0,000	-3,100	0,002	-0,001	0,000
FiscalSpace	0,040	0,007	5,360	0,000	0,025	0,054

[a] the ratio between the outstanding amount of general government interest payments on public debt and GDP

APPENDIX 5

Pool Mean Group Estimation by the Countries: Decomposition of Changes in the Residual