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The Borrowing Costs of Selected Countries of the European Union – the Role of the Spillover of External Shocks

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Abstract

During the recent European public finance crisis the reactions of policy makers were largely motivated by the mounting spreads in the financial markets. But it is not clear to what extent risk premia on the markets really reflect the dynamics of economic fundamentals and to what extent they are determined by other factors. Bearing in mind that market sentiment can trigger divergence in spreads from the levels implied by the fundamentals, this paper draws attention to the importance of the spillover of external shocks and financial contagion on the price of borrowing in selected EU countries and in Croatia. The analysis carried out shows that the measure of spillover and contagion employed in the paper was the dominant factor in explaining risk premia during the recent crisis of public finances. The results also hold true for the levels and for the variability of spreads. From this point of view the spreads relating to Croatia are no exception – the variations in them were much higher than those that could be expected to derive from the dynamics in fundamentals. Nevertheless, it has to be said that such results do not imply that markets ignore movements in fundamentals. Thus a decomposition of spreads in Croatia over the last two years of the sample observed (from the second quarter of 2010 to the second quarter of 2012) indicates a constant rise of the adverse impact of fundamentals on Croatian spreads, which does not hold good for other countries of Central and Eastern Europe, which are often used as comparisons when analysing the risk associated with Croatia.

JEL:

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Keywords:

spillover of shocks, public finance crisis

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Contents

1 Introduction

During the recent European public finance crisis the reactions of policy makers were in a large part motivated by the rising spreads on the financial markets.[1] But the extent to which movements in markets are genuine reflections of the dynamics of economic fundamentals is not clear, nor is the extent to which they are determined by other factors. This paper analyses the credit risk perception of Croatia and selected European Union countries on the international financial market. The basic drivers of CDS and bond spreads are identified[2], after which their impacts on the movements in spreads are quantified. For this purpose, in addition to the variables that are usually employed in the literature, i.e. macroeconomic fundamentals and indicators of global risk aversion, particular attention is devoted to impact of the spillover of external shocks and financial contagion on the spreads of selected European countries. The impact of such shocks is especially important for small countries like Croatia, which are most often not the generators of these joint variabilities of spreads and domestic policies can have no effect on the dynamics of them in the short run. As for the contribution made to the literature concerning Croatian spreads, this paper systematically discusses an important component of spreads that existing literature has not seriously considered.

In general, the spread[3] for a given country is affected directly or indirectly by a number of factors. Primarily, spreads should reflect the credit risk of a country and accordingly the macroeconomic fundamentals can be expected very largely to define the dynamics of spreads, via their influence on the associated probability of default of the bond issuer. Apart from the macroeconomic fundamentals, the price of borrowing is also affected by global risk appetite, like the price of other financial assets that are freely traded on the market. For example, in a period when the global market climate is such as to deter investors from risk, they require a greater premium to take on additional units of risk, and in such conditions the price of borrowing will rise.

Although in the literature two basic groups of variables (macroeconomic fundamentals and indicators of risk aversion[4]) are employed when analysing the spreads by linear models, developments in the markets during the recent European public finance crisis tend to suggest that these variables are not sufficient to explain

1 The term spread is used in the paper both for sovereign CDS premia for the debt of given countries and also for the difference between yields on the bonds of a given state and the German Bund yield.

2 Credit default swap for government bond is a financial instrument or derivative that enables its purchaser to transfer credit risk related with the bond to the seller of the instrument. By purchasing a sovereign CDS the creditor of the state (or until recently any interested market participant) buys for an annual premium (CDS spread) insurance should the issuer of the bond (the state) default on payment of bond. Although such instruments are often criticised because they are bought "over-the-counter", and therefore are largely unregulated, they are still a very popular measure of risk. Investors buy such instruments for several reasons: either directly to insure their investment in bonds or for speculative purposes. In order to prevent speculation with CDS in the EU on November 1, 2012, a regulation came into force that, among other things, said CDS could be bought only for insurance of positions in bonds. (Regulation EU no. 236/2012). It is not yet entirely clear what the consequences of this regulation with respect to the dynamics and interconnections of the spreads of EU countries.

3 In theory CDS and bond spreads should have very similar dynamics. Indeed, suppose that i is the yield of a one-year bond, r is the yield of an equivalent non-risky instrument and cds is the pertaining credit risk insurance premium for the bond. Then the purchase of the insured portfolio that consists of this bond and insurance in the form of CDS is approximately equal to the purchase of a non-risk bond for the following holds: $i - cds = r$. From this it follows that $cds = i - r$, which means that CDS and bond spreads are in theory equivalent. In practice there are a number of reasons why CDS and bond spreads diverge (De Wit, 2006) but as a rule there is a high correlation between them.

4 The literature concerning the determinants of spreads is very extensive and includes, among other papers, Eichengreen and Mody (2000), Min (1998), Ferrucci (2003), Alexopolou, Bunda and Ferrando (2009), Petrova, Papaioannou i Bellas (2010) as well as Caceres, Segoviano and Guzzo (2010).

spread dynamics. The variation in spreads was much higher than that which would be implied by the movements in fundamentals and risk aversion. Movements on the market show that an important component in the variability of spreads is linked with the spillover of financial shocks between countries. Further, the intensity of these spillovers often exceeds the intensity of spillovers that derive out of normal connections among the fundamentals of countries. In that case we speak of financial contagion. If in an analysis of spreads the spillover indicators are ignored, if they are not included in the econometric model, the parameters associated with the macroeconomic fundamentals and indicator of risk aversion, because of their high correlation with the measure of spillover, can be highly biased. For this reason Caceres, Segoviano and Guzzo (2010) focus on the importance of external shocks for spread dynamics and construct for a number of countries not only the standard fiscal fundamentals and measures of risk aversion but also an additional measure of external shock spillover and financial contagion on the financial markets, the so-called spillover coefficient.[5]

Determinants of spreads for the sovereign bonds of the Republic of Croatia have been analysed several times, including, among others, in Bobetko, Dumičić and Funda (2011), Žigman and Cota (2011) and Dumičić and Ridzak (2011). In these analyses the authors bring out from several perspectives the importance that macroeconomic fundamentals might have on the financial markets. But in spite of the statistical significance, the amplitudes of their estimates show that the dynamics of macrofundamentals had but a slight economic effect on the cost of borrowing in the given period. For example, the reaction of spreads to an increase in the budgetary deficit of one percentage point is less than 13 base points in Bobetko, Dumičić and Funda (2011) and less than four base points in Žigman and Cota (2011). Similarly, in Dumičić and Ridzak (2011) fiscal fundamentals are not even statistically significant when they enter the specification independently, while the reaction of spreads to a rise in real GDP of 1% is smaller than six base points. Bearing in mind the significant variability of spreads of European countries in the recent period, these elasticities suggest that the variability of spreads was indeed much more marked than that which is implied by the dynamics of fundamentals. On the other hand, the risk aversion indicators employed have been shown to be important in the explanation of spreads.

The objective of the current paper is to examine the effect of spillovers and financial contagion on spreads of EU countries and to consider where the spreads for Croatia are in this context. First of all, as motivation, a simple factor analysis for the sovereign spreads of selected countries is carried out suggesting the existence of very strong common sources of the variability of European spreads. After that, for each country analysed, an index of spillover and contagion, as proposed by Segoviano (2006) and Segoviano and Goodhart (2009) is constructed. This index sums up in a theoretically coherent way bilateral dependences among the spreads of European countries and enables a more detailed insight into sources of spillover on the financial markets. Decomposition of the indices of spillover for the countries analysed shows that during the 2008 financial crisis the countries of CEE were the key source of spillover and contagion for European spreads. There are two basic channels for this contagion. First of all, markets revalue the existing business models of foreign banks in countries of Central and Eastern Europe (CEE), which spills over onto the perception of risk of the countries from which the mother banks come. Secondly the rise in spreads for CEE has in this period brought about a re-examination of the sustainability of the model of growth of these countries, since the long-term expansion of the region is founded primarily on external sources of financing. Unlike the credit crisis of 2008, the main sources of spillover and contagion in the recent public finance crisis were the countries of the PIIGS group (Portugal, Italy, Ireland, Greece and Spain).

After construction of the spillover and contagion index, decomposition of spreads for a group of European countries to economic fundamentals, a measure of global risk aversion and spillover indicator is conducted. The relative importance of each variable for the variability of spreads is calculated (in the sense of the decomposition of the R^2 statistic) and the relative importance of each variable for the spread level.[6] Decomposition of

5 As well as in Caceres, Segoviano and Guzzo (2010) the spillover of external shocks onto the price of borrowing during the recent public finance crisis in the EU has been analysed in, for instance, Claeys and Vasicek (2012) and in Antonakakis and Vergos (2012).

6 Caceres, Segoviano and Guzzo (2010) carried out a similar analysis, but for a smaller number of EU countries. Unlike that paper, in this work the analysis is conducted on a more recent time sample and a larger number of countries are analysed, including countries of CEE. Then, apart from individual country analyses, there is also here a panel analysis of spreads. Finally, while Caceres, Segoviano and Guzzon (2010) analyse only the impact of individual variables on the change in the level of spreads, in this work a composition of the levels and the variances of spreads is also presented.

the variance of spreads shows that it is the effect of spillover and contagion that is responsible for most of the spread variance in the sample observed. On average the share of spillover in spread variance exceeds 50%. The finding of the analysis that the relevance of the fundamentals for the variability of spreads rises significantly when the models are evaluated on a shorter sample that includes only the period of the recent public finance crisis is crucial. It has to be emphasised that the contribution of the indicator of global risk aversion to the variability of spreads is statistically significant, but economically negligible.

Decomposition of the spread levels shows that during the recent public finance crisis spreads increased for all countries to levels considerably above the values that can be reasonably implied by the fundamentals. In other words, the effect of spillover and financial contagion was increased in the recent period for all countries, and this effect is responsible for most of the changes in spreads during the recent crisis. This particularly applies to PIIGS countries. On the other hand, the favourable effect of fundamentals reduced spreads for a number of old and new members of the EU, being most pronounced in Austria and Germany. The list of countries that recorded the most important adverse effect of fundamentals on changes in spreads is led by Ireland, Portugal and Croatia.

Particular attention is devoted to decomposition of spreads from those countries of CEE with which Croatia is most often compared with respect to risk, such as Hungary, Romania and Bulgaria. In the short term, the spreads of these countries are determined by the spillover and contagion component, and it is dominant in the decomposition of the levels. On the other hand, the effect of fundamentals is also important, but it changes very little over the short and medium term. The impact of fundamentals is diverse in selected countries from CEE. Thus the share in the spread related to fundamentals has stagnated in Romania in the last two years of the sample observed (from the second quarter of 2010 to the second quarter of 2012), fallen in Hungary and because of considerably more favourable domestic economic trends has fallen considerably in Bulgaria. An exception among these countries is Croatia, for here the absolute share in the spread related to fundamentals has significantly risen in the recent period.

In the following chapter, there is a detailed analysis of the impact of external shocks on spreads, and a measure of spillover and financial contagion is constructed. After that, based on linear models, the influence of a number of economic fundamentals, global risk aversion and the measure of spillover onto the spreads of EU countries and Croatia are estimated. On the basis of these estimates, the importance of the individual variables for the variability and level of spreads is calculated. In the third and last chapter the main conclusions of the work are stated.

2 Impact of external shocks on spreads

This chapter provides a motivation for the use of the spillover measure in the analysis of selected EU countries. For this purpose, first of all a simple analysis is conducted, in which from a group of 15 countries[7] a small group of factors is extracted; it is then shown that with just two or three factors it is possible to comprehend almost the whole variance of the observed group of spreads. This indicates the existence of powerful common components underlying the dynamics of all the spreads. After that, based on Caceres, Segoviano and Guzzo (2010) , for each country analysed, a spillover index is constructed, i.e. a time series that measures the probability of default for each country, depending on the occurrence of a crisis in the remaining countries. The calculation of the spillover index is technically rather demanding, it being necessary to work out the probability of default of a given country from the dynamics of CDS spreads (Espinoza and Segoviano, 2011) and also the joint probability of default by a number of countries (Segoviano, 2006 and Segoviano and Goodhart, 2009). Both methodologies are sketched out below.

7 The following countries are included in the analysis: Austria, Belgium, Bulgaria, France, Croatia, Ireland, Italy, Hungary, Lithuania, Germany, Poland, Portugal, Romania, Slovenia and Spain. Daily data in the period from the second quarter of 2008 to the second quarter of 2012 are analysed.

The methodological outline applied enables not only a construction of a measure of spillover but also the identification of the source of the spillover.

2.1 Factor analysis of CDS spreads

Financial markets data show that the spreads of European countries have a very strong common component, which tends to suggest their dynamics have common source. The high degree of this common variance can be ascribed to some main causes. In the first place the consequence of similarity among economic fundamentals of the group of countries can be the high synchronisation of the spreads of these countries. The reason for this is clear – if investors evaluate the risk of default from one debt issuer on the basis of the strength of the macrofundamentals, it can be expected that similar fundamentals will lead to similar dynamics in sovereign spreads. Then, the ever greater economic integration of European countries increases the vulnerability of countries to common shocks.[8] Then because of the integration of financial markets the general market sentiment has a potentially powerful effect on spreads. For example, a consequence of enhanced risk aversion during periods of turbulence on the markets is an additional risk premium that investors then require and that they incorporate directly into the price of the debt. Apart from that, it is a known empirical fact that correlations among the prices of financial assets rise rapidly in turbulent periods, while during normal periods on the market lower correlations among prices enable investors to achieve a better quality portfolio diversification, while this is not possible during increased correlation in turbulent periods.[9] In connection with this, correlation among spreads can considerably rise above the level implied by real trends in given countries, fiscal fundamentals, changes in policy and the like. This kind of increased synchronization of dynamics on financial markets and the consequence spillover of external trends onto domestic spreads that are not the result of the usual economic connection is called financial contagion (Forbes and Rigobon, 2001).

