Measuring Sovereign Bond Spillover in Europe and the Impact of Rating News

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Abstract

Interdependence has been commonly studied for stock or exchange rate markets. The recent European sovereign deft crisis shifted interest to sovereign bond markets. Although there is by now strong evidence that sovereign risk premia are driven by a common factor, little is known about the detailed linkages between sovereign bond markets. To fill this gap, we analyse bilateral linkages between EU sovereign bond markets over time, using the forecast-error variance decompositions from a VAR with daily data since 2000 on sovereign bonds yield spreads of EU countries. This framework allows measuring the spillover from shocks to a specific sovereign bond market to other markets. Our results indicate that spillover has substantially increased since 2007. However, there is a lot of heterogeneity in the bilateral spillover sent and received between specific sovereign markets. Spillover is more important than domestic factors for all EMU countries. While the CEE countries affect each other mutually Denmark, Sweden, and the UK are insulated from the impact of other EU countries. Further, we extend the previous event-study evidence on sovereign rating news and analyze the dynamic linkages between sovereign spreads and sovereign ratings actions in our VAR framework. We find that overall effect of ratings news on sovereign risk premia is limited, which is consistent with the claim that most rating action do not come as surprise for the markets. Yet, the rating spillover is very heterogeneous; in particular, it is substantially stronger for downgrades, especially in the lower rating scale. Interestingly, the impact is often stronger on bond spreads of other sovereigns than domestically.

Keywords: spillover, contagion, sovereign bond spreads, fiscal policy, Eurozone, financial crisis, sovereign ratings.

JEL classification: G12, C14, E43, E62, G12, H62, H63.

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1. Introduction

The global financial crisis started with losses on subprime loans in some US banks but had widespread consequences as uncovered debt positions triggered the collapse of major financial institutions both in the US and Europe. Massive public aid provided to financial sector has undermines public sector balances and unleashed the feedback loop between banking and sovereign debt crisis. Rising sovereign credit risk and fiscal consolidation in turn threaten economic recovery. The sovereign debt crisis of the eurozone is so far the last chapter of the global financial crisis. It is characterized both by the cross-country dimension of fiscal trouble and its potential international spillover. In addition, the rating actions further reinforce the spillover on financial markets. As a result, the evolution of sovereign spreads and rating decisions have become headline news across Europe. The interdependence across markets has been commonly studied for stock or exchange rate markets but substantially less for (sovereign) bond markets.

The sovereign bond yield spreads are usually understood to compensate investors for an additional risk of default, transactions costs and macroeconomy-related risks. If investors are able to distinguish different sovereign bonds, the spread should (at least in long-term) depend mainly on idiosyncratic variables such as country's fiscal position, output growth, exchange-rate volatility or liquidity. However, since the introduction of the common currency the sovereign bond yields of most EMU countries substantially converged. Consequently, most empirical studies find that the overall explanatory power of idiosyncratic variables is for European sovereign bond yield spreads rather limited and suggest that conditions on international financial markets are important for explaining the dynamics of European sovereign spreads (Codogno *et al.*, 2003, Schuknecht *et al.*, 2010; Bernoth *et al.*, 2006; Sgherri and Zoli, 2009). This so-called 'common factor' reflects generalised risk aversion on international markets, and its importance has arguably increased since the start of the global financial crisis in general and of the sovereign debt crisis of eurozone in particular.[4]

The importance of global factors for domestic financial markets logically reflects the intensification of economic and financial links between different countries. Sovereign bond markets have become interconnected too. In the past, only countries with high domestic savings and developed financial systems based on bank financing could issue public bonds (IMF, 2006). The opening to international capital markets has likely blunted the rise in financing costs for governments, as governments now have access to a large pool of savings. The downside of bond market integration is that financing is much less stable, as changes on international financial market influence domestic bond markets.

Sovereigns – even in industrialised countries – can now be subject to financing crises because of spillover or contagion (Kaminsky and Reinhart, 2000, Forbes and Rigobon, 2002).[5] Foreign

[4] These exogenous factors have been always found to be decisive for the borrowing costs of governments of emerging countries (Eichengreen and Mody, 2002; Codogno et al., 2003; IMF, 2004; Calvo and Talvi, 2004).

[5] In most of this paper we use the term "spillover" rather than "contagion", which is usually understood in a narrower sense. See more below.

investors pool countries in the same group even if these do not share similar economic fundamentals. The literature on contagion has been expanding since 1990's, though it was mostly aimed at emerging rather then developed countries and analyzed stock and exchange rate markets rather than bond markets. The financial crisis shows that both industrialised and emerging markets can be subject to strong comovements. Research on sovereign bond markets shows that early in the Financial Crisis, a surge in global risk aversion (Mody, 2009) and risk of contagion (Caceres *et al.*, 2010) were a significant factor influencing European sovereign spreads. Idiosyncratic factors were mostly related to the threats that the size of the rescue packages and the position of the domestic banking sector pose for public debt (Ejsing and Lemke, 2009; Attinasi *et al.,* 2009; Gerlach *et al.,* 2010). Ang and Longstaff (2011) analyze sovereign CDS spreads for US Treasury, individual US states and major European countries finding that systemic sovereign risk has its roots in financial markets rather than in macroeconomic fundamentals.

Empirical tools typically control for this global factor with a proxy for the 'global factor', but do not detail the size and directions of the transmission channels behind the spillover in bond markets. Most of the existing literature of spillovers aims at stock markets or foreign exchange markets (Soriano and Kliment, 2006). Only a few recent studies on sovereign bond spreads have started to separate the role of global risk aversion and country specific risk, and measure the degree of spillover in the sovereign bond market. Caceres *et al.* (2010) calculate a country-specific spillover coefficient based on the joint probabilities of distress, extracted from CDS credit default swap spreads. Favero and Missale (2011) analyze the sovereign yields spreads in the eurozone to evaluate rationales for a common Eurobond. They argue that default risk is the main driver of the yield spreads but it is determined by the interaction between domestic fiscal fundamentals and other countries' risk spreads.[6]

The transmission channels behind the spillover on bond markets can be quite diverse. One particular channel is related to the rating action on sovereign debt. The sovereign rating decisions by main credit rating agencies (S&P, Moody's and Fitch) have been recently paid special attention to and the rating action taken on debt of one country are often deemed to spill over to other sovereign bond spreads. The reason is that banking regulation, collateral rules, credit default swap contracts or investment mandates force domestic and foreign investors to relocate their savings towards higher qualified bonds in response to the rating revision or adjustment (Sy, 2010). Most existing empirical research uses event-study techniques to test whether the bond returns around the date of rating change are in abnormal range. Pre-crisis consensus finding was that a rating downgrade reduces the sovereign bond spreads of other countries (Gande and Parsley, 2005), although most of this effect could have been anticipated in the bond market already (González-Rozada and Levi Yeyati, 2005). Afonso et al. (2011) extend this evidence on sovereign bond and CDS spreads of EU countries finding that significant response of bond and CDS spreads after the rating announcement, particular a negative one. They also find that spillover effects exist especially among EMU countries and from lower rated countries to higher rated countries. Arezki et al. (2011) confirm the previous findings (spillover is stronger for downgrades and for EMU countries) with

[6] Claeys *et al.* (2011) proxy linkages between bond markets by economic distance measures to derive a spatial measure of financial integration, and show that the spillover curbs around half of changes in domestic bond rates.

VAR with sovereign CDS spreads, stock market indices and banking and insurance sub-indices. Besides, they find that rating spillover effect goes beyond sovereign debt markets.