In order to illustrate the importance of external dynamics[10] for spreads of government bonds, a simple factor analysis on the CDS spreads of a group of 15 European countries has been conducted.[11] In the first step of the analysis using the principal components analysis the common factors from the group of spreads are estimated, i.e. those variables that by definition summarise the information (variability) of the analysed group of spreads (Stock and Watson, 2002). If $x_1,...x_{15}$ denote the spreads of given countries and $F_1,\dots,F_k$ the evaluated factors ,the consequence of the assumed structure of the model is that each of the spreads can be written as (different) combination of the (same) factors:

$$x_i = \lambda_{i1} F_1 + \dots + \lambda_{ik} F_k + \varepsilon_i .$$

It is important to point out that before the actual evaluation of the factors all the spreads are standardised so that they all have zero expectation and unit standard deviation. This is a usual procedure in the literature in order to prevent the undesirable domination of unusually high spreads in the extraction of the principal sources of variation in the data. But because of this kind of standardisation factor analysis is not particularly useful in a direct analysis of the levels of spreads, rather in the first place it offers a deeper insight into the analysis of second moments – variances and correlations. Nevertheless, by using simple regression models, it is possible to link the level of spreads and the common factors.

Table 1 gives the basic statistics of the estimated factors. The factors are consistently estimated with the principle components method (Stock and Watson, 2002). Table 1 suggests that only two or three factors are sufficient to capture almost total variance of all the fifteen countries. Thus the first factor is responsible for as

8 Krznar and Kunovac (2010) quantify the impact of external shocks on domestic inflation and GDP. The basic finding of that analysis is that external shocks have a dominant impact on the domestic economy.

9 Ang and Bekaert (2003) as well as Markose and Yang (2008) analyse asymmetrical correlations on the world markets, while Kunovac (2011) discusses correlations for European markets, including Croatia.

10 Thinking of the mentioned similarity of fundamentals, the increased integration of markets and economies as well as contagion.

11 The mentioned theoretical equivalence of CDS and bond spreads suggests that it is possible to carry out an analogous analysis of bonds.

much as 67% of the total variance of all the spreads, and the first two factors cumulatively describe more than 90% of the total variance of data. The fact that these two factors capture more than 90% of the total variance of the analysed CDS spreads of 15 countries suggests the existence of powerful common sources of volatility on the European CDS and bond market.[12]

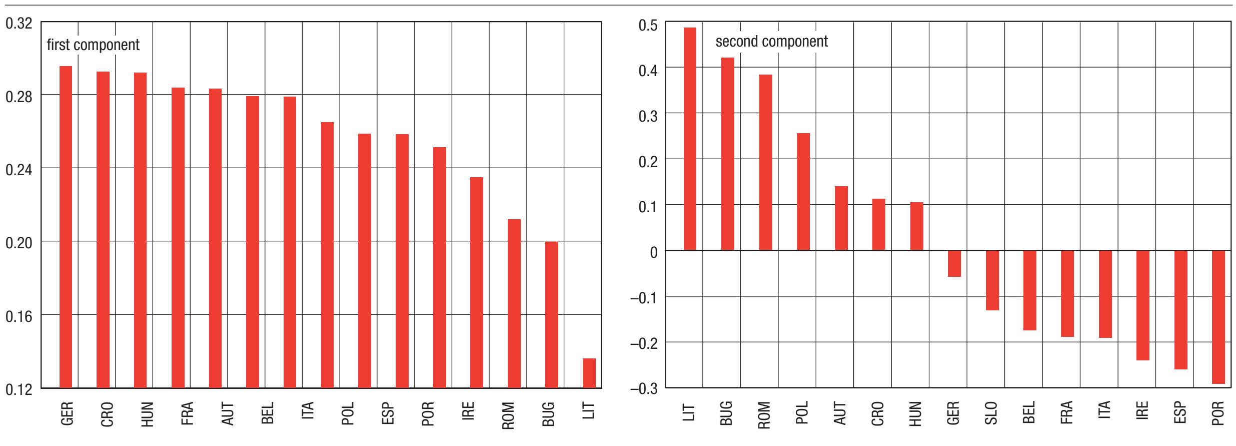
Table 1 Principal components analysis

	Variance	Cumulative variance	Cumulative (share)
1	9.99	9.99	0.67
2	3.72	13.71	0.91
3	0.60	14.31	0.95
4	0.21	14.52	0.97
5	0.14	14.66	0.98
6	0.09	14.76	0.98
7	0.06	14.82	0.99

Source: Author's calculation.

It is difficult to assign the factors a meaningful structural interpretation. But by the definition of the principal components , the factors are mutually orthogonal linear combinations of CDS spreads with maximum variance. In order to acquire a better insight into their construction, Figure 1 gives factor loadings corresponding to each CDS for the first two factors.

Figure 1 Factor loadings of the analysed countries in the first and second principal component



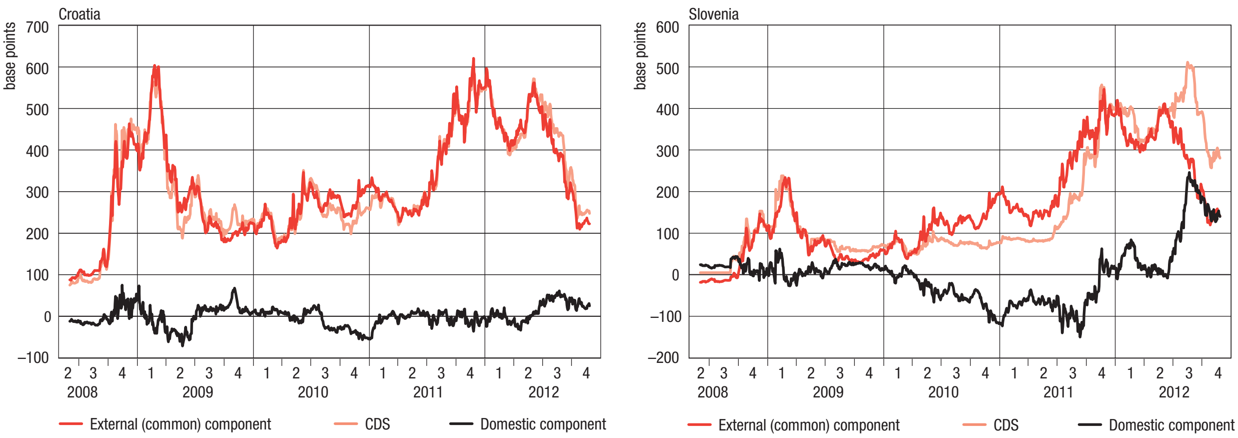
Source: Author's calculation.

Several basic conclusions are inferred from this figure. Firstly, the first factor, i.e. the representant of the most important common direction of the variation of the spreads is very important for the dynamics of all the spreads observed, save for that of Lithuania. Further, the expected result of the analysis is that among the countries that dominate the dynamics of common variations are the old EU member states – Germany, France, Italy, Austria and Belgium and after that countries with marked problems in their public finances. Rather unexpectedly, at the very top, in second and third places are the factor loadings for Croatia and Hungary. This need not be interpreted as these countries being the sources of common variance, rather that in the period under observation their CDS spreads followed the common movements on the market uncommonly closely. To do

12 The same analysis is carried out on first differences too. In this case the proportions of the variance explained for the first few factors are somewhat lower than in the case of the analysis of spreads in the levels. The conclusions, however, remain the same.

with the interpretation of the second factor, the factor loadings on the figure show that its dynamics are to the greatest extent determined by countries that recorded considerable rise of spreads during the financial crisis starting in 2008. One has to bear in mind that the factors are identified only up to the constant, and, among other things, their sign is undefined. For this reason the high negative values for countries from the PIIGS group suggest that this factor identifies their dynamics too.

Figure 2 Decomposition of CDS spreads for Croatia and Slovenia to the external and the idiosyncratic component



External dynamics constructed by the regression CDS = $\alpha + \beta F_1 + \gamma F_2 + \epsilon$, while the domestic component is obtained as the residual of the model.
Source: Author's calculation.

In order to be able to distinguish to what extent the dynamics of spreads are caused by common sources, i.e. the estimated factors, and which part is characteristic of the domestic, idiosyncratic component, a simple linear regression is estimated, in which we explain the CDS spreads of a given country only with the estimated common factors and the constant. From the perspective of small countries like Croatia that are not the generators of the common variability on the international market, the mentioned common factor can be identified with the external movements, i.e. the trends that domestic policy cannot influence. Figure 2 shows the decomposition of CDS spreads to the common external component and the remaining part, which we (imprecisely) call the domestic component. In order to illustrate the heterogeneity of the dynamics of spreads for various countries, we will show the decomposition for two countries with a very diverse dynamics of spreads in the observed period –for Croatia and Slovenia. The figure suggests that the spread dynamics for Croatia in the last few years is strongly correlated with external trends.

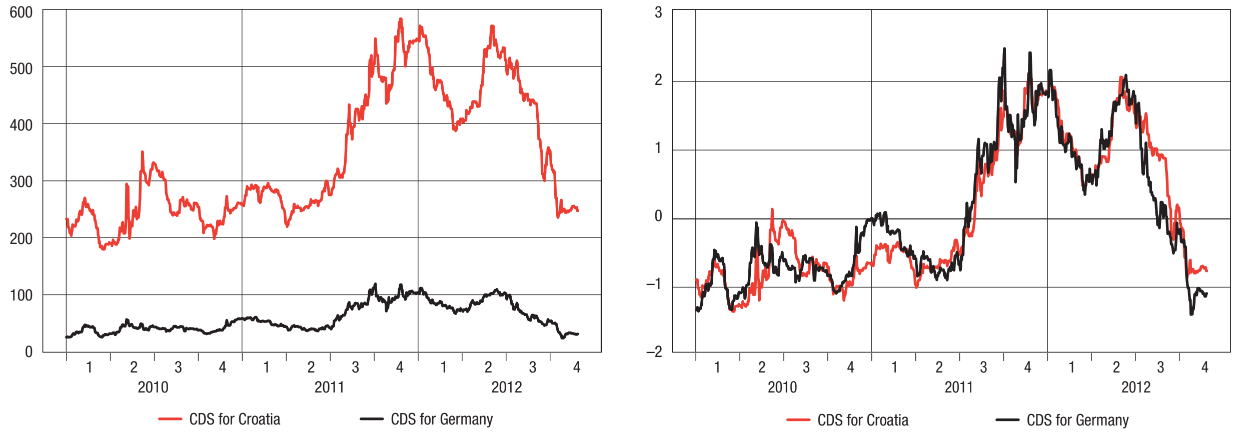
It would be a mistake to conclude on the basis of this analysis that the influence of macro and fiscal fundamentals on the cost of borrowing is negligible. It has to be said first of all that the analysis carried out is precise in its explanation of spreads only up to the constant. This means that although the estimated factors do cause spread dynamics, it is not identified at which level this occurs.[13] For example, the fact that the spreads of Germany and Croatia have the largest loadings in the first factor only indicates that they were exceptionally highly correlated, but it tells us nothing of the level on which the spreads move.[14] This is clearly seen in Figure 2, which shows the CDS spreads for Germany and Croatia on a real scale and then on a standardised scale. It is also visible that in spite of the great difference between the spreads of these countries there is a high correlation between them at a daily level.

It is possible that economic fundamentals do act on the level and intensity of reaction of domestic spreads as multipliers of external shocks (Rocha and Moreira, 2010; Calvo, 2003). This means that although investors classify the risk of an issued debt, evaluating the economic fundamentals, inter alia, the importance that these

13 A simultaneous analysis of a number of countries with the use of a panel model would be more useful in this context. In such a case the fixed effects identify the remaining heterogeneity among countries. On the other hand, in a simple regression model for a single country it is very difficult to interpret the constant.

14 By adding a constant to a series the correlation remains unchanged.

Figure 3 CDS spreads for Germany and Croatia, real and standardised scale



Sources: Bloomberg and author's calculation.

fundamentals have for the spreads cannot be totally identified and quantified by simple linear models in which the fundamentals enter the calculation additively as regressors of the model. Apart from that, the high synchronisation of spreads of a given state with the aggregate (common) trends on the market can be the consequence of the fact that the fundamentals of a given state do not deviate significantly from the average fundamentals measured in the relevant group of countries. Finally, in such conditions, where the fundamentals do not differ significantly from the average it is possible that investors in their analysis of the spreads of small countries do not carry out (an expensive) analysis for every country, but to a given measure evaluate the debt by averaging it in relation to the market. But then in the event of a major domestic shock, when the fundamentals would begin to deviate markedly from the normal values, investors could receive a signal that a new comprehensive evaluation of the riskiness of a given country is required. An example of this is the rise in spreads for Slovenia in the second half of 2012. In this period, because of increased uncertainties to do with the country's public finances and the need to rehabilitate the banking system, Slovene spreads rose to record values, in spite of the fact that the reduction of averseness to risk had a favourable effect on the price of borrowing in Europe. Figure 2 shows that notwithstanding the favourable climate on the market in this period, trends in spreads were dominantly influenced by adverse domestic trends.

2.2 Measure of spillover

In the previous chapter it was empirically established that there are statistically significant common sources of variation in the spreads of European countries. A question is raised concerning the extent to which and how shocks that rattle one country are transferred beyond its borders. Segoviano (2006) and Segoviano and Goodhart (2009) proposed a methodology that attempts to give an answer to the question and construct a spillover index for a given country. For country Z_i the spillover index is calculated as

$$\begin{aligned} SI(Z_i) &= \sum\nolimits_j \Pr(\textit{default in } Z_i \mid \textit{default in } Z_j)\Pr(\textit{default in } Z_j) \\ &= \sum\nolimits_j \Pr(\textit{default in } Z_i \textit{ and default in } Z_j), \end{aligned}$$

According to the above definition the spillover index is the linear combination of conditional probabilities of default for country Z_i given default of all the other countries. These probabilities are weighted by the probability of the default of a given country. The formula implies that apart from the actual intensity of the spillover of an external developments onto domestic spreads, it is also possible with this methodology to calculate the extent to which any given country is responsible for the spillover of the crisis onto the spreads of country

Z_i.When calculating the spillover index of some given country it is first necessary to evaluate the probability of default for all the analysed countries and also the joint probability density functions of all pairs of countries. After that the probabilities of simultaneous default by two countries can be calculated according to the formula.