In this paper, we aim to provide new evidence on the sovereign bond spillover across EU countries by detailing the bilateral linkages between these markets over time. We study the period since 2000 when reliable daily data on sovereign bond yields are available for most EU countries. Therefore, using such extended sample in terms of time coverage and country we can study the changes that occurred after the onset of global financial crisis in general and recent European debt crisis in particular in countries both inside and outside the eurozone. The spillover measure is based on the forecast error variance decomposition of a VAR model including different asset prices (Diebold and Yilmaz, 2009, 2011). Shocks to an asset price contribute to explaining the variance in the other asset prices some periods ahead. This percentage contribution represents the spillover. We estimate a VAR including EU sovereign bond yield spreads relative to the German 10 year bond yield controlling for common factors (such as volatility or short-term market liquidity). We track the magnitude and direction of spillover between each pair of markets over time. Hence, we do not only link the sovereign bond spread to domestic events but also detail the importance of foreign factors. A particular attention is dedicated to rating announcements. We analyze the dynamics linkages between these discrete events and sovereign yield spreads. We aim to identify (i) whether the rating action spur financial instability or if the rating "news" rather come as no surprise to the markets, (ii) whether there is spillover effect of rating actions across countries and (iii) what is the differential effect of different rating actions (downgrades vs. upgrade, negative vs. positive outlook) by different rating agencies (S&P, Moody's, Fitch).

The paper is structured as follows. In section 2, we review our empirical approach to measure sovereign bond spillover based on the VAR method of Diebold and Yilmaz (2009, 2011) and the main features of the dataset. The main empirical results on spillover between sovereign bonds are discussed in section 3. In section 4, we extend our VAR model to test the spillover effect of sovereign rating news. The final section summarises the main results, and discusses some policy implications.

2. Empirical framework

2.1 Measuring sovereign bond spillover

We use the approach proposed by Diebold and Yilmaz (2009, 2011) that bases the measure of spillover on the forecast variance decomposition of a VAR model including prices of different assets (x_t). Diebold and Yilmaz (2009) start from the estimation of a covariance stationary variable VAR(p):

$$x_t = \sum_{i=1}^{p} \Phi_i x_{t-i} + \varepsilon_t \qquad (1)$$

with x_t including n variables and $\varepsilon_t \sim (0,\Sigma)$ a vector of independently and identically distributed disturbances. The VAR can be rewritten in its moving average representation:

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} \tag{2}$$

where some regularity conditions on the A_i matrices apply. The moving average coefficients are the key to understanding the dynamics of the VAR. The decomposition of the variance of the forecast error of some variable *i*, at *h* steps ahead, records how much of the variance owes to shocks in another variable included in the VAR *h* periods after the shock. Therefore, it shows the percentage contribution of a shock to one variable to the time series variation of another variable. Call θ_{ij}^h this *h*-step ahead forecast error variance decomposition, and $\lambda_{ij}^h = \theta_{ij}^h \Big/ \sum_{j=1}^{n} \theta_{ij}^h$ the percentage contribution of θ_{ij}^h in the effect of error variances in forecasting x_i due to shocks to x_j, over all n variables.

Let us define *own variance shares* to be the fractions of the *h*-step-ahead error variances in forecasting x_i due to shocks to x_i, for i=1, 2,..,n, and *cross variance shares* to be the fractions of the *h*-step-ahead error variances in forecasting x_i due to shocks to x_j, for i, j = 1, 2,.., n, such that $i \neq j$. Diebold and Yilmaz (2009) suggest using these cross variance shares to measure the spillover from one series x_i to another x_j.

As the variance decomposition depends on the ordering of variables in the VAR, Diebold and Yilmaz (2011) adopt the generalized VAR or GVAR framework of Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998). In contrast to the Cholesky identification of the VAR model, which attempts to orthogonalize shocks, under the generalized approach shocks may be correlated but this is accounted for by using the historically observed distribution of the shocks. As a consequence, GVAR estimates are invariant to ordering.

Using the forecast decomposition of this GVAR, *the total spillover* index measures the contribution of spillover of shocks between all variables included in the VAR to the total forecast error variance. The total spillover TS^h is nothing else than the sum of the cross variance shares across all variables (at a certain forecast horizon h). When we express it as a ratio to the total forecast error variation, we get the total spillover index, i.e.:

$$TS^h = 100. \sum_{i \neq j}^{n} \lambda_{ij}^h \Big/ \sum_{i,j=1}^{n} \lambda_{ij}^h \tag{3}$$

The method permits calculating the direction of spillover. A market *i* receives a spillover from all other *n-1* markets, and this *directional spillover* DS^h can be expressed as follows:

$$DS_{\rightarrow i}^h = 100. \sum_{j \neq i}^{n} \lambda_{ij}^h \Big/ \sum_{i,j=1}^{n} \lambda_{ij}^h \tag{4}$$

Similarly, we can measure the spillover a market *i* transmits to all other *n-1* markets by

$$DS_{\leftarrow i}^h = 100. \sum_{j \neq i}^{n} \lambda_{ji}^h \Big/ \sum_{i,j=1}^{n} \lambda_{ji}^h \tag{5}$$

The directional spillover details how much of the total spillover comes from, or goes to, a particular source. The net spillover from a market *i* to all other markets *j* is then the difference between the gross shock received from and sent to all other markets, i.e. $NS^h = DS_{\rightarrow i}^h - DS_{\leftarrow i}^h$. This measures

how much each variable *i* contributes to all other *n-1* markets on net. It is also possible to calculate then *the net pairwise spillover* that shows how much each market *i* contributes to another market *j* in net terms. For this, we need to obtain:

$$NS^{h}_{i\leftrightarrow j} = 100.\left[\lambda^{h}_{ij} \Big/ \sum_{k=1}^{n} \lambda^{h}_{ik} - \lambda^{h}_{ji} \Big/ \sum_{k=1}^{n} \lambda^{h}_{jk} \right] \qquad (6)$$

The spillover index is *a measure of interdependence* between financial markets. The approach of Diebold-Yilmaz (2009, 2011) improves over partial equilibrium approaches as it measures transmission from one market to another. I.e. it provides an index number between 0 and 100 that reflects the contribution of a shock originating in one market and flowing to another. The index is therefore not a simple measure of co-movement of markets that reflects a similar response to a common shock, but measures the importance of an idiosyncratic shock in a market onto other markets, which is in line with Forbes and Rigobon (2002).[7]

Although the approach measures spillover, it does not allow identifying its reason. In particular, it sidesteps the controversial issue of contagion. The "true" contagion is usually distinguished from other market co-movements either by its transmission mechanism or by its size. Kaminsky and Reinhart (2000) stick to the first approach, which defines contagion as a co-movement between markets that cannot be tracked back to fundamental linkage between the two markets (via trade or finance). Forbes and Rigobon (2002) rely on the latter and argue that contagion shall be understood as a significant increase in cross-market linkages after a shock to one country a sudden increase of co-movement between two assets unconditional on the market volatility while a conditional correlation shall be rather tilted interdependence. We rely on FEVD from VAR rather then any kind of contemporaneous correlation, it which is more intuitive in terms of spillover direction. Still, the spillover can either reflect the co-movement of fundamentals or be due to contagion. We believe that most spillovers occur because of the latter as we use high-frequency (daily) data, whose dynamics cannot by its nature being affected by developments of macroeconomic fundamentals nor by the news related to these fundamentals, which have also smaller (monthly, quarterly) frequency.

However, in case of sovereign bond markets there is another thorny issue, which is the presence of common factors. This issue is very relevant for European sovereign debt markets, which are very integrated, and numerous evidence ((Codogno *et al.*, 2003, Schuknecht *et al.*, 2010; Bernoth *et al.*, 2006; Sgherri and Zoli, 2009)) suggest that big chunk of the spread variability of individual countries is driven by these common factors. The approach of Diebold and Yilmaz (2009) in principle distinguished between *own variance shares* and *cross variance shares* of the error variance, with the later indicating spillover. The latter part includes for market *i* both billateral spillovers *vis-à-vis all other markets j* as well as *vis-à-vis common factors F*. To address the issue we extend the VAR approach of Diebold and Yilmaz (2009, 2011) towards factor-augmented VAR (FAVAR). Following Bernanke et al. (2005) we use two step strategy. . In the first step, we use factor analysis to extract the common factors that (arguably) drive significant part of the yield

[7] In contrast to approaches measuring the effect of a benchmark external factor, the method reflects that prices move contemporaneously on different financial markets, and this spillover is stronger between markets that are more closely connected. If spillover between markets is relevant, then this will affect all neighbouring markets in general equilibrium.

spreads of EU countries. In the second step, we estimate VAR that besides the original n variables x_t contains additional k factors Fi.