The methodology is based on the construction of a consistent information multivariate density optimising methodology (CIMDO) distribution used to model joint movement and the pertaining interaction of risks of given countries. The basic idea of the methodology is to find a common dynamics of risk for several countries, assuming that it is always consistent with the previously calculated unilateral probabilities of default of a given country. These unilateral probabilities of default are calculated from the dynamics of sovereign CDS spreads as proposed by Espinoza and Segoviano (2011). With the help of this methodology, it is possible to calculate the conditional probabilities of default of a country given the economic and financial turbulences in some other country. For example, it is possible to answer questions such as: what is the perception of the probability of a Croatian default given that for example Greek or Portugal defaults?

2.2.1 Calculation of the probability of default t of a single country – Pr(*default in* Z_i)

For the purpose of calculating the probability of individual countries defaulting, we sketch out the methodology proposed in Espinoza and Segoviano (2011).

The basic linear asset pricing formula. The basic linear formula models the behaviour of investors with a utility function U defined over spending c_t and c_{t+1} in periods t and $t + 1$ (Cochrane, 2001):

$$U(c_t, c_{t+1}) = u(c_t) + \beta E_t(u(c_{t+1})).$$

At period t an investor decides to spend or invest an exogenously defined initial endowment e_t, where ξ is the amount that he decides to invest in some asset at price p_t. At period $t + 1$ the investor then possesses an initial endowment from this period e_{t+1} and the current value of the investment from the past period. His problem in choosing the amount to spend can be written as an optimisation problem:

$$\max u(c_t) + \beta E_t(u(c_{t+1}))\, t.d.$$

$$c_t = e_t - p_t\xi$$
$$c_{t+1} = e_{t+1} + (p_{t+1} + d_{t+1})\xi = e_{t+1} + x_{t+1}\xi,$$

where d denotes dividend. By plugging conditions into the above problem and equating the first derivative with zero the basic linear asset pricing formula is obtained:

$$p_t = E_t(\beta \frac{u'(c_{t+1})}{u'(c_t)} x_{t+1}) = E_t(m_{t+1}x_{t+1})$$

where $m_{t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)}$ is the stochastic discount factor (SDF).

A risk-neutral measure. From the linear formula it follows:

$$p_t = E_t(m_{t+1}x_{t+1}) = \sum_s \pi(s) m_{t+1}(s) x_{t+1}(s),$$

where s are the states of the world (for example, a period of crisis or calm), and π is the probability measure with respect to which we calculate expectation. Then the so called risk-neutral measure is defined as:

$$\hat{\pi}(s) = R^f_{t+1} m_{t+1}(s) \pi(s), \tag{1}$$

in which R^f_{t+1} is the available risk free rate. This is the probability with respect to which a risk neutral investor would calculate expectations in such a way that they agree with the market prices. This can be seen from:

$$p_t = \sum_s \pi(s) m_{t+1}(s) x_{t+1}(s) = \frac{1}{R^f_{t+1}} \sum_s \hat{\pi}(s) x_{t+1}(s). \quad (2)$$

The standard approximation for a risk-neutral probability of default from the dynamics of CDS spread S is:

$$\hat{\pi}(default) = \frac{S}{(1-R)}, \quad (3)$$

in which $(1 - R)$, is the recovery rate. We can illustrate the formula with the following simple example. In negotiating a CDS premium a security buyer has an expected cost equal to S (or rather, he pays S irrespective of whether the default has occurred). On the other hand, his expected pay off is $\hat{\pi}(default)(1-R)$ (if there is no default, he gets nothing, while in the case of default he receives $1 - R$). From equating these two amounts $\hat{\pi}(default)(1-R) = S$ the above expression is derived.

Probability of default. Assuming the existence of two states of world: default and non-default, the linear formula becomes:

$$p_t = E_t(m_{t+1}x_{t+1}) = \pi(default) E_t(m_{t+1}x_{t+1} \mid default) + \pi(non\text{-}default) E_t(m_{t+1}x_{t+1} \mid non\text{-}default).$$

and from formula (1) is derived the formula for the probability of default:

$$\pi(default) = \frac{\hat{\pi}(default)}{R^f E_t(m_{t+1} \mid default)}.$$

Since we do not observe $E_t(m_{t+1} \mid default)$, Espinoza and Segoviano (2011) propose an estimation of the probability of default on the basis of the conditional expectation and variance of SDF m_{t+1} under normality assumption. Indeed, then $E_t(m_{t+1} \mid default)$ is the truncated normal random variable and the following holds:

$$E_t(m_{t+1} \mid default) = E_t(m_{t+1} \mid m_{t+1} > threshold(= T)) = \mu_t + \sigma_t \lambda(\alpha_t)$$

where $\alpha_t = \frac{T-\mu_t}{\sigma_t}, \mu_t = E_t(m_{t+1}), \sigma_t = Var_t(m_{t+1})$ *i* $\lambda(\alpha_t)$ is an inverse Mills ratio. The above expression can be calculated only after $E_t(m_{t+1})$ *i* $Var_t(m_{t+1})$ are calculated from the dynamics of some risk-free instrument of the dynamics of VIX. Finally, the sought probability of default is:

$$\pi(default) = \frac{\hat{\pi}(default)}{R^f E_t(m_{t+1} \mid m_{t+1} > T)} = \frac{\hat{\pi}(default)}{R^f(\mu_t + \sigma_t \lambda(\alpha_t))} \quad (4)$$

with an exogenously given threshold T.

Endogenous threshold. Threshold T can be endogenised in such a way that it is written as $T = E(m) + \Phi^{-1}(1 - \pi(default))\sqrt{Var(m)}$ and put into (5). Endogenisation of this kind makes the calculation difficult in the sense that now the probability of default is the solution of a non-linear equation ($\pi(default)$ is on both sides of the expression).

2.2.2 Calculation of the probability of simultaneous default in two countries – Pr(*default in* Z_i and *default in* Z_j)

In order to calculate the index of spillover, apart from the previously calculated probabilities of a single country default, it is necessary to be able to calculate the probability of a simultaneous default by two countries, Pr(*default in* Z_i and *default in* Z_j). More precisely, Segoviano (2006) and Segoviano and Goodhard (2009) calculate the probability of a simultaneous default of two countries so that it is consistent with the previously calculated unilateral probabilities of default of a given country Pr(*default in* Z_i) = PD_i and Pr(*default in* Z_j) = PD_j.

For this purpose they construct a consistent information multivariate density optimising methodology (or CIMDO) distribution on the basis of the minimal cross entropy principle, see Kullback, 1959). The basic principle of the methodology is the construction of a (two-dimensional) *posterior*[15] distribution p such that the predefined prior distribution q is updated by the information obtained empirically. That is, there are requirements on the two-dimensional *prior* distribution (the simultaneous dynamics of two countries) of the form that previously calculated probabilities of default for the individual countries be the result of the pertaining marginal distributions (the dynamics of the given countries). The *posterior* distribution that fulfils those requirements is called a CIMDO distribution.

What has been described can be formalised in the following way. For the purpose of constructing the two-dimensional distribution p of interest it is necessary to minimise the cross-entropy by minimising the CIMDO function C:

$$C(p,q) = \iint p(x,y) \ln \frac{p(x,y)}{q(x,y)} dxdy,$$

with additional restrictions that ensure consistency of the two-dimensional distribution p with previously calculated probabilities of default for a given country:

$$\iint p(x,y) I_{[x^{default},\infty]}(x)\, dxdy = \Pr(default\ in\ Z_x) = PD_x \text{ and}$$

$$\iint p(x,y) I_{[y^{default},\infty]}(y)\, dxdy = \Pr(default\ in\ Z_y) = PD_y .$$

Finally, for function $p(x,y)$ to be a density function, a third condition is necessary:

$$\iint p(x,y)\, dxdy = 1 .$$

The pertaining Lagrangian then is:

$$L(p,q) = C(p,q) + \lambda_1 (\iint p(x,y) I_{[x^{default},\infty]}(x)\, dxdy - PD_x) +$$

$$+\lambda_2 (\iint p(x,y) I_{[y^{default},\infty]}(y)\, dxdy - PD_y) + \mu (\iint p(x,y)\, dxdy - 1) .$$

Solving the problem gives the optimum density:

$$\hat{p}(x,y) = q(x,y) \exp(-(1 + \hat{\mu} + \hat{\lambda}_1 I_{[x^{default},\infty]}(x) + \hat{\lambda}_2 I_{[x^{default},\infty]}(y))) .$$

The calculated densities finally by direct integration enable the calculation of the simultaneous default by the two countries as

$$\Pr(default\ in\ Z_i\ and\ default\ in\ Z_j) = \iint \hat{p}(x,y) I_{[x^{default},\infty]}(x) I_{[y^{default},\infty]}(y)\, dxdy .$$

2.3 Sources of spillover in Europe

Applying the methodology presented for each of the 14 European countries[16] the index of spillover is calculated. This index is primarily useful as indicator of spillover in an econometric decomposition of spreads

15 *Prior* and *posterior* distribution related to the minimisation of entropy do not have the same interpretation as in Bayesian statistics.

16 Analysis was carried out on the same panel of countries as in the case of principal components analysis, but not including Slovenia, because data about generic bonds that we use for decomposition of spreads are not available.

into basic determinants. If the measure of spillover or contagion is left out of the linear specification, regression estimates are likely to be biased. Apart from that, the construction of the spillover index suggests the way in which it is possible to identify the contribution of the spillover of a given individual country to the spreads of the remaining countries in the group. In the interpretation of contributions of a given country to the spillover index, attention has to be paid to the construction of the index. Construction of the spillover index shows that the contribution of a given country to the spillover to country Z_i:

$$\frac{\Pr(default\ in\ Z_i \mid default\ in\ Z_j)\Pr(default\ in\ Z_j)}{SI(Z_i)}$$

depends on two essential components. Firstly, the connection of two countries is given by the expression $\Pr(default\ in\ Z_i | default\ in\ Z_j)$, which is multiplied by the riskiness of that country[17], $\Pr(default\ in\ Z_j)$. This means that the contribution to spillover is driven by a combination of two possible sources – by the intensity of the crisis in country-source Z_j and the strength of the connection with the country to which the crisis is being spilled over. The spillover index can be written also as the sum of the simultaneous default of some country and of all the other countries in the panel. It has to be said that although Segoviano and Goodhart (2009) interpret the index as a measure of contagion and spillover, this definition of an index does not permit a causal interpretation of transmission of shocks from one country to another. In other words, although the index may indicate the possibility of contagion and spillover, it is in fact only a good indicator of the interconnections between sovereign spreads. Unlike the standard correlation, this index with the help of theCIMDO distribution captures much more complicated links between variables through all the moments of underlying distribution but, without any true causal interpretation of the transmission of external shocks.

In order to acquire a better insight into the sources and intensity of the interconnections on the financial markets, for each of the 14 countries analysed the impact of the remaining countries to its spillover index has been calculated. Then, this decomposition is calculated for two characteristic quarters on the financial markets. Firstly, for the first quarter of 2009 at the height of the financial crisis and after that for the last quarter of 2011 at the height of the uncertainty concerning the public finances of peripheral eurozone countries.

For ease of viewing the results for given countries, Table 2 gives a succinct display of three characteristic blocs of European countries. The first bloc consists of developed members of the eurozone, which were not at the centre of the recent crises – Germany, Austria, France and Belgium. The second bloc consist of countries on the periphery of the eurozone that were at the centre of recent public finance crisis – Ireland, Italy, Portugal and Spain (PIIGS excl. Greece) and the final bloc consists of countries of CEE (Croatia, Hungary, Poland, Romania, Bulgaria and Lithuania). Results at individual country level are given in the table in the Annex.

Table 2 Decomposition of the spillover index for three blocs of countries for the first quarter of 2009 and the first quarter of 2011 (in brackets)

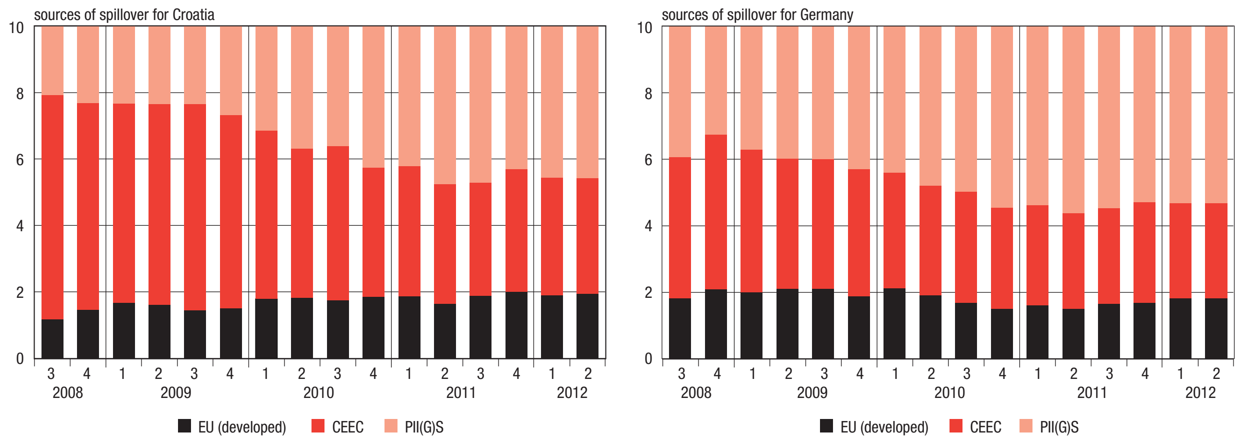
	EU (developed)	PII(G)S	CEEC
EU (developed)	21.7 (20.4)	27.8 (24.1)	16.5 (20.3)
PII(G)S	34.1 (47.3)	25.2 (40.7)	21.9 (42.6)
CEEC	44.2 (32.3)	46.9 (35.2)	61.6 (37.1)

NB: Sources of spillover are given in rows.
Source: Author's calculation.