The factor model assumes that for individual i, the observable multivariate k-vector is generated by:

$$X_i - \mu = LF_i + \varepsilon_i \quad (7)$$

where μ is a $k \times 1$ vector of variable means, L is $k \times m$ matrix of coefficients, F_i is a $m \times 1$ vector of unobservable variables or *common factors* and ε_i represent a vector of error terms or *unique factors*. Therefore, the idea is to express p observable variables in terms of m unobservable common factors and k unobservable unique factors. The matrix L represents the factor loadings linking unobserved common factors to observed data. The model can be estimated after additional moment and covariance restrictions are being imposed. We impose the common assumption that factors are orthogonal and use minimum average parcial (MAP) method to determine the number of factors. The principal factor method is used to estimate the factor loadings.

Overall, this approach allows us to study the general spillover between sovereign bond markets, and dissect the strength and direction of the spillover between any two markets, when common factors are controlled for. In particular, we can compute the percentage contribution of a change in daily quoted government bond prices on the variation in sovereign bond prices of each particular market as well as common factors included in the VAR model.

2.2 Measuring the impact and spillover of sovereign rating news

Research on the role of the sovereign rating action has typically applied event studies to test whether rating decisions have an impact on returns, or just reflect market wisdom. The event study compares abnormal differences in returns at selected time horizons before and after the time rating news is made public. In particular, it is tested whether there is some abnormal difference between the model-predicted and actual changes in the yield spreads, commonly by using rating dummies. Different types of rating news, like upgrades versus downgrades, outlook revisions or a combination of both, are usually having different effects on the yield spread (Gande and Parsley, 2005, González-Rozada and Levi Yeyati, 2005, Afonso *et al*. (2011). However, the dynamic relationship between spreads and rating news can be more complex: (i) the relationship can be two-sided given that sovereign risk premia as embedded in bond yield spreads might trigger rating decision but the latter can in turn affect the sovereign risk premia, (ii) the horizon of the impact is rather uncertain, (iii) rating action taken on one sovereign borrower can affect risk premia of others and vice-versa.

To deal with the previous points, we further extend the previous analysis and include a dummy for rating adjustments similarly as Arezki et al. (2011). In comparison to previous studies on the impact of ratings, our approach separates the 'usual' spillover on bond markets from the impact of rating news on bond spreads. Not only does the model allow examining the impact of ratings. In addition, we can examine if spillover on sovereign markets is related to actions by the 'Big 3' agencies, or is just reflecting financial integration.

2.3 Specification

The basic (FA)VAR model contains two lags of the domestic bond spread of 16 EU countries versus the German long-term bond yield as well as two lags of common factors obtained in the first step. Assuming that the factors are truly common to all EU countries implies using the same factors for all the countries. However, this represent a certain problem for the FAVAR analysis as our factors will not be independent of the other variables in the VAR. To be specific, in an equation for a bond spread of particular country *i*, the factor was extracted using data from all *n* countries including *i.* Though, given that each country loading represents relatively small share of the overall loading set, we believe that the issue is not material. In addition, we include the factors as endogenous variable.

We compute the forecast error variance decomposition at a horizon of 10 days (one week and a half) which should be sufficient to capture the horizon at which spillover across markets occurs. The VAR is complemented by two control variable, which track the factors that have common effect on yields spreads, in particular monetary policy and liquidity conditions (EONIA) and overall market sentiment (VIX). These variables are assumed to be exogenous.

We then track the effect on the sovereign rates following a 'dummy shock', as in (7) where z_t include the bond yields spreads x_t as in (1) as well as the dummy for rating news:

$$z_t = \sum_{i=1}^{p} \Phi_i z_{t-i} + \varepsilon_t \qquad (8)$$

These dummies corresponding to the dates for the rating changes and we use both (i) *a step-dummy* where each rating category is assigned a particular numerical values on selected scale of all countries (going from a maximum of AAA to a minimum of D as in Arezki *et al.* (2011), or (ii) *an impulse dummy* as in Romer and Romer (2011) at the day of the rating/outlook change. We moreover examine (i) the differential effect of *rating downgrades and upgrades*, (ii) the effect of *changes in the revision outlook* (negative vs. positive), (iii) the differential effect of *rating action of each rating agency* (S&P, Moody's, Fitch), and (iv) the differential effect of *rating actions related to single sovereigns*. The variety of ways to tract the rating actions is related to the fact that it is not obvious what event represents the proper rating news and possibly trigger or is triggered by sovereign yield spread dynamics.

2.4 Dataset

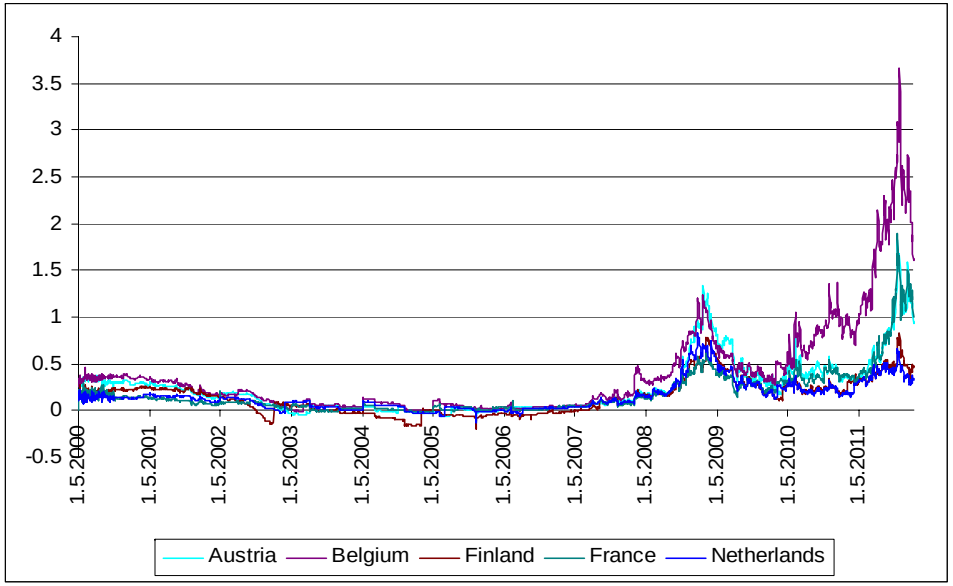
We use daily data on 10-year sovereign bond yield spreads of 16 EU countries over the corresponding German bond yield over the period May 2000 up to February 2012 (closing price).[8]

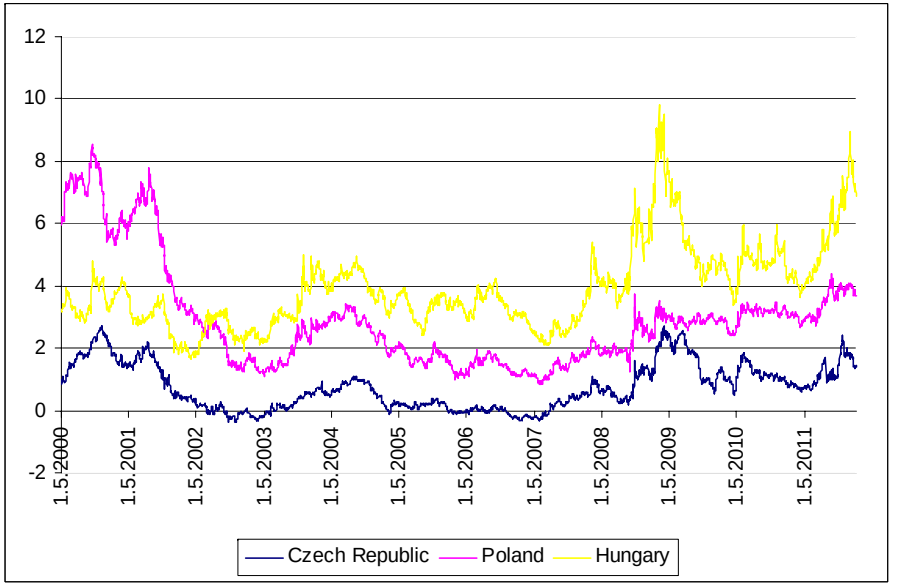
[8] The sample size is driven by the data availability. Therefore, some countries such as Luxembourg could not be included. For most of the CEE, the bond yield quotations are available only for a few last years. Therefore, they could not be included to the sample either. Due to availability reasons we also disregard to use sovereign CDS quotations. In particular, these products became popular only on the onset of the crisis around 2007 and their market is still rather limited for some sovereigns, e.g. the CEE. In addition, the recent developments regarding Greek debt crisis resolution cast some doubt about the viability of these products.

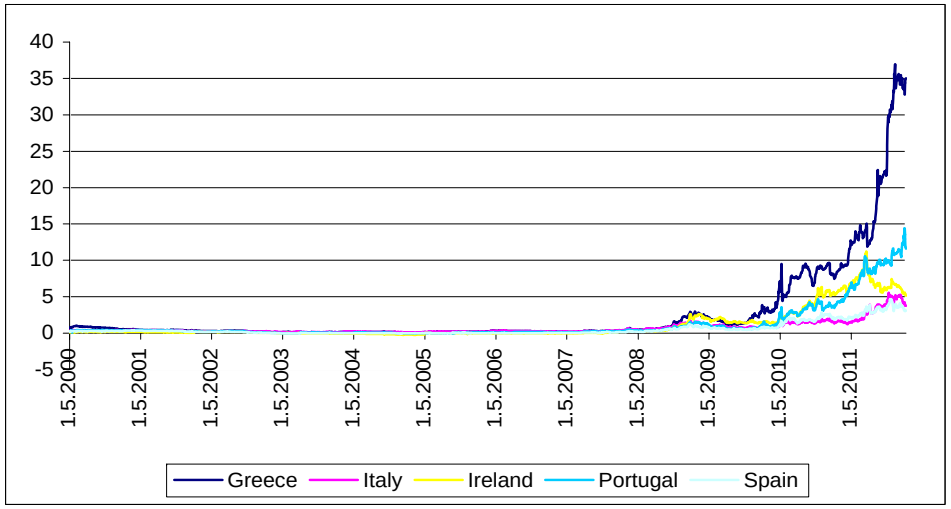
Figure 1 shows the spreads for 4 different groups of countries: a core EMU where spreads are moderate but have nonetheless risen a lot since the start of the Financial, and then again the Fiscal Crisis (Austria, Belgium, France, Finland, Netherlands), the PIIGS countries where spreads have boomed (Portugal, Ireland, Italy, Greece and Spain), the CEE countries (Czech Republic, Hungary, Poland) and the non-EMU countries (Denmark, the UK and Sweden). The selection of the benchmark 'risk-free rate' can slightly distort the results if there is a 'flight to quality' towards the 'safe haven' German bonds. This problem is in our case at least partially mitigated as this flight affects the spreads for all countries in the same way, and we measure spillover by the contribution of a shock to one country's spread to forecast-error of another rather than looking at contemporaneous correlation that can arguably increase with common change in 'risk-free rate' occur. Additional control variables in the VAR include short-term interest rate (EONIA) to control for effect of monetary policy, and the Chicago Board Options Exchange index of implied volatility (VIX) to control for overall market sentiment. The main source for the data are *Thomson Reuters Datastream*.

The sovereign ratings are local currency long-term debt for each country from the main credit rating agencies (S&P, Moody's, Fitch). As noted before, there are different possible ways to create variable tracking the rating actions. Figure 2 demonstates this. Panel a) tracks the overall evolution of sovereign ratings in EU countries (by rating agency) over the last decade using the step-dummy. In this case each rating category is assigned a numerical value (from AAA – 1, to CCC – 17) and these values are simply summed up across countries. Panel b) draws an impulse dummy at the date when rating action (by each rating agency) was taken. Panel c) further distinguishes the downgrades (positive value) and upgrades (negative value) and at the same time demonstrates that rating actions (on different sovereigns), notably downgrades are often clustered within a single day. Finally, Panel d) is the same as panel c) but rather then rating changes the changes in rating outlook are recorded, which might arguably indicate rating action ex-ante and as such might represent the unique news.

Figure 1. Bond spreads on German 10 year bond yield.







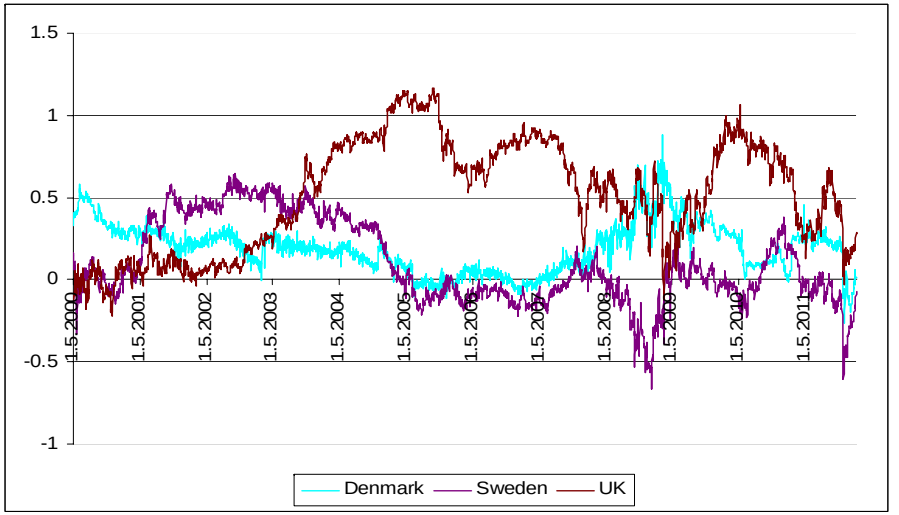
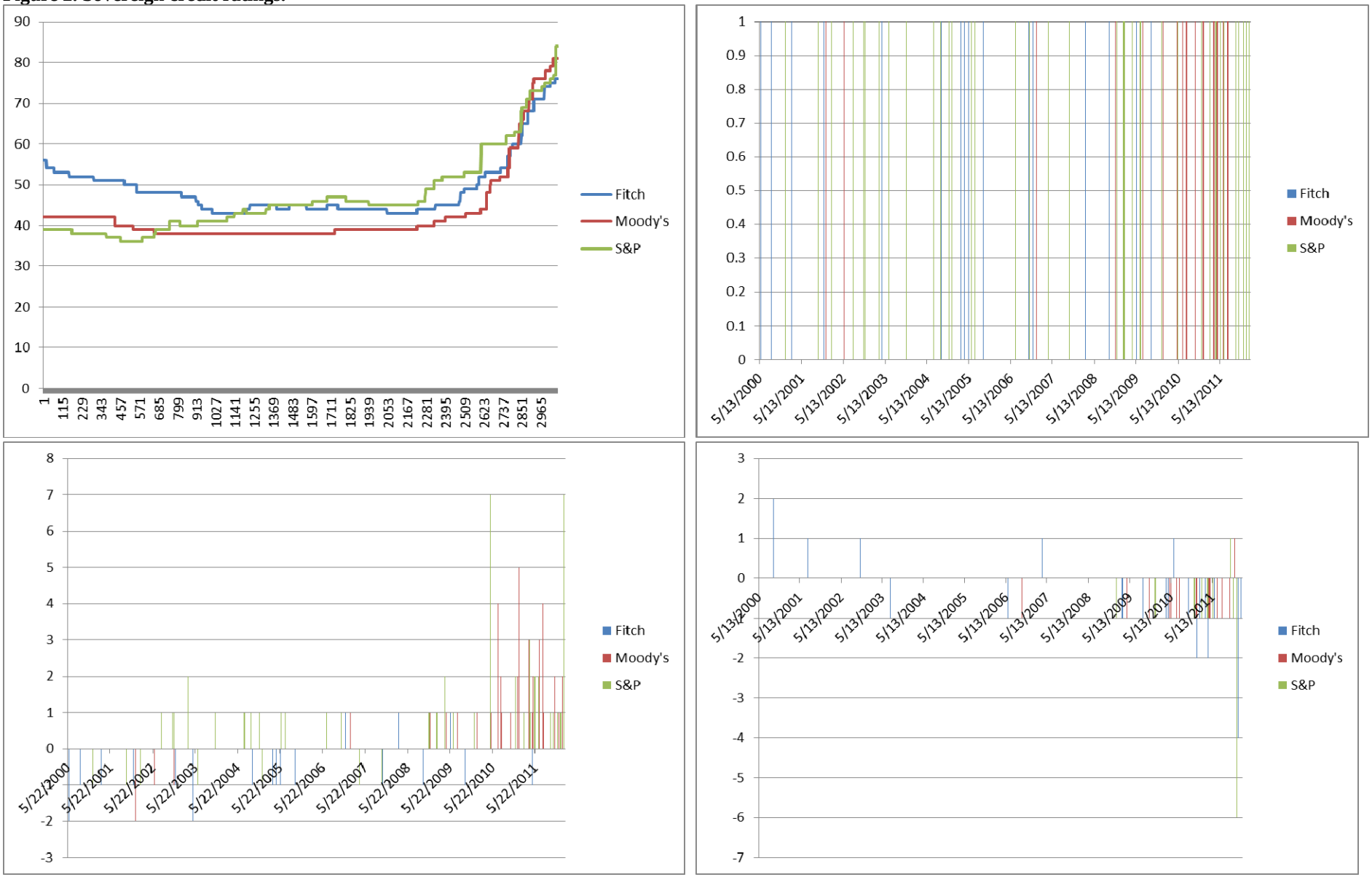