Decomposition of the spillover index shows that the countries of CEE were important sources of spillover for the financial crisis beginning in 2008. This dynamic is a consequence of the fact that the perception of the riskiness of the countries from the CEE group suddenly rose after mid-2008. The main reason was that at that time, because of the global credit crunch and the increased distrust among banks and other participants on the financial market, external financing of countries of CEE was considerably more difficult. Since the several years of expansion of the countries of the region had been founded precisely on external sources of financing, the markets revaluated the risk inherent in this kind of model of financing and required larger yields

17 The calculated probabilities of default for given countries and the spillover and contamination indices are given in the Annex.

Figure 4 Shares in the spillover index for German and Croatian CDS



Source: Author's calculation.

on the debt issued. For this reason the concerns of the market to a certain extent spilled over onto countries from which the banks present on the market of CEE came. This bloc thus took part in the spillover index to the spreads of developed Europe (44%), onto spreads of PIIGS group (47%) while for the more than 60% of the spill to the CEE bloc the dynamics of the remaining members of the same bloc were responsible. On the other hand, at the peak of the uncertainty concerning the public finance crisis in the first quarter of 2011, the central sources of spillover/contagion were countries from the PIIGS bloc. These countries were thus responsible for almost half of the effect of the spillover to the spreads of developed Europe and for more than 40% on the spreads of countries from the CEE bloc (as compared with about 20% during the past financial crisis).

A common characteristics of the spreads of all the European countries is that during the recent public finance crisis the main sources of spillover were the peripheral eurozone countries, while the countries of CEE were still important sources of spillover and yet with a lower intensity than in the financial crisis of 2008 to 2009. This is illustrated in Figure 4, which, as an example, shows a decomposition of sources of spillover for Germany and Croatia in the period from the third quarter of 2008 to the second quarter of 2012.

2.4 Decomposition of spreads of the EU and of Croatia

In this chapter with simple linear models we decompose CDS premia and bond spreads for the group of European countries into the three observed components.[18]

Macroeconomic fundamentals. The fundamentals are represented by the total public debt and the budgetary balance (expressed as deficit) as a percent of GDP, real growth and per capita GDP. A high public debt and budgetary deficit can be related to difficulties in debt servicing experienced by some country. Hence a positive connection is expected between public debt and the price of borrowing and a negative connection between budgetary deficit and spreads. The rate of growth of real GDP and the level of GDP per capita should have a favourable effect on the possibility of meeting obligations and are expected to be related with lower spreads on the debt of some country. Data are taken from Eurostat.

Global risk aversion. The risk aversion measure reflects the general willingness of investors to take on risk. In a period when the global climate on the market is such that investors are not inclined to take on risk, they require a higher premium for taking on additional units of risk and for this reason the cost of borrowing rises. Thus a positive relation between spreads and risk aversion can be expected in simple linear models.

18 In the calculation of bond spreads yields on generic bonds derived from one-year to ten-year bonds as calculated by Merrill Lynch are used. Spreads are calculated from the German benchmark bond. For this reason in the decomposition of bond spreads, Germany is excluded from the analysis.

Then, risk aversion is an autonomous component in the cost of borrowing and is not necessarily correlated with the macroeconomic fundamentals In this paper, global risk aversion is represented by the VIX index (Chicago Board Options Exchange Market Volatility Index) but in the literature also uses some other indicators of aversion, for example the German analogue to VIX, called VDAX. Data are taken from Bloomberg.

Spillover and financial contagion. Apart from the channel of the common measure of general risk aversion, external shocks are incorporated into the price of borrowing by bilateral connections between countries. For example, economic links between countries are often reflected in financial indicators of these countries and accordingly the consequences of a shock in one country will spill over by the ordinary channels to other countries. When the intensity of such spillovers is much greater than implied by the link between fundamentals, we speak of financial contagion. The spillover index that is used in this paper should identify the effect of spillover and financial contagion on the spreads of the countries analysed. As distinct from global risk aversion, which is the same for all countries, the spillover index is characteristic for each country and takes into account bilateral links of the country for which the spillover is being calculated and all the other countries in the sample.

In the first step of the analysis on the observed panel of countries we estimated the linear relations between spreads (CDS and bond spreads) and selected fundamentals – public debt, budgetary deficit and real growth. The purpose of this simple model is to illustrate which part of the variability of the spreads can be explained by the dynamics of key macrofundamentals and fiscal fundamentals. After that by sequential addition to the specification of the measure of global risk aversion (VIX) and the spillover index, we analyse the magnitude of the marginal effect of the addition of these indicators on the ability to the model to explain the dynamics of spreads. Models are estimated on weekly data from the period from the second quarter of 2008 to the second quarter of 2012. Quarterly data concerning the fundamentals are available, and they are interpolated to the weekly level by linear interpolation.

Table 3 Effect of fundamentals, risk aversion and spillover on CDS and bond spreads

	CDS spread					Bond spread				
Deficit (% GDP)	–15.3	–15.5	–8.3	–10.3	–1.1	–16.6	–17.0	–9.3	–13.8	–2.1
	***	***	***	***	–	***	***	***	***	–
Debt (% GDP)	0.0	0.0	–2.3	–0.4	1.6	0.1	0.1	–2.4	0.1	1.7
	–	–	***	***	***	–	–	***	–	***
GDP (%)	–39.0	–38.0	–25.9	–27.7	–19.5	–46.8	–44.1	–30.6	–34.4	–28.5
	***	***	***	***	***	***	***	***	***	***
VIX		0.3	0.0	0.7	1.0		0.8	0.4	1.5	1.4
		–	–	***	***		–	***	***	***
Spillover			2749	2465	2331			2975	2579	2429
			***	***	***			***	***	***
GDP (*p. c.*)				–0.03	–0.12				–0.04	–0.15
				***	***				***	***
C	149.1	140.5	114.1	118.0	518.7	150.9	126.6	96.7	91.1	613.1
	***	***	***	***	***	***	***	***	***	***
R^2	0.14	0.14	0.73	0.81	0.88	0.13	0.13	0.63	0.73	0.79
Fixed effects	no	no	no	no	yes	no	no	no	no	yes

NB: The symbol *** indicates statistical significance at 1%.
Source: Author's calculation.

The estimates of Table 3 suggest the following basic findings. First of all, the variables used are correlated in a similar way and similar intensity with CDS and bond spreads, which is expected considering the mentioned theoretical equivalence between them. The results are, with few exceptions, similar in a quantitative and qualitative sense, independently of which spreads are concerned. Then, the results from the table suggest that the variability of spreads of the analysed countries is significantly greater than would be implied by macroeconomic fundamentals. For example, the model in which we explain spreads only with basic fundamentals

– budgetary deficit, public debt and real growth explains a very small part of the variation in the spreads. In this case the R^2 statistic is below 15%. The correlation between the fundamentals and spreads is generally of the expected sign. An exception is the negative correlation between public debt and spreads in given specifications, which is attributed to two basic reasons. Firstly, the fact that the effects of the budgetary deficit and the size of foreign debt on spreads overlap to a great extent can result in corresponding estimates with an unexpected sign. Secondly, in certain segments of the period under observation the spreads and the public debt had opposite dynamics for some of the countries analysed. In other words, the market did not always perceive increased indebtedness as risky behaviour.

We will observe that the addition of a measure of global risk aversion, in this case the VIX index, does not contribute significantly to the explanation of the variation of spreads as compared to the basic model that explains spreads only by the dynamics of basic fundamentals. But adding the spillover index to the specification will describe an important share in the variation of the spreads, and R^2 jumps to 63% in the case of bond and 73% in the case of CDS spreads. Then, so as to take into consideration in the model any possible heterogeneity among the countries in the sense of significantly different levels at which the spreads trend, we also included per capita GDP into the specification, which additionally improves the model in the sense of describing the variations of spreads. Finally, so as to include in the model any possible remaining inter-country heterogeneity, a model with fixed effects is also estimated.

Although statistically significant, the economic effects of fiscal variables on spreads were not strong. The reaction of spreads to an increase in a budgetary deficient of 1 percentage point was on average below 20 base points. Similarly, a fall of GDP by 1 percentage point was accompanied by a rise in spreads of an average 35 base points (according to the models). In spite of this unexpected direction of correlation between public debt and spreads in the last specification that involves fixed effects the direction of the correlation was as expected. But the intensity was once again weak and on average a rise in debt expressed as a percentage of GDP by 1 percentage point was matched by a rise in CDS spreads by 1.6 base points and in bond spreads by 1.7 base points. The weak reactions of spreads to change in fundamentals tell of the relative importance of given factors for the price of borrowing in the short term.

2.5 Relative importance of spillover for variability and level of spreads of countries of the EU and of Croatia

Although the models estimated in the previous chapter do give a certain insight into the relative importance that the index of spillover and contagion has for dynamics of sovereign spreads in Europe, in this chapter the problem is approached more systematically. We shall distinguish here between two types of importance of some variable in the model: the importance of a variable for describing the variability of spreads and the importance of a variable for describing the level of spreads.

Relevance of a variable for the variance of spreads. In determining the degree of importance of some variable for the variability of spreads in a regression analysis the marginal effect that the inclusion of this variable has on the R^2 statistic is considered. In brief, it is necessary to identify the share in the explained variation of spreads that we can ascribe to the variation of the given individual variable. If the variables with which we explain the dynamics of spread are not mutually correlated, the problem of the decomposition of variance is trivial. In that case there is a unique effect of a given variable on the R^2 statistic that can be identified with the sequential introduction of variables into the model. But the variables used to explain the dynamics of spreads are highly correlated with each other, which hinders the decomposition of the variance. When regressors are correlated a marginal increase in the R^2 statistic when introducing a new variable into the model depends on the extent to which information that this variable provides is not necessary for an explanation of spreads in the sense that it is already included in the variables already present in the model. In other words, the order of variables in the model is important when calculating the marginal contribution that the inclusion of a given variable into the model has. Motivated by Lindeman, Merenda and Gold (1980) we approached the problem by calculation for each possible order of the variables in the model[19] for each variable in the model the marginal impact that its addition has on the R^2 statistic. The final estimate of the contribution of the variance of a given variable is calculated as the average of these marginal contributions over all possible orders of the variables of the model. In brief, for variable x, the contribution of variance, the LMG statistic, as it is called,[20] is calculated:

$$LMG(x) = \frac{1}{p!} \sum_{permutacija\ r} seqR^2(x \mid r),$$

where $seqR^2(x|r)$ is the marginal change of the R^2 statistic due to adding the variable x to the model, given the order r.

The relevance of the variable for the level of the spread. Sometimes it is necessary to decompose the level of the dependent variable, in our case the level of spreads, to the contributions of individual independent variables. For a general linear model:

$$y = \alpha + \sum_i \beta_i x_i + \varepsilon_i,$$

the contribution to the level of y of variable x_i can be calculated as $\hat{\beta}_i x_i$, where $\hat{\beta}_i$ is an estimate of the parameter β. The mean of the dependent variable can then be written as a linear combination

$$\bar{y} = \hat{\alpha} + \sum_i \hat{\beta}_i \bar{x}_i,$$

i.e. as sum of constant and linear combination of mean values of independent variables and from this point of view such a decomposition is complete. Yet in such ad hoc model it is often difficult to make a meaningful interpretation to contributions calculated in this way. Among other things, multicollinearity can blur the impact of individual variables on spreads, while the consequence of possible inconsistency in the estimated parameters is an overestimation or underestimation of the impact of given variables on the spreads. Finally, the above decomposition shows that in the decomposition of the levels of spreads the constant α also comes in, which most often can be assigned a meaningful interpretation only with great difficulty. In spite of the potential problems in the decomposition of the level of spreads it still, in a wider sense, shows the extent to which correlation between spreads and the pertaining determinants is built in to the level of the spreads.

Decomposition of variances of spreads. Based on this methodology, we quantified for the analysed group of countries the impact that spillover and contagion, global risk aversion and macrofundamentals have on bond and CDS spreads. In the first step on a panel of countries the variance was decomposed, as can be seen in Table 4. Apart from decomposition of variance in the whole period under analysis, especially shown is the decomposition on the shorter period: from the second quarter of 2010 to 2012, so that we would identify any possible redistribution of importance of the determinants of spreads during the recent public finance crisis.

The results indicate several basic findings. Again the importance of individual variables is similar in both CDS and bond spreads. Then, the measure of spillover and contagion explains a large part of the R^2 statistic for both kinds of spreads in both of the time intervals under observation. In the whole of the period observed

Table 4 Contributions of individual variables to variance of spreads calculated with a panel regression (percentage points

		R^2	VIX	Spillover	GDP	Deficit	Debt	Growth	Fundamentals (∑)
Bonds	Q2/2008 – 2012	72.7	1	63	18	9	4	5	36
	Q2/2010 – 2012	75.6	1	53	15	12	10	9	46
CDS	Q2/2008 – 2012	80.7	0	68	15	8	4	5	32
	Q2/2010 – 2012	81	0	55	13	12	6	14	45

Source: Author's calculation.

19 For a 6 regressor model there are 6! = 720 sequences.

20 After Lindeman, Merenda and Gold (1980)

the estimated shares are very high and come to 63% for bond and 68% for CDS spreads. These shares fall by 10 percentage points (for bonds) and 13 points (for CDS premia) in favour of macroeconomic and fiscal fundamentals in the present period that covered just the recent crisis. Measures of global risk aversion are responsible for the negligible share of variance in the description of the spreads at an aggregate level. From the fundamentals used, per capita GDP describes the largest part of the variance of spreads, but since the applied models do not include fixed effects, per capita GDP controls for heterogeneity of levels of spreads among countries. For this reason this variable contributes to the total explained variance of the model with a contribution of between 13 and 18 percentage points. The remaining macroeconomic fundamentals have less importance for spread variability, but it is essential to point out that the share of them in the variance was almost doubled in the recent crisis of public finances. The influence of fundamentals on the variability of spreads, not including per capita GDP, thus rose to 31 from 18% for bonds and to 20 from 17% from CDS spreads.