Figure 2. Sovereign credit ratings.



3. Sovereign bond yield spillover in Europe

3.1 Common factors in European sovereign spreads

The results of factor analysis using 16 EU sovereign yield spreads (vis-à-vis Germany) are available in Table 1. The factors are constructed as orthogonal and minimum average parcial (MAP) method was used to determine the number of factors. The principal factor method is in turn used to estimate the factor loadings. While three factors have been selected, results how that the first principal factor is able to explain over 70 % of the variance. The first factor loadings suggest that most of the commonality share countries of eurozone, which loading are close to unity. On the contrary, the non-EMU countries have loadings substantially lower, reaching even negative value in case of Sweden and the UK. The second's and third's factor to explain the variance is substantially more limited. In addition, their loadings do not seem to have any logical interpretation.[9] This might be related to the fact that eurozone commonalities are well tracked by the first factor and non-EMU countries represent rather heterogeneous group. The second and third factors feature loadings with both positive and negative sign with no logical pattern. The time evolution of the three factors is drawn in Figure 3. The evolution of all three factors is very smooth until the financial crisis onset in 2008, which holds especially for the first factor. The first factor reaches a spike in late 2008 and early 2009 as the global financial crisis hit the EU and there was a significant increase of yield spreads, notably in eurozone. The second spike appears at in late 2011 during the mot acute phase of the debt crisis. The second factor reaches the peak in late 2008 and early 2009 alike the first factor and since then its value declines steadily. The third factor reaches its minimum in 2008/09 inversely to the former two and since then steadily increases.

Alternative methods were used to determine the number of factor and estimate the factor loadings were just as robustness check providing almost entirely similar result. The previous factor analysis assumes that the factor loading do not change across time, which can be a rather restrictive assumption in face of significant turbulent changes that occurred in European sovereign debt markets. Consequently, we performed the factor analysis on two subsamples with different cutting date along years 2009 -2011. Although the results pointed to some differences between the two periods, the first factor were consistently explaining at least 65 % of the variance and its factor loadings did not change notably. On the other hand, the loading and time evolution of the other factors varied. Consequently, we consider the first factor as the reliable measure of common factor in European sovereign spreads. In addition, consistently with Bernanke et al. (2005) we test the sensitivity of the results when other two factors are included.

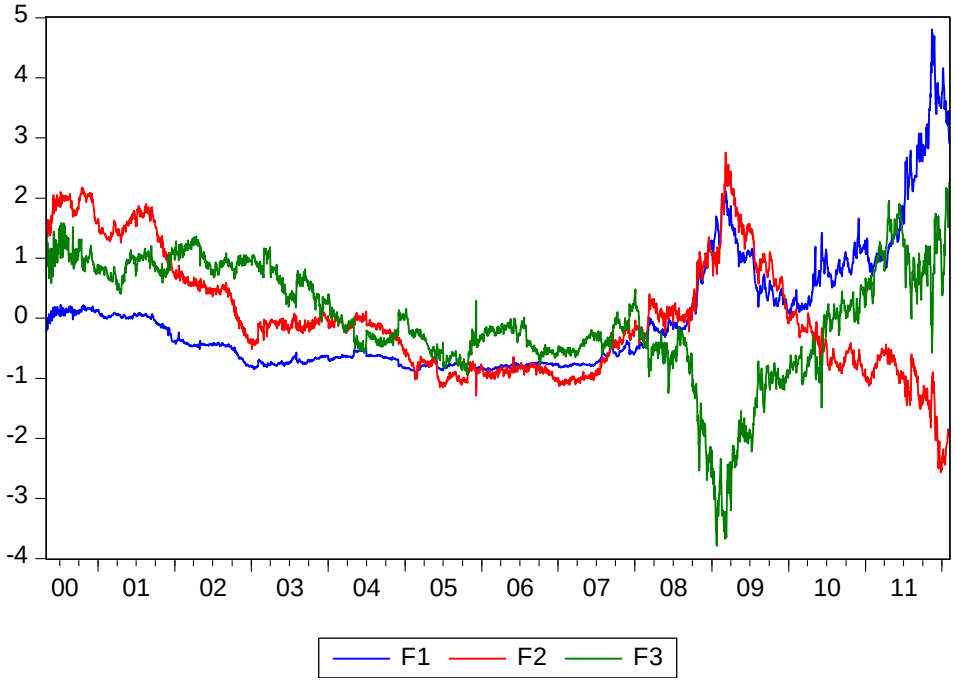
[9] The use of limited number of series from which the factors are extracted as well as the fact that all the series are represent the same variable (sovereign bond yield) simplifies the interpretation of the extracted factors.

Table 1. Factor loadings

	Unrotated Loadings		
	Factor 1	**Factor 2**	**Factor 3**
AUT	0.94	0.18	-0.15
BEL	0.97	-0.14	0.08
CZR	0.64	0.58	-0.08
DNK	0.29	0.79	-0.11
ESP	0.92	-0.28	0.17
FIN	0.87	0.37	-0.12
FRA	0.96	-0.11	0.00
GBR	0.26	-0.64	-0.47
GRC	0.86	-0.39	0.24
HUN	0.75	0.06	-0.45
IRE	0.85	-0.29	0.15
ITA	0.95	-0.28	0.07
NLD	0.84	0.29	-0.32
POL	0.33	0.66	0.37
PRT	0.88	-0.37	0.25
SWE	0.37	0.21	0.44

Factor	**Variance**	**Cumulative**	**Difference**
F1	9.60	9.60	6.92
F2	2.68	12.28	1.58
F3	1.10	13.38	---
Total	13.38	35.25	

Figure 3. Time evolution of factors



3.2 Spillover and linkages across markets

We first look at the spillover between all 16 EU sovereign bond markets. Table 1 reports the contribution of a shock to bond spreads on other markets. Each entry of the table displays the coefficient λ_{AB}: the column for each country A can be read as the contribution from a shock to the bond spread in that market to bond spreads in other markets. The entry (A,A) is the percentage contribution of a shock in explaining the movement of the domestic bond spread. The row for each country B can be read as the spillover market B receives from a shock to the spreads in other markets. The two bottom rows of the table sum the effect of shocks to market A on all others (either including the own effect or not). The right hand column sums the effect country B receives from all other markets. In addition, we include the first factor of the spreads yields representing the common effect. The column/row of the common factor represents again the spillover the common fact send to /receives from individual bond markets.[10]

Table 1 summarises this directional spillover for the full sample May 2000- October 2011. It captures the linkages on financial markets and shows the structure and intensity of the degree of spillover between different sovereign bond markets as well as spillovers between individual bond markets and common factors. The total spillover amounts to 58,7 %, meaning that more than half of the variation in sovereign bond spreads can be explained by shocks to bond spreads in other countries. Only 44% of all movements are caused by purely domestic factor, i.e. idiosyncratic dynamics of the spread in the past. This in line with what other studies find: a major part of the bond spreads are not determined by domestic factors but by international bond markets.[11] In particular, we distinguish between effect of (i) *common factor of European debt markets* (tracked by estimated 1. factor from factor analysis) and (ii) *individual bond markets of other EU countries* (tracked by yield spreads of remaining 15 EU countries). In contrast to previous studies, our result is not derived from a partial equilibrium assumption, in which global conditions cause domestic changes, but if fully accounts for the feedback of domestic markets to international markets.

This total spillover is an aggregate of all spillover between different markets, and does not reflect the large variety of spillover effects between bond markets. We can observe from the bilateral entries in Table 1 that the country-specific effect of spillover is not alike for each country. For non-EMU members (Denmark, Sweden and the UK) the domestic factor accounts for over two-thirds of the changes in the bond spread, and for the CEE (the Czech Republic, Hungary, Poland) it is around one half, but the idiosyncratic change amounts to just one fourth for the EMU countries (with slightly higher share for Greece, Portugal and Ireland). Hence, EMU bond markets are strongly integrated and shocks to spreads mostly affect other markets, rather than being idiosyncratic.

The previous is also apparent from the spillovers between individual bond markets and the European common factor. The strongest spillover exists for EMU countries. The main spillovers to

[10] VIX and EONIA are included in the VAR as exogeneous variables (therefore, FEVD are not available) to control for commonalities related to overall market sentiment and short-term liquidity conditions / monetary policy. If we consider these variables as endogeneous, which might be plausible for EONIA, the picture does not change significantly.
[11] Claeys *et al.* (2011) find that about 60% of a change in long term interest rates spills over across markets.

the common factor originate in Belgium, Italy and Spain. On the contrary, the main receivers are Austria, Finland, France and the Netherlands. This can be of course likely related to the factor construction when the former and latter countries have higher factor loadings. Interesting, if this common factor is removed (see Table A.1 in Appendix), the overall picture does not change much. The main difference is that the total spillover decreases given as own variable shares (i.e. the diagonal elements) increase. Therefore, omitting the presence of the European common factor might cause upper bias in case of own variance shares (and at the same time lower bias for cross-variance shares. Interestingly, it seems to be hold for practically all countries, even though for non-EMU whose factor loadings in the factor were small or even negative. This corroborates on the importance to take into account the common factor.[12]

The most interesting part are the bilateral linkages between individual bond markets. Although we prefer to use the term *spillover* rather than *contagion*, which has in this literature very specific meaning, we believe that big chunk of this spillover is of contagious nature, i.e. its effect of one market on another once all common effects are removed. Still we prefer the term spillover as we neither address the issue of *fundaments correlation* nor whether *the effect is of abnormal size*.

These bilateral linkages between countries are quite distinct between non-EMU, CEE and EMU countries. For the non-EMU countries, bilateral linkages both among them and with the other EU countries are weak. Less than 15% of the shocks to bond spreads to these three countries spills over to other markets. The most extreme case is the UK whose sovereign borrowing cost does not seem to have any effect on the other EU countries at all. The same applies to the spillover the non-EMU countries receive. The three countries are relatively insulated from bond markets in the Eurozone. Nonetheless, Denmark or Sweden are substantially more linked to the EMU because of strong trade linkage to the core eurozone countries (Denmark also through participation in ERM2). A similar explanation holds for the CEE whose effects on other markets are rather limited, although their bilateral linkages are strong. About one third of all the spillover to other markets only occurs between the Czech Republic, Hungary and Poland themselves. Despite its economic proximity and the importance of its banking sector, Austrian bond prices do not affect by much the CEE spillover nor are they influenced very much by the CEE bond markets.[13]

[12] Alternative way to take the common factor into account is to de-factorize the spread series for each country, i.e. subtract the common factor. The remaining spread can be interpreted as idiosyncratic risk premium of each country. The analysis with defactorized series (see Table A.2 in Appendix) confirms the previous results. Though, in this case one must be cautious with the result interpretation. While the bilateral spillover do not change substantially, main difference can be found on the diagonal representing own variance shares. In particular, the group of main spillover transmitters shifts from Belgium, Spain and Italy towards the core-EMU countries: Finland, the Netherlands and France. Moreover, the importance of non-EMU countries (Denmark, Sweden and the UK) on the spillover transmission increases substantially. This seems to document the fact that, on the one hand, the core-EMU countries are important as they drive the common factor (which is not present here but the importance of these countries is reflected in the factor loadings in Table 1.). On the other hand, the non-EMU countries represent the shocks unrelated to core-EMU developments.

[13] For the group of CEEs, Ebner (2009) and Alexopoulous et al. (2009) confirm the dominance of global factors for sovereign yield determination, especially during crisis periods. Babecký et al. (2010) find that the Financial Crisis caused only temporary divergence of the Czech vis à vis the Eurozone bond market. Bubák et al. (2011) look at volatility spillover in CEE stock markets confirming increased shock transmission during periods of market uncertainty but also that Czech and Polish currencies that float freely are subject to more volatility spillovers than the Hungarian forint, whose exchange rate is being managed.

Within the EMU we can according to the bilateral spillover identify three groups of countries: (i) a core of EMU countries: Austria, Finland, France and the Netherlands, where domestic factors (see the main diagonal) are of very minor importance, the countries effect each other and are also very strongly affected by the common factor, (ii) Belgium, Italy and Spain (though Belgium could be also listed in the former group), where domestic factor are again subdued in favour of mutual bilateral effects as well as the effect of common factor and (iii) Portugal, Ireland and Greece, where domestic dynamics is slightly more importance and the common factor slightly less..

The Belgian, Italian and Spanish bond market seem to represent a systemic link on European bond markets. Italy and Spain logically stands out due to its relatively higher levels of public debt but mainly due to size of their bond markets. The importance of Belgium can come a bit as surprise but the country also suffers from high public debt and also has (had) an internationally exposed banking system. At the same time, Belgium economically rather belongs to the core EMU countries, and despite a high public debt it pays a subdued credit risk. This makes Belgium actually the country with the most open bond market in Europe: it is both the biggest receiver of shocks abroad as well as the country that affects (in relative terms) most the other EU countries. Italy and Spain come in relative terms as second and third most relevant countries. Both the negative value of net spillover that is the difference between spillover *transmitted to other* and spillover *received from others* demonstrates the importance of these countries. On the opposite side, the figures for non-EMU countries demonstrate how separated these countries are.[14]

[14] As a robustness check we included VIX (tracking the market sentiment (tracked by VIX) and EONIA (tracking the short-term liquidity conditions) as endogeneous variables. We find that market sentiment has strongest spillover effect on sovereign bond spreads of three CE countries. This seems consistent with the notion that emerging countries are much more vulnerable to overall risk aversion on the market. The spillover to PIIGS is rather small, which can seem a bit surprising. Yet, during most of the time of EMU exisntece, the yield spreads of these countries moved closely together with other EU countries as the market did not perceive these sovereign being exceptionally risky. The spillovers between individual bond markets and EONIA, which represent the short-term liquidity conditions as well as monetary policy, is rather limited. The most notable finding is that the strongest, albeit relatively small spillover from EONIA appear in case of Sweden.