In order to get a better insight into the sources of variation in spreads at the level of a given individual country, the previous analysis was repeated for each country separately. Table 5 provides a decomposition of the variance of bond spreads[21] for the whole period from the second quarter of 2008 to 2012 and the period of the recent public finance crisis.

Table 5 Contributions of individual variables to variance of spreads (percentage points)

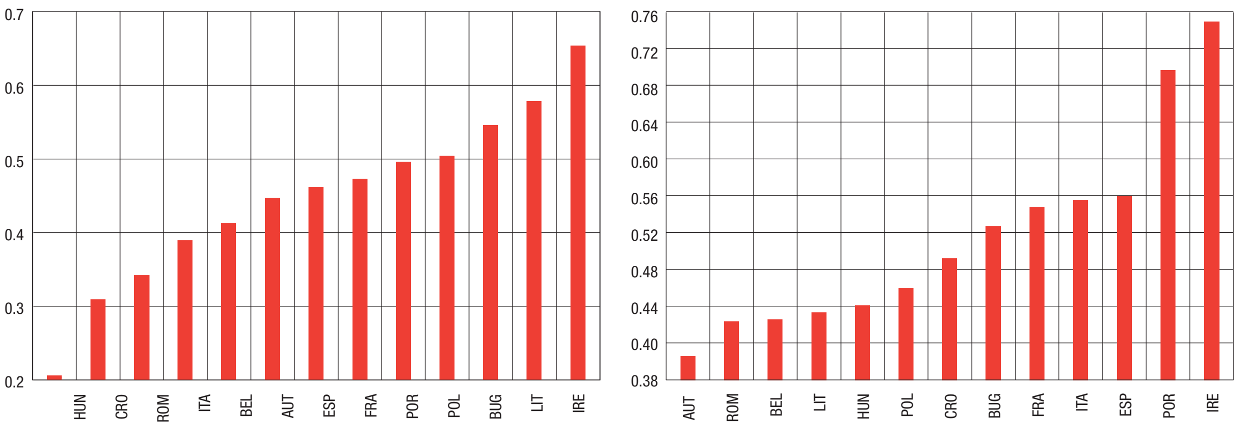
Q2/2008 – 2012	R^2	VIX	Spillover	GDP	Deficit	Debt	Growth	Fundamentals (∑)
Austria	85.9	3.4	51.8	9.5	4.4	22.7	8.2	44.7
Belgium	89.5	1.6	57.1	18.4	5.0	14.2	3.7	41.3
Bulgaria	89.9	35.2	10.3	11.8	4.4	29.9	8.4	54.5
Croatia	84.2	17.9	51.3	3.1	6.2	11.1	10.4	30.8
Spain	96.2	1.7	52.3	2.8	2.5	37.6	3.2	46.1
France	87.9	1.1	51.6	19.5	4.7	20.1	3.0	47.3
Hungary	91.6	2.2	77.3	5.2	1.5	6.1	7.6	20.5
Ireland	85.8	2.3	32.4	9.1	12.9	29.3	14.0	65.3
Italy	95.3	1.6	59.5	6.2	4.3	26.6	1.8	38.9
Lithuania	87.1	14.2	28.0	11.0	5.0	10.1	31.7	57.8
Poland	88.7	16.4	33.2	18.4	3.3	11.4	17.2	50.4
Portugal	93.7	3.7	46.7	0.3	1.8	43.7	3.7	49.6
Romania	81.1	35.6	30.2	3.9	3.1	7.0	20.2	34.2
Average	89.0	10.5	44.7	9.2	4.6	20.8	10.2	44.7
Q2/2010 – 2012	R^2	VIX	Spillover	GDP	Deficit	Debt	Growth	Fundamentals (∑)
Austria	82.1	6.6	54.8	7.2	13.0	10.6	7.7	38.6
Belgium	89.8	5.9	51.5	9.4	7.4	6.5	19.3	42.6
Bulgaria	89.5	32.6	14.7	19.0	9.7	15.1	8.9	52.7
Croatia	96.9	10.6	40.2	5.0	2.5	10.0	31.8	49.2
Spain	93.5	3.2	40.8	3.6	21.8	16.7	13.8	56.0
France	87.5	3.1	42.1	15.6	12.3	11.1	15.9	54.8
Hungary	97.1	2.1	53.8	12.1	5.3	9.3	17.4	44.1
Ireland	91.0	1.2	23.9	9.4	13.2	25.6	26.8	75.0
Italy	94.7	7.5	37.0	9.4	17.1	11.2	17.7	55.5
Lithuania	93.0	10.2	46.5	3.6	4.3	3.6	31.8	43.3
Poland	86.6	12.1	42.0	7.0	17.6	6.7	14.7	46.0
Portugal	89.6	0.9	29.5	9.5	17.0	29.4	13.8	69.7
Romania	91.5	10.6	47.1	9.8	14.6	5.1	12.8	42.4
Average	91.0	8.2	40.3	9.3	12.0	12.4	17.9	51.5

Source: Author's calculation.

21 For simplicity of presentation only the results for bond spreads are shown. CDS spread results are given in the Annex.

In line with expectations there is significant heterogeneity in the decomposition of variance among countries, but from the results shown the basic conclusions do nevertheless obtain. Just as at the aggregate level, now the external factors too are essential in explaining the variability of spreads of all the countries, but this share fell in favour of fundamentals in the recent period. It has to be said that during the recent crisis, as expected, the importance of fundamentals for the variation of the spreads rose for those countries hardest hit by the crisis. Unlike the estimates in the whole period, during the recent crisis, Ireland, Portugal, Spain and Italy had the greatest share of fundamentals in the explanation of variance. But the importance of fundamentals rose significantly for countries that have in the whole sample the lowest share of fundamentals in variance – Hungary and Croatia. The importance of fundamentals for Hungary jumped in the recent period from 20 to 44% and for Croatia from 31 to 49%. The order of importance of fundamentals for dispersion of spreads for the whole period and for the recent public finance crises is shown in the figure.

Figure 5 Share of fundamentals in the total variance of bond spreads in the whole of the observed period (first figure) and for the recent crises in public finances (second figure)



Source: Author's calculation.

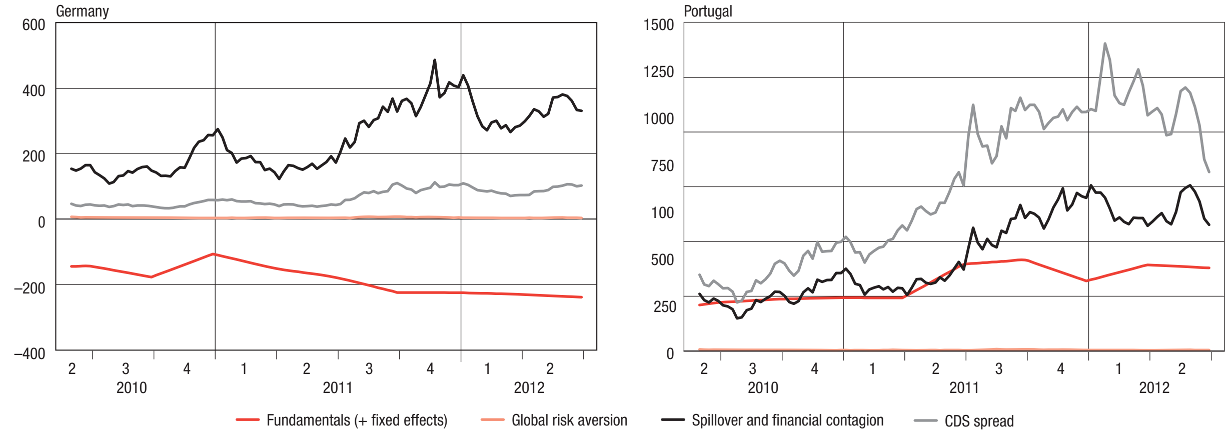
Decomposition of spread levels. On the basis of the estimated panel model with fixed effects the levels of spreads of countries of the European Union and of Croatia were decomposed into components built into spreads by the constant of the model (and fixed effects), fundamentals, risk aversion and spillover and contagion index. The potential problem of this kind of decomposition lies in it not being a priori clear how to interpret a constant, i.e. fixed effects in the model. But since the fixed effects for each country measure that part of the spreads that changes with very low frequency (the constant) and is characteristic of exactly that country, we consider them part of the fundamentals, yet a component of the fundamentals that does not change in the short or medium term.

Since decompositions of the level of spreads depend on the sample within which the model is being estimated, and bearing in mind that the primary interest lies in the decomposition of spreads for the recent period, the results of the period from the second quarter of 2010 to 2012 are shown. This is essential because the fundamentals have a stronger effect on spread in the recent period, but the increase in relevance of fundamentals for spreads would be underestimated if the parameters were estimated over a longer period.[22]

For the purpose of illustrating the method, Figure 6 shows the decomposition of spreads for Portugal and Germany. These two countries are interesting because they illustrate well how the markets build favourable economic trends (Germany) and adverse trends (Portugal) into the price of borrowing. Although the spreads of both countries are powerfully affected by the effects of financial contagion and the spillover of external shocks, the Portuguese fundamentals encourage investors to build in an additional risk premium of about 200

22 The annex presents the results for CDS and bond spreads for the whole period from the second quarter of 2008 to 2012, and also for a shorter period, from the second quarter of 2010 to 2012.

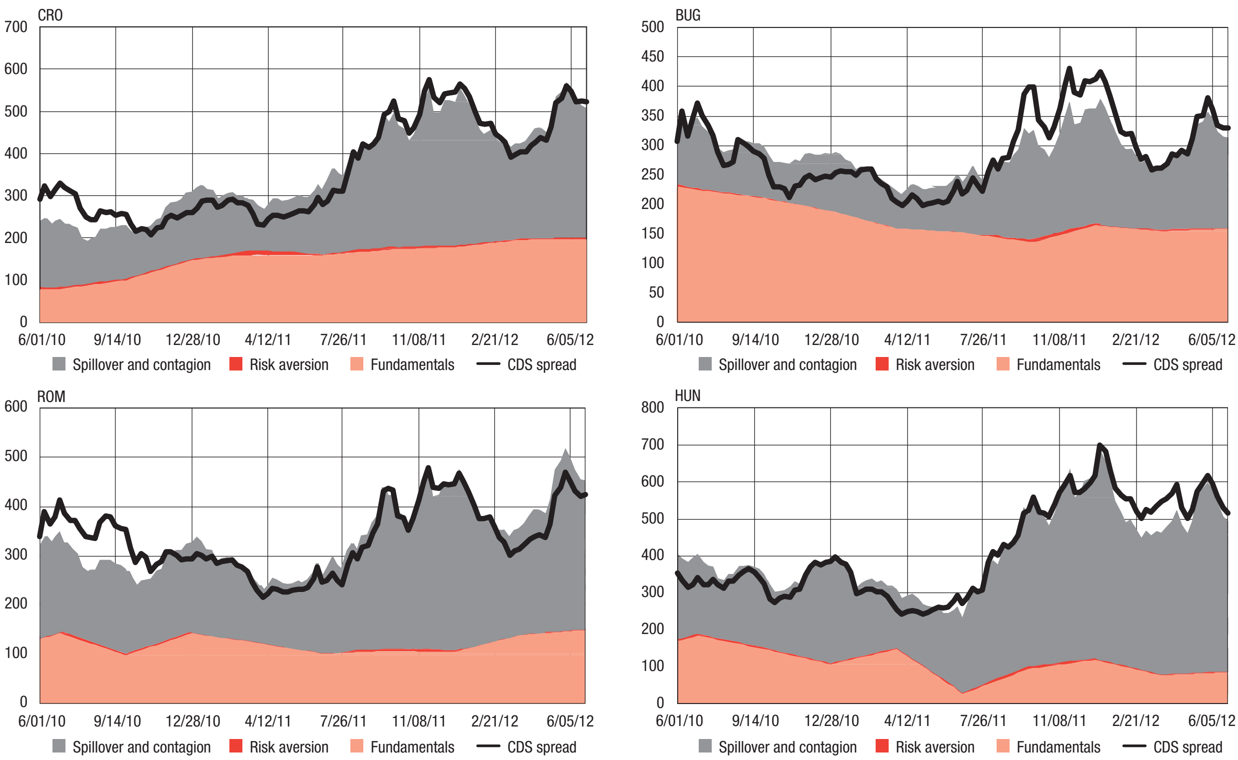
Figure 6 Decomposition of the spreads to fundamentals, global risk aversion and effect of spillover/financial contagion for Germany and Portugal



Source: Author's calculation.