Table 1. Spillover table, full sample (May 2000- February 2012)

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	From Others
CZE	52.52	7.51	6.65	2.51	0.52	0.74	1.65	2.74	3.48	4.01	0.80	0.83	1.94	4.04	0.91	0.03	9.14	47.48
POL	6.94	61.17	6.38	1.10	0.21	0.22	0.77	1.78	2.44	2.97	1.09	1.12	1.95	5.32	0.79	0.02	5.74	38.83
HUN	6.86	8.79	54.43	2.35	0.46	0.42	0.63	3.00	2.99	3.60	1.66	1.30	3.10	3.60	0.09	0.06	6.68	45.57
AUT	1.69	1.54	2.56	21.79	3.83	6.49	9.60	11.01	7.44	9.18	2.00	1.50	3.72	0.39	0.09	0.08	17.09	78.21
FIN	1.53	0.96	0.79	8.52	26.30	10.77	8.83	7.96	4.45	5.05	1.38	1.38	3.59	0.87	0.41	0.60	16.62	73.70
NLD	1.60	0.84	1.61	7.77	8.39	25.56	8.39	7.68	5.44	5.29	1.59	2.30	4.36	1.35	0.47	0.97	16.39	74.44
FRA	1.54	1.33	1.54	9.58	3.84	6.54	18.97	11.77	8.16	11.49	2.33	1.36	3.27	0.98	0.28	0.25	16.79	81.03
BEL	1.67	1.41		7.12	2.56	4.51	8.10	20.94	13.34	13.60	1.89	2.28	5.65	0.22	0.14	0.07	14.74	79.06
ESP	1.36	1.04	1.15	5.24	1.43	3.45	6.40	10.64	27.19	14.85	2.93	3.61	7.79	0.13	0.13	0.27	12.39	72.81
ITA	1.75	1.39	1.39	3.93	1.27	2.62	4.25	12.33	17.65	26.29	3.02	3.68	6.67	0.18	0.06	0.07	13.46	73.71
GRC	1.12	0.79	0.76	2.59	1.56	1.89	4.81	9.29	9.69	7.78	35.52	6.04	9.02	0.01	0.01	0.11	9.02	64.48
PRT	0.79	0.67	0.98	2.19	0.27	0.82	1.30	8.52	10.00	6.53	5.93	37.73	16.43	0.01	0.15	0.03	7.63	62.27
IRE	1.07	0.79	1.00	3.23	1.78	2.44	3.69	7.79	9.77	4.99	5.33	10.31	38.32	0.01	0.05	0.03	9.41	61.68
DNK	3.99	4.13	4.75	1.25	2.20	2.26	2.25	0.56	0.24	0.32	0.30	0.23	0.33	64.17	5.24	0.18	7.60	35.83
SWE	1.25	1.01	0.56	0.15	0.58	0.84	0.38	0.23	0.46	0.31	0.04	0.13	0.09	4.70	87.21	0.63	1.44	12.79
GBR	0.20	0.15	0.14	0.33	0.83	1.89	0.53	0.25	1.97	0.84	0.30	0.92	0.80	0.13	1.14	87.63	1.94	12.37
FACTOR	3.15	2.27	2.62	8.78	4.42	6.31	8.05	11.53	10.03	11.51	2.86	3.56	6.70	1.18	0.28	0.28	16.46	83.54
To others	36.51	34.60	34.64	66.65	34.14	52.20	69.64	107.09	107.54	102.33	33.43	40.57	75.39	23.11	10.23	3.67	166.07	997.82
To others (+ own)	89.03	95.76	89.07	88.44	60.44	77.76	88.61	128.03	134.73	128.61	68.96	78.30	113.72	87.28	97.43	91.30	182.53	58.7%
From others	47.48	38.83	45.57	78.21	73.70	74.44	81.03	79.06	72.81	73.71	64.48	62.27	61.68	35.83	12.79	12.37	83.54	
Net spillover	10.97	4.24	10.93	11.56	39.56	22.24	11.39	-28.03	-34.73	-28.61	31.04	21.70	-13.72	12.72	2.57	8.70	-82.53	

Share on spillover transmission	3.66	3.47	3.47	6.68	3.42	5.23	6.98	10.73	10.78	10.26	3.35	4.07	7.56	2.32	1.03	0.37		
Share on spillover absroption	4.76	3.89	4.57	7.84	7.39	7.46	8.12	7.92	7.30	7.39	6.46	6.24	6.18	3.59	1.28	1.24		
Share on overall spillover	8.42	7.36	8.04	14.52	10.81	12.69	15.10	18.66	18.07	17.64	9.81	10.31	13.74	5.91	2.31	1.61		

3.2 Time variation

The analysis based on full sample estimates might not fully uncover the change over time in all these bilateral linkages. The Financial Crisis is commonly believed to have significantly increased co-movements across asset markets, and the Fiscal Crisis starting in 2010 the co-movements across sovereign bond markets. Figure 1 shows how the spreads of all EU countries have closely moved together since early 2002, and how the PIIGS have seen a divergent move away from the German 10 year bond rate since 2010. However, as noted earlier in this literature simple visual inspection as well as simple contemporaneous correlation between spreads might give a misleading picture.

In addition, there are some econometric issues related to the full sample estimation. First, although some of our time series are non-stationary, it does not represent a major issue for our VAR estimation as the estimated coefficients (and the impulse responses or the FEVD) are still consistent, albeit less efficient (Sims XXX, Lütkepohl XXX). Second, we test the overall structural stability of the VAR. In particular, we apply Bai-Lumsdaine-Stock (1998) test on the VAR model for the central 70% part of the sample (between February 6 2002 and May 4 2010), which shows that a significant break occurs on April 20 2010 for the homoskedastic version (and the break has a very small confidence interval in that week) and August 31 2009 for the heteroskedastic version (with a wider confidence interval between July and September 2009). While the standard trimming sample discards first and last 15% observations, the results are robust to using 1/99% and 5/95% trimmming. Although the breakdate around the onset of European debt crisis seems plausible, there is still case that besides this major break, other structural breaks occurred. In fact, the stability of VAR is rejected in post-2009/2010 period testing whether all AR coefficients lie within the unit circle. To deal with this issue as well as to examine this time-variation in spillover, we follow Diebold and Yilmaz (2009) run the VAR model over a 200-day rolling window and reproduce all linkages for each pair of markets.

Figure 2 summarises the evolution of total spillover across time using rolling sample with 200-days window. We can see that the phenomenon of spillover as a measure of interdependence among markets has not been limited to periods of financial stress. Indeed, the spillover has been substantial most of the time as the index never falls below 50%. We can compare our estimate that varies between 50 and 80% with Diebold and Yilmaz (2009) who estimate such (return) spillover for global stock markets (1995-2007) between 40 and 55%.[15] The total sovereign bond spillover oscillates between 55 and 70% till the end of 2007 when it significantly increase from low of 55 % to substantially higher value of 80 %. The 2001-2007 period shows a high level of spillover as most movements in bond rates were driven by the same factors We can observe some specific spikes in spillover, for example, after September 11th, the application of the Excessive Deficit Procedures to some EU countries or the revision of the Stability and Growth Pact in March 2005. The decline in overall spillover since 2006 indicates a period in which investors on bond markets started to perceive sovereign issuers as distinct.

[15] While our total sovereign bond spillover from whole sample analysis is 56%, their stock market spillover index is 35%.

The start of the Financial Crisis in mid-late 2007 raised again the co-movement of sovereign bond spreads. The spillover index shoots up to 75 % and it has remained at this high level with peaks of 80 % until the end of the sample (February 2012). We observe how the spillover peaks at the height of the Financial Crisis in 2008, when the crisis continues on financial markets in 2009 and as the eurozone sovereign debt crisis unfolds during Spring 2010. In order to better perceive the fluctuations since the Financial Crisis, Figure 3 shows a close up image of Figure 2 starting I January 2008. We can discern the consequence of some major events on the co-movement of bond spreads, like:

A. the collapse of Lehman Brothers (September 2008);
B. the bankruptcy of Dubai World (November 2009);
C. the fiscal trouble of Greece (May 2010);
D. the set up of the European Stability Mechanism (February 2011);
E. the spread of the Fiscal Crisis to Spain and Italy (June 2011), and the measures adopted in August and September 2011 by the ECB.

Figure 2. Total spillover plot, 200-day window, 10 steps ahead forecast, full sample (May 2000- February 2012).