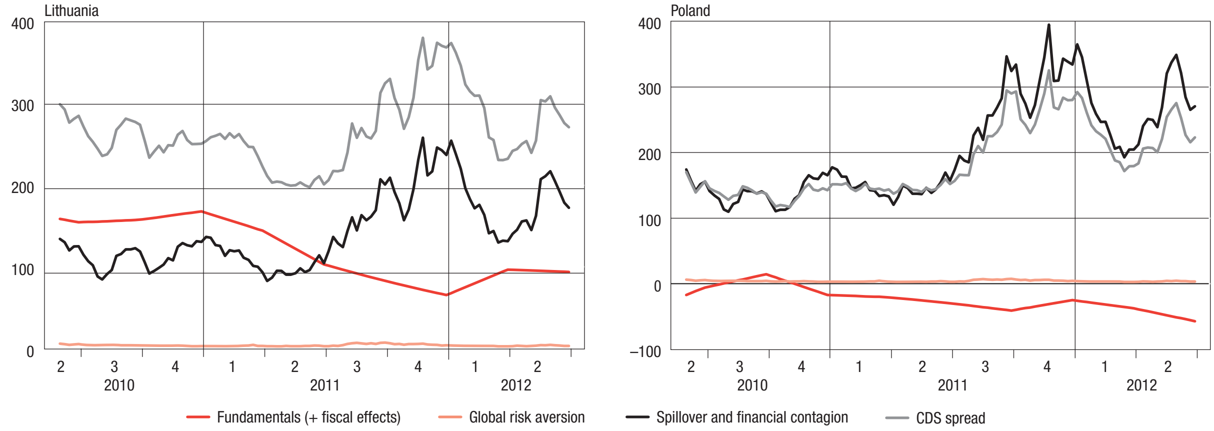
base points in 2010, and the share of fundamentals rose to 400 points from 2011. On the other hand, German fundamentals have a favourable effect on the pertaining CDS spreads and palliate the strong effect of spillover by about 150 pints in 2010 and more than 200 points in the second period. An essential finding that derives from the decomposition of spreads for Portugal is that during the recent crisis the spreads rose significantly above the levels implied by the (admittedly poor) fundamentals. We find similar things in other countries powerfully hit by the public finance crisis, where the component of spillover also dominates the levels of spreads. Unlike them, in countries with smaller problems in public finances, like Germany, Austria and France, the

Figure 7 Decomposition of spreads to fundamentals, global risk aversion and the spillover/financial contagion effect for Croatia, Bulgaria, Romania and Hungary



Source: Author's calculation.

Figure 8 Decomposition of spreads to fundamentals, global risk aversion and the spillover/financial contagion effect for Lithuania and Poland



Source: Author's calculation.

strong impact of spillover is to an extent cancelled out by favourable fundamentals that ultimately reduced the level of the spread.

There is particular interest in the decomposition of the spreads for those countries of CEE such as Hungary, Romania and Bulgaria that are frequently compared with Croatia with respect to risk. Decomposition for these countries, together with the CDS spreads obtained is shown in Figure 7. The results show that the applied models describe spread dynamics very well. The sum of the individual components of spread is very close to total spreads obtained. The characteristic common to all these countries is that the pertaining spreads are caused in the short term by the component of spillover and contagion and for most of the observations this component is dominant in the decomposition of the levels. For example, in the last month of the sample, June 2012, decomposition carried out showed that on average an important part of the level of spreads was related to the effect of spillover and contagion, by as much as 440 base points in Hungary, 330 in Croatia, 320 in Romania and 160 i Bulgaria. On the other hand, the effect of fundamentals is also important, but changes very little in the short and medium term. Then the adverse effect of fundamentals is different for selected countries from CEE. In Romania, for example, the absolute share has been static in the last two years of the same, has fallen to a certain extent in Hungary, and because of the much more propitious domestic economic trends has fallen significantly in Bulgaria. An exception among the countries is Croatia. Here, the absolute share of the spread related to fundamentals has risen considerably, from 80 base points in mid-2010 to 200 points in mid-2012.

It has to be said that the effect of fundamentals on spreads is not adverse for all countries from CEE. For example, from the decomposition of spreads for Poland it can be seen that the domestic fundamentals have had a favourable effect on spreads and on average reduced them by 60 base points in the middle of 2012. The last country of this bloc is Lithuania, whose fundamentals on average affected the spreads adversely, but this effect was reduced considerably in the recent period because of the relatively successful fiscal consolidation. The decomposition of spreads for Poland and Lithuania is given in Figure 8.

In order to get a better insight into the relative importance of domestic fundamentals and external effects of spillover and contagion, Table 6 gives for every country the amounts of spreads related to trends in fundamentals, the spillover index and global risk aversion. For the sake of comparison the results for two periods are given. The first period, June 2010, is characterised by the beginning of the recent crisis in public finances, and the second period, June 2012, is the last month in the sample.

Data from Table 6 show that during the recent crisis of public finances the spreads for all countries rose considerably above the values implied by the fundamentals. In other words, the spillover and financial contagion effect rose for all countries in the recent period (row *Δ* spillover) and this effect is responsible for most of the change of spreads during the recent crisis. This particularly holds true for the PIIGS countries. Thus in

Table 6 Decomposition of the levels of CDS spreads

6/2010	Austria	Belgium	Bulgaria	Croatia	Germany	Spain	France	Hungary	Ireland	Italy	Lithuania	Poland	Portugal	Romania
Fundamentals	21	–6	227	77	–145	–55	–30	167	–37	–12	158	–17	209	129
Spillover	129	168	108	154	153	243	129	232	234	242	134	174	260	188
VIX	6	6	6	6	6	6	6	6	6	6	6	6	6	6
CDS	93	119	307	291	46	256	84	351	274	240	299	170	347	340
6/2012														
Fundamentals	–108	–83	158	196	–239	47	–94	84	179	–23	93	–57	379	148
Spillover	251	356	151	307	331	544	302	405	502	534	172	270	576	301
VIX	3	3	3	3	3	3	3	3	3	3	3	3.2	3	3
CDS	171	248	330	523	102	567	194	516	590	520	271	223	817	424
Δ fundamentals	–129	–77	–69	119	–94	102	–64	–83	216	–11	–65	–40	170	19
Δ spillover	122	188	43	153	178	301	173	173	268	292	38	96	316	113
Δ CDS	78	129	23	232	56	311	110	165	316	280	–28	53	470	84

Source: Author's calculation.

2012 as against 2010 the effect of spillover and contagion rose by 201 base points in Spain, 292 in Italy, 268 in Ireland and 170 in Portugal. On the other hand, as already mentioned, the favourable effect of the fundamentals reduced the spreads for a number of old and new countries of the EU, the most significant influence being for Austria (129 base points) and Germany (94 base points). The list of countries that recorded the most significant adverse effect of fundamentals on the change in spreads is headed by Ireland (170 base points), Portugal (170 base points) and Croatia (119 base points).

2.6 Testing the robustness of the results

In order to verify the robustness of the estimated specifications, the following additional regressors of the model were used: indicators of the labour market, measures of inflation and indicators of external vulnerabilities – international reserves, external debt and balance of payment deficit. The dynamics of these indicators do not affect the results qualitatively and for this reason were left out of the final specifications. Apart from that, instead of the values of fundamentals obtained, the analysis was carried out with the help of exclusively projected fundamentals, use being made of the available half-yearly forecasts of the European Commission (Bobetko, Dumičić and Funda, 2011). Analysis in this case indicates qualitatively the same main conclusions.

As an alternative to VIX, the specification that VDAX has as indicator of risk aversion was also tested out. The reason for this is the questionable relevance of the VIX index for European markets, for it measures investor fears in the sense of expected volatility for stocks from the S&P 500 index. This is why the German analogue was taken instead, i.e. the DAX index of implied volatility VDAX. The very high correlation of the two indices shows that both are good indicators of global risk aversion. The results, then, do not change significantly in response to the risk aversion measure selected.

Finally, the first main component of the spreads of the analysed countries was chosen as alternative to the spillover index. This choice of measure of spillover is restrictive for in this case all the countries have the same spillover and contagion index. In other words the absolute share of spillover in the level of spreads is the same for all countries, if the results are based on the standard panel regressions. The results in this case differ considerably from the specifications shown and have to be interpreted as share of spillover onto spreads averaged by all the countries analysed.

3 Conclusion

This paper has identified some basic determinants of CDS and bond spreads for countries of the EU and Croatia. Existing literature about domestic spreads has been supplemented by special attention having been devoted to the impact of the external components of spillover and financial contagion on the spreads. The results of the analysis draw attention primarily to the importance that spillover and contagion can have on the price of foreign borrowing. Apart from that, the paper leads to a number of basic conclusions.

Above all, the analysis conducted shows that during the last few years the dynamics of European spreads have primarily been caused by the component of the spillover of external shocks. On average more than 50% of the variance of the spreads can be explained by the dynamics of the measure of spillover applied. Further, from the decompositions of the levels of the spreads it can be seen that during the recent public finance crisis the spreads for all countries rose considerably above the values implied by the fundamentals. In other words the effect of the spillover and financial contagion is responsible for most of the change in spreads in the recent crisis. From this point of view, Croatia is no exception. Most of the variation of domestic spreads is correlated to the dynamics of external trends.

Although macroeconomic fundamentals do not have a dominant effect on the dynamics and level of spreads, they do make an impact on the cost of borrowing for all the countries analysed. A favourable impact of fundamentals was reflected on the spreads of a number of old and new members of the EU, most significantly those for Austria and Germany. The list of countries that recorded the most important adverse effect of fundamentals on the change of spreads was led by Ireland, Portugal and Croatia. The finding of the analysis that the importance of fundamentals for trends in spreads has been growing in the recent period is an essential one.

Special attention is devoted to the decomposition of the spreads of those countries of CEE with which Croatia is often compared in terms of risk, such as Hungary, Romania and Bulgaria. In the short run the spreads of these countries are determined by the spillover and contagion component and it is dominant in the decomposition of levels. The absolute contribution of fundamentals to the level of spread of these countries is on the whole static or is on the decline. An exception is Croatia, in which the absolute share in the spreads that is related to the fundamentals has risen considerably, from 80 base points in mid-2010 to 200 base points in mid-2012. This gives weight to the fact that the implementation of fiscal consolidation and reforms that will tend to improve business operation conditions and enable higher growth is necessary for reduction of financing costs.

The results of the paper, apart from indicating the relative importance of individual indicators for the cost of borrowing, also give a better insight into the differences in risk perception for Croatia and other EU countries by foreign investors. Also, the decomposition of spreads into domestic and foreign factors will help in the identification of that part of the price of external borrowing that domestic politics can influence and will help in the definition of policies that can made the conditions of financing more favourable.

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Annex

1. Decomposition of spillover index

Sources of spillover are given in the rows of the table. The average value in the last column shows the average influence of a given country on the spreads of the other countries.

Q1/2009	AUT	BEL	BUG	CRO	GER	ESP	FRA	HUN	IRE	ITA	LIT	POL	POR	ROM	Average
AUT		9.6	5.7	6.6	6.0	9.1	9.0	7.8	8.6	9.2	6.6	8.1	8.8	6.9	7.9
BEL	7.9		3.7	4.6	6.4	8.4	9.9	5.6	7.5	8.5	4.2	6.1	8.2	4.6	6.6
BUG	5.0	3.9		10.3	2.6	3.7	3.5	6.7	5.3	3.9	13.1	5.9	4.5	10.5	6.1
CRO	7.3	6.3	13.1		3.8	6.2	5.7	9.2	7.4	6.4	12.3	8.9	6.4	12.5	8.1
GER	4.5	5.9	2.2	2.6		5.0	7.9	3.0	5.0	5.1	2.3	3.6	4.6	2.4	4.2
ESP	7.4	8.4	3.4	4.5	9.2		9.0	6.0	6.7	9.8	4.0	5.9	9.0	4.6	6.8
FRA	5.1	6.9	2.3	2.9	7.6	6.3		3.5	5.5	6.1	2.6	3.9	5.6	2.8	4.7
HUN	10.8	9.5	10.6	11.5	10.4	10.3	8.5		11.1	10.6	11.2	14.2	10.0	13.5	10.9
IRE	8.2	8.0	6.5	7.1	8.7	7.7	7.4	8.6		8.3	7.1	8.4	7.8	7.7	7.8
ITA	9.2	10.3	4.5	5.8	11.2	12.0	10.6	7.6	8.3		5.3	7.9	9.9	5.7	8.3
LIT	8.3	6.4	18.8	13.8	7.0	6.2	5.7	10.1	8.1	6.7	1	0.2	6.8	14.9	9.5
POL	10.3	9.5	8.6	10.2	10.3	9.3	8.8	13.0	10.3	10.1	10.3		9.4	10.3	10.0
POR	6.4	7.3	3.7	4.2	8.0	8.0	7.1	5.2	6.2	7.2	4.3	5.4		3.7	5.9
ROM	9.6	8.0	17.0	15.9	8.7	7.9	6.9	13.7	9.9	8.1	16.8	11.4	9.2		11.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Q4/2011	AUT	BEL	BUG	CRO	GER	ESP	FRA	HUN	IRE	ITA	LIT	POL	POR	ROM	Average
AUT		6.4	4.7	4.9	3.3	5.7	6.8	5.2	5.0	5.4	5.4	6.0	4.7	5.4	5.3%
BEL	10.0		6.3	7.3	4.4	9.7	11.2	8.2	9.2	9.8	7.0	8.8	8.6	7.7	8.3%
BUG	3.1	2.6		5.9	1.2	2.4	2.5	3.5	3.4	2.6	6.9	3.3	3.7	5.5	3.6%
CRO	5.8	5.5	10.6		2.2	5.3	5.1	6.7	6.4	5.5	8.9	6.5	7.0	9.2	6.5%
GER	4.7	4.0	2.6	2.7		3.4	5.4	2.9	2.9	3.3	2.8	4.0	2.5	2.8	3.4%
ESP	9.6	10.5	6.3	7.7	11.4		10.7	9.4	9.4	12.4	6.9	8.7	11.0	7.8	9.4%
FRA	8.0	8.4	4.4	5.1	9.2	7.4		5.7	6.2	7.2	5.0	6.9	5.5	5.3	6.5%
HUN	8.7	8.7	9.0	9.6	9.6	9.3	8.2		10.4	9.4	8.4	10.6	11.0	10.3	9.5%
IRE	10.5	12.4	10.8	11.5	13.5	11.8	11.2	13.0		13.1	10.9	11.4	15.3	12.3	12.1%
ITA	10.6	12.2	7.7	9.2	13.4	14.3	12.0	10.9	12.2		8.3	10.4	13.2	8.9	11.0%
LIT	4.3	3.5	8.2	5.9	3.8	3.2	3.4	3.9	4.0	3.3		4.4	4.2	5.9	4.5%
POL	7.2	6.6	5.9	6.6	7.2	6.1	6.9	7.5	6.4	6.3	6.7		6.1	6.5	6.6%
POR	11.5	13.5	14.0	14.7	14.7	16.1	11.5	16.1	17.8	16.5	14.2	12.7		12.4	14.3%
ROM	6.2	5.6	9.6	9.0	6.2	5.3	5.2	7.1	6.7	5.3	8.6	6.4	7.3		6.8%
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

Source: Author's calculation.

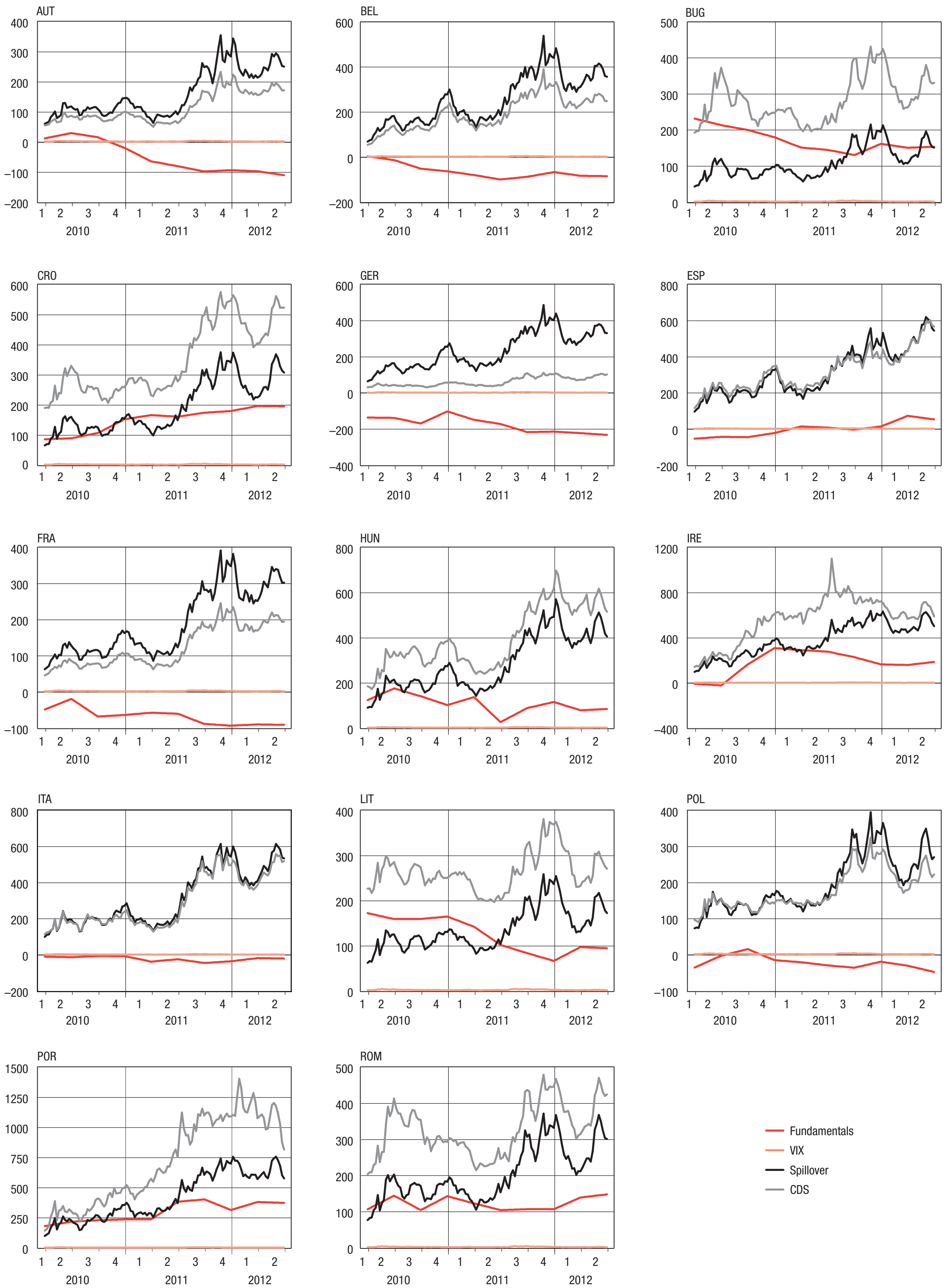
2 Decomposition of variance of CDS spreads

The table gives the contributions to the R^2 statistic of individual variables of the model, in which vix means the VIX index; spillover means the employed spillover index; gdppc is the real GDP per captia; deficit means the fiscal deficit (expressed as % of GDP); growth means real growth in GDP; and the column fundamentals means the sum of individual influences of fundamentals. All the values are given in percentage points.

Q2/2008 – 2012	R^2	VIX	Spillover	GDPpc	Deficit	Debt	Growth	Fundamentals
AUT	98.7	3.5	57.1	9.4	5.2	19.5	5.4	39.4
BEL	99.3	1.1	49.1	23.4	6.0	18.3	2.1	49.8
BUG	92.3	29.0	49.3	2.7	5.7	6.2	7.1	21.7
CRO	96.8	11.1	59.0	3.6	5.3	16.4	4.6	29.9
GER	94.7	2.3	53.2	16.7	2.7	21.3	3.8	44.5
ESP	99.4	2.0	49.5	3.7	3.1	38.6	3.0	48.5
FRA	99.8	1.3	45.9	22.3	3.6	23.8	3.1	52.8
HUN	97.5	4.7	74.6	4.3	1.9	6.8	7.7	20.6
IRE	94.9	2.4	40.2	8.6	8.9	31.1	8.8	57.4
ITA	99.4	1.7	58.7	4.3	4.1	29.1	2.2	39.6
LIT	93.2	19.9	32.4	6.0	4.1	12.1	25.6	47.8
POL	96.6	13.9	52.9	3.2	3.7	13.7	12.7	33.3
POR	97.9	4.1	46.9	0.3	1.4	44.1	3.2	49.0
ROM	93.4	27.0	43.8	2.7	3.0	7.8	15.8	29.2
Average	96.7	8.9	50.9	7.9	4.2	20.6	7.5	40.3
Q2/2010 – 2012	**R^2**	**VIX**	**Spillover**	**GDPpc**	**Deficit**	**Debt**	**Growth**	**Fundamentals**
AUT	99.5	4.5	42.3	10.5	17.7	16.5	8.4	53.2
BEL	99.5	3.4	47.3	12.7	7.0	8.9	20.8	49.3
BUG	94.6	14.9	61.6	7.8	5.1	4.4	6.1	23.5
CRO	98.5	5.2	46.4	11.8	4.1	18.2	14.4	48.4
GER	94.9	4.9	36.2	12.9	25.3	6.2	14.4	58.8
ESP	98.9	1.4	37.2	2.3	23.2	20.0	15.8	61.4
FRA	99.8	3.7	37.6	16.8	14.6	12.4	15.0	58.7
HUN	98.8	3.6	61.6	6.2	2.5	7.8	18.3	34.8
IRE	96.5	1.1	40.8	5.9	8.7	38.1	5.5	58.1
ITA	99.5	7.9	34.7	8.3	17.4	12.6	19.1	57.4
LIT	95.2	8.3	71.0	4.4	6.2	3.6	6.5	20.7
POL	98.8	8.7	44.1	2.1	18.7	12.5	13.9	47.2
POR	96.1	0.6	29.5	9.6	18.4	28.9	12.9	69.9
ROM	93.3	8.1	69.8	6.6	6.1	6.9	2.5	22.1
Average	97.4	5.4	47.2	8.4	12.5	14.1	12.4	47.4

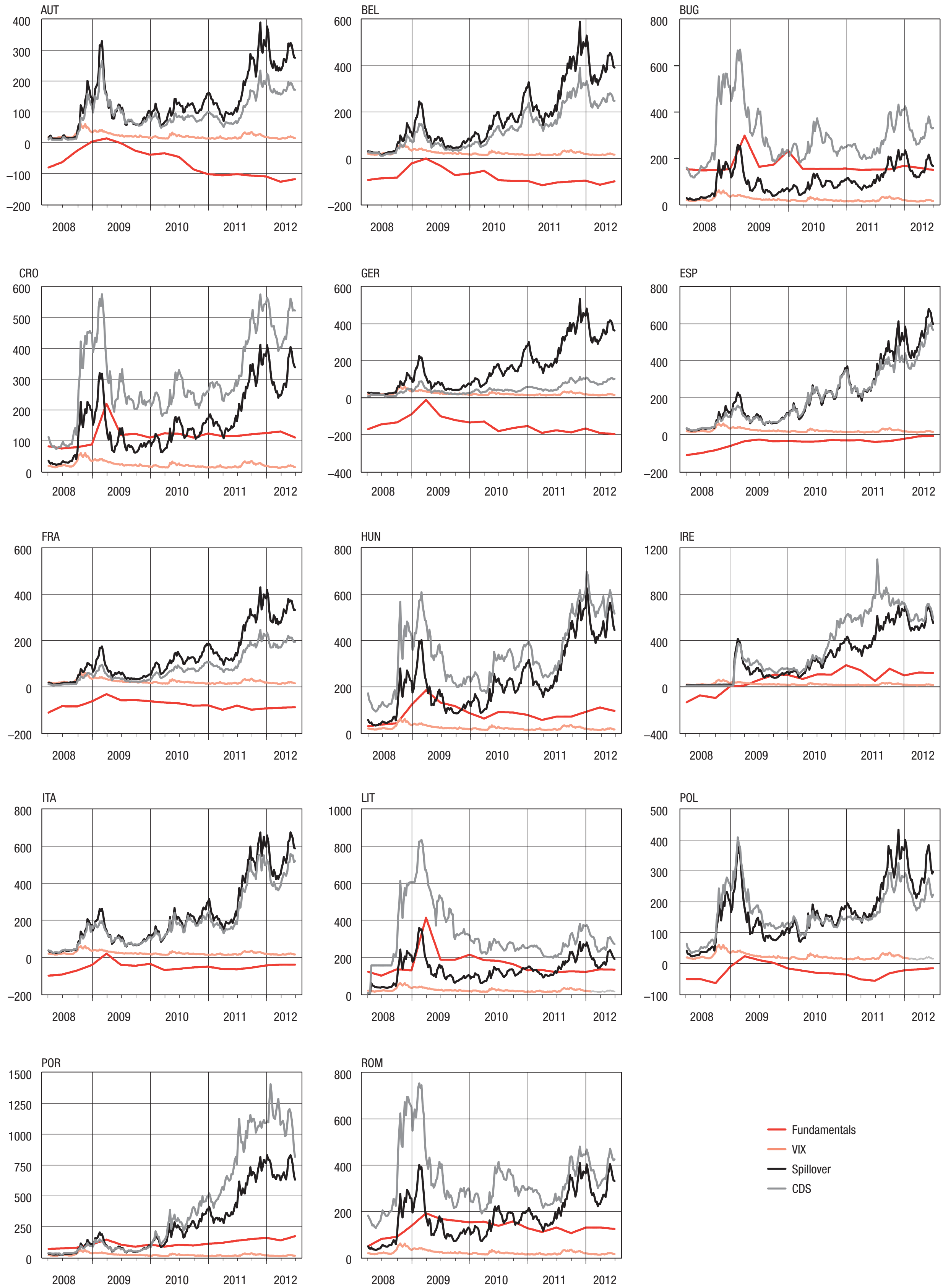
Source: Author's calculation.

3 Decomposition of levels of CDS spreads for the period from the second quarter of 2010 to the second quarter of 2012



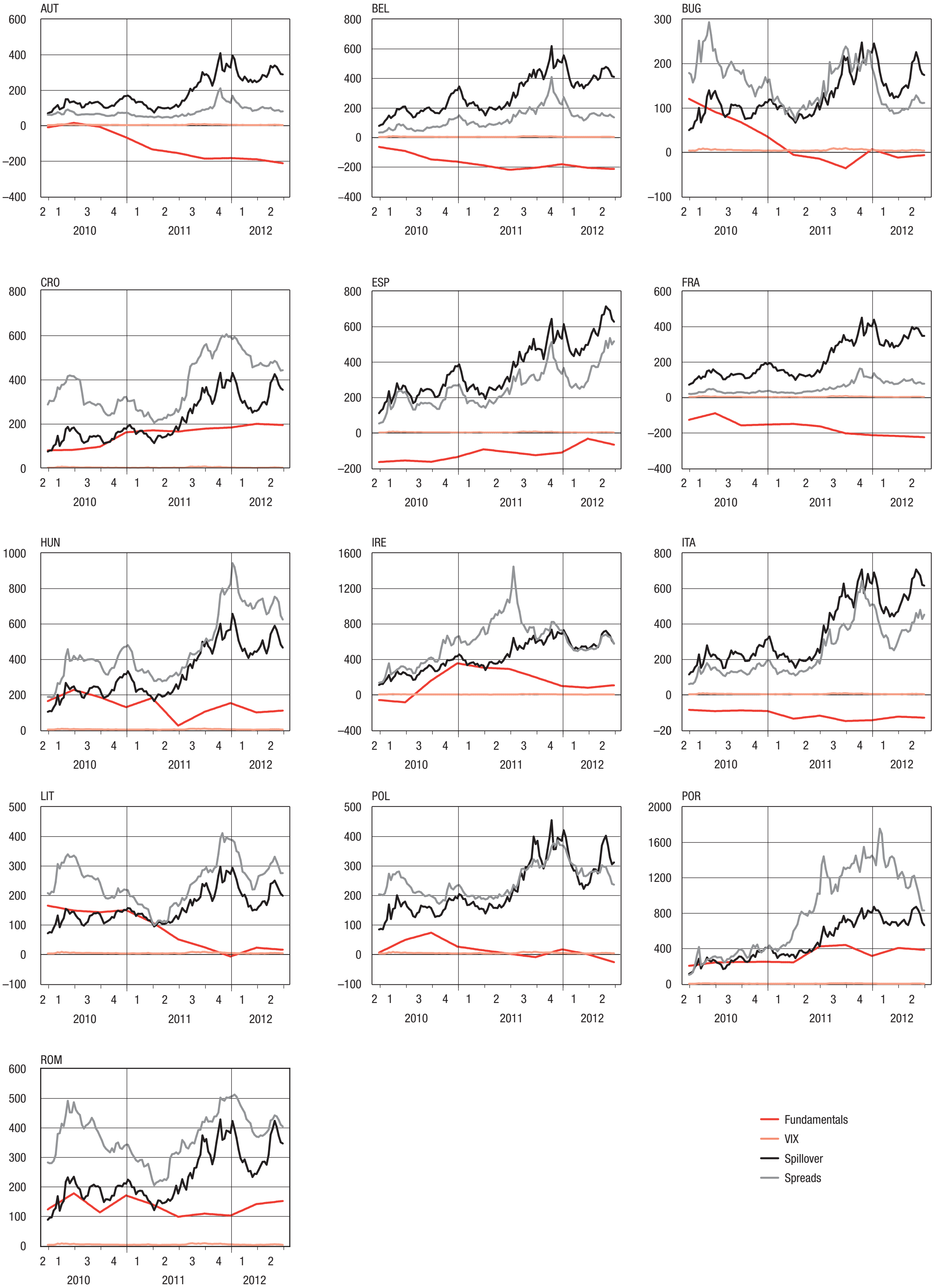
Source: Author's calculation.