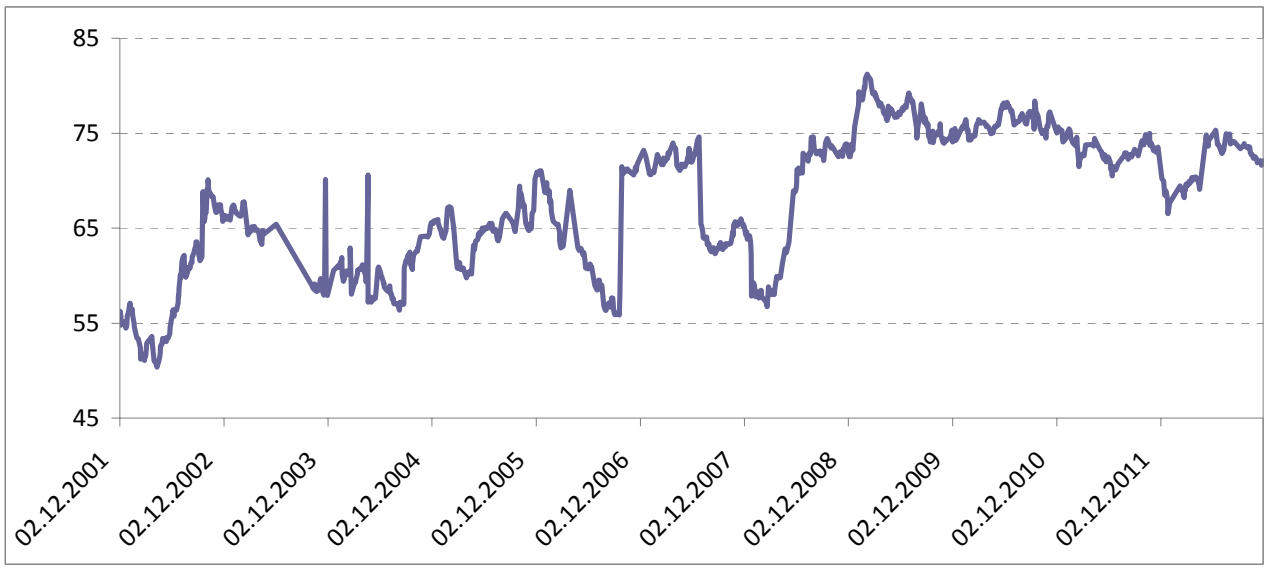


Figure 3. Total spillover plot, 200-day window, 10 steps ahead forecast, sample 2008-2011

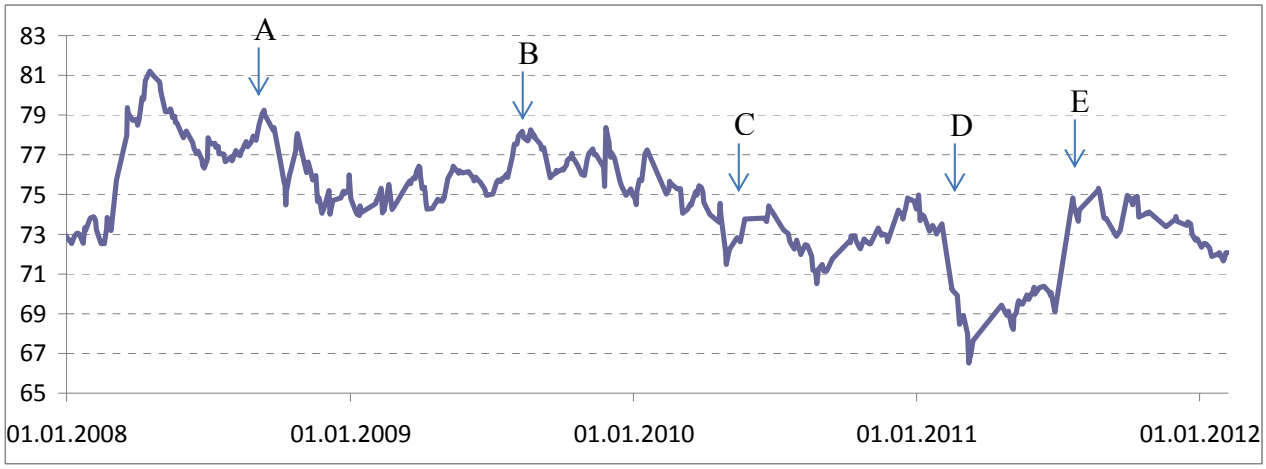


Table 1. revealed substantial differences across countries in terms of their importance for spillover transmission and absorption (over the whole data sample). The time-varying counterpart with decomposition of the different groups of EU countries on total spillover transmission and total spillover absorption are drawn in Figure 4 and 5. In order not to clutter the graph, we have grouped countries as in Figure 1 into core EMU, PIIGS, the non-EMU and CEE countries In Figure 4, one can appreciate the notable increase of PIIGS in terms of spillover transmission in the last years. On the other hand, the very last fee moths show certain decoupling of these countries and rising importance of core-EMU countries as in the pre-crisis times. The limited spillover transmission potential of countries outside the EMU is evident, though there are a few exception periods such as 2008 when three CEE countries emerged as one of the key spillover transmitters. This period represent the onset of crisis in CEE region and substantial uncertainties related to the health of local banking sector. Figure 5 in turn reveals that the overall increase in spillover absorption is related mainly to EMU countries, both the core and the PIIGS.

Figure 4a. Decomposition by countries of the total spillover transmission, full sample (May 2000- February 2012)

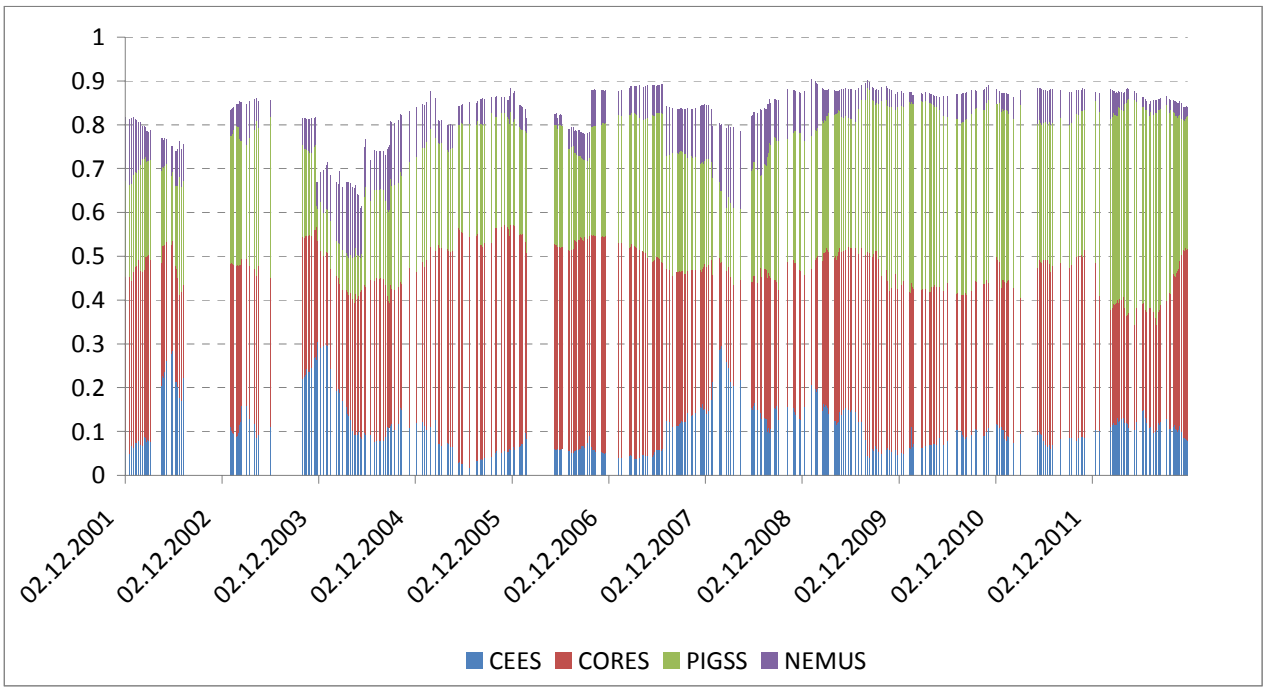