4 Decomposition of levels of CDS spreads for the period from the second quarter of 2008 to the second quarter of 2012



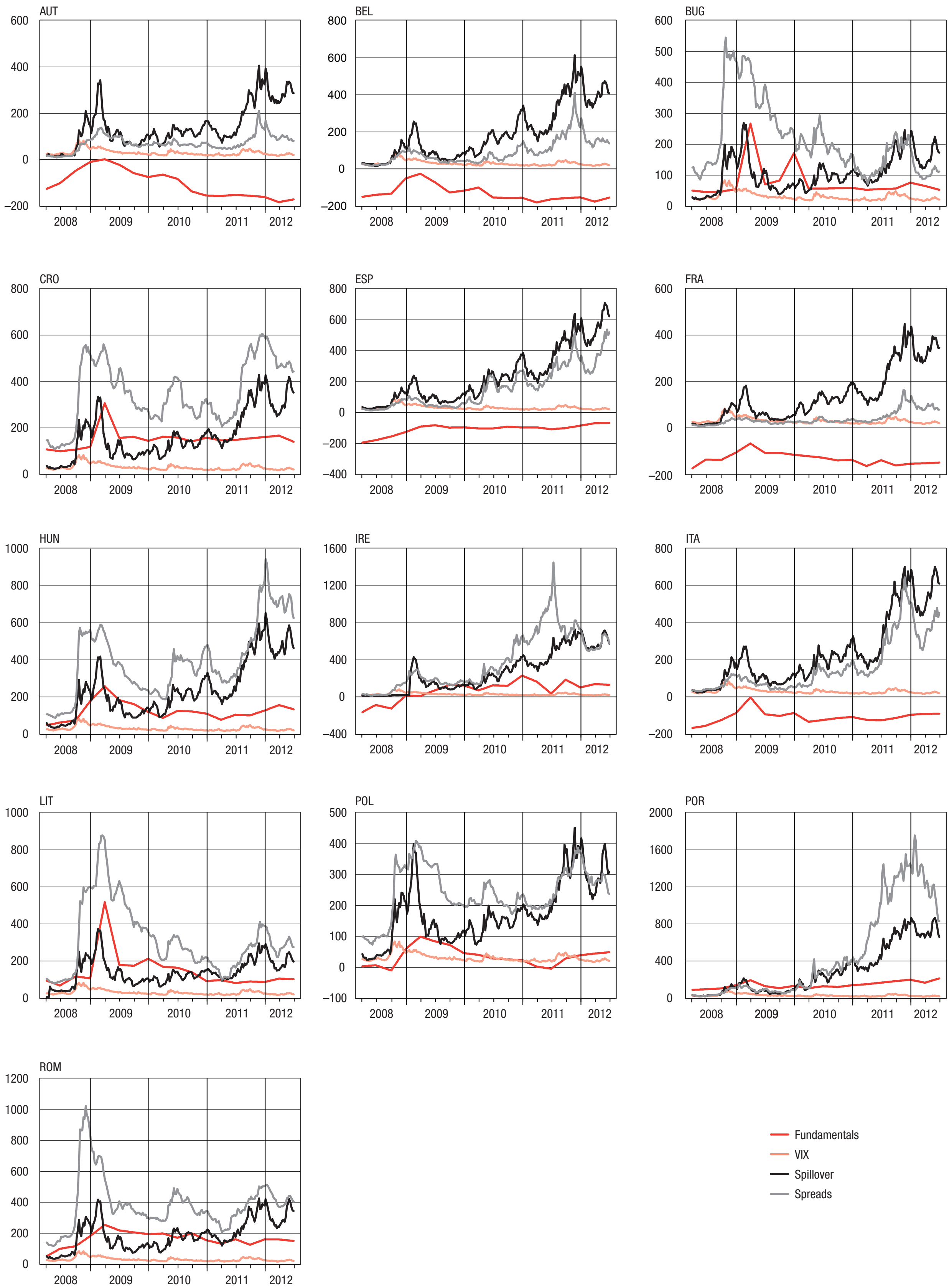
Source: Author's calculation.

5 Decomposition of the levels of bond spreads for the period from the second quarter of 2010 to the second quarter of 2012



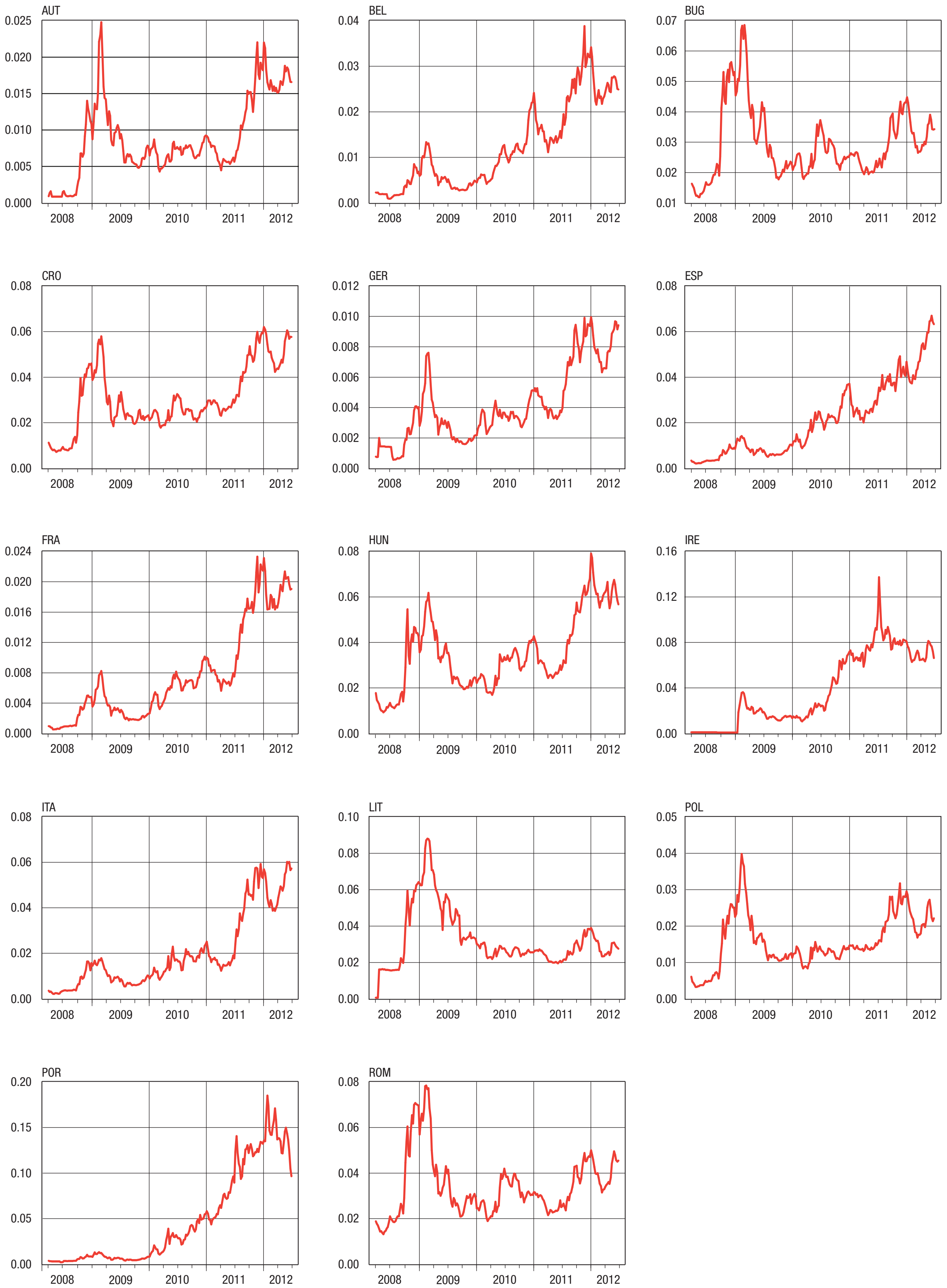
Source: Author's calculations.

6 Decomposition of the levels of bond spreads for the period from the second quarter of 2008 to the second quarter of 2012



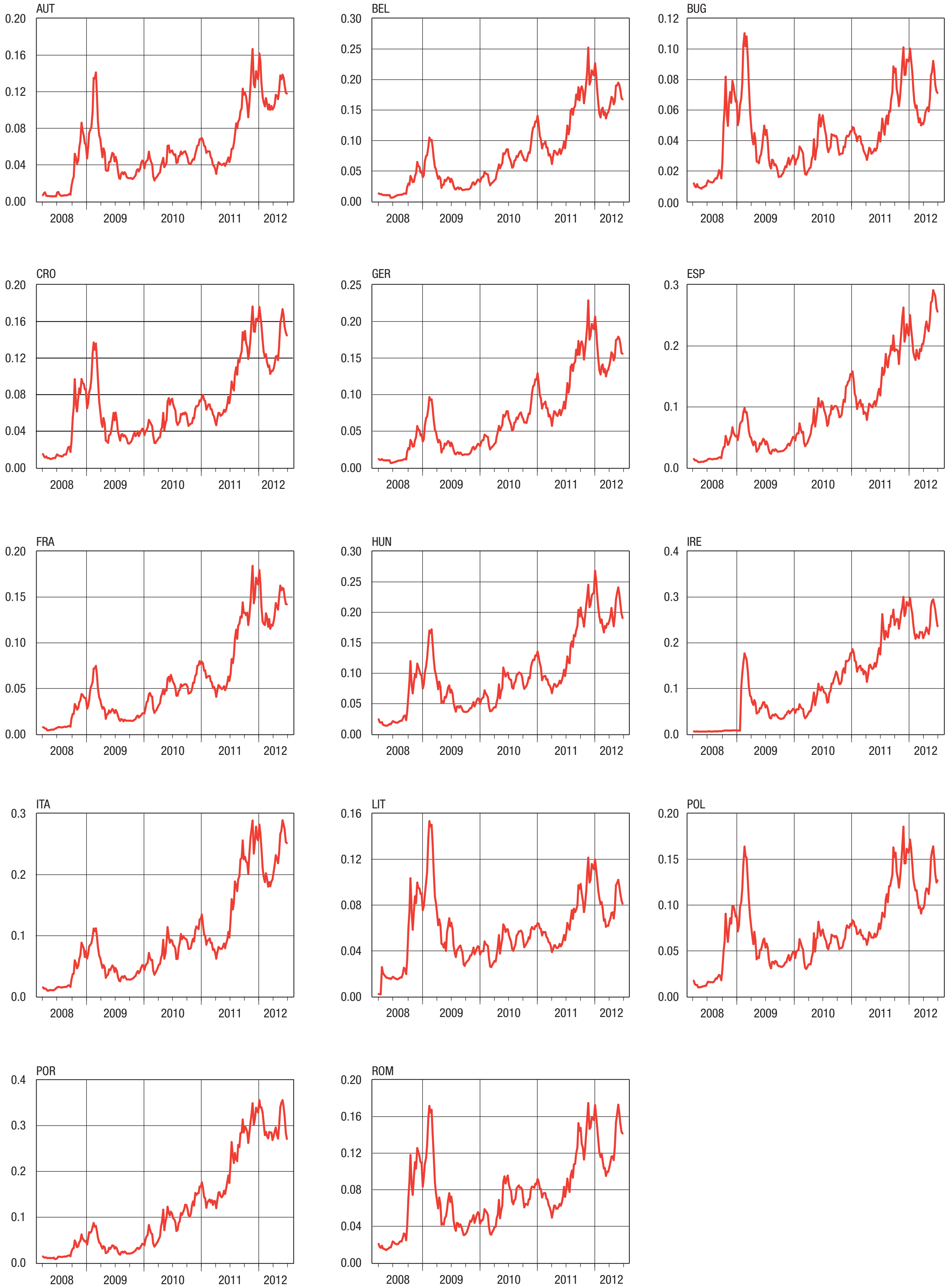
Source: Author's calculation.

7 Probability of default



Source: Author's calculation.

8 Index of spillover and financial contagion



Source: Author's calculation.

9 Sources of data

The analysis carried out is based on information drawn from several sources. The CDS spreads applied are five-year spreads, and are drawn from Bloomberg. Data concerning sovereign bonds relate to generic bonds derived from bonds issued for a period of from one to ten years. These generic bonds are calculated by Merrill Lynch, the data source is Bloomberg. Source of information about macroeconomic fundamentals is Eurostat. Finally, data about the VIX index, the indicator of risk aversion, are taken from Bloomberg.

The following Working Papers have been published:

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Additional information, such as acknowledgments, should be incorporate in the text at the end of the introductory section.

The second page should contain the abstract and the key words. The abstract is required to be explicit, descriptive, written in third person, consisting of not more than 250 words (maximum 1500 characters). The abstract should be followed by maximum 5 key words.

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References cited in the text are listed at the last page of the manuscript in the alphabetical order, according to the authors' last names. References should also include data on the publisher, city and year of publishing.

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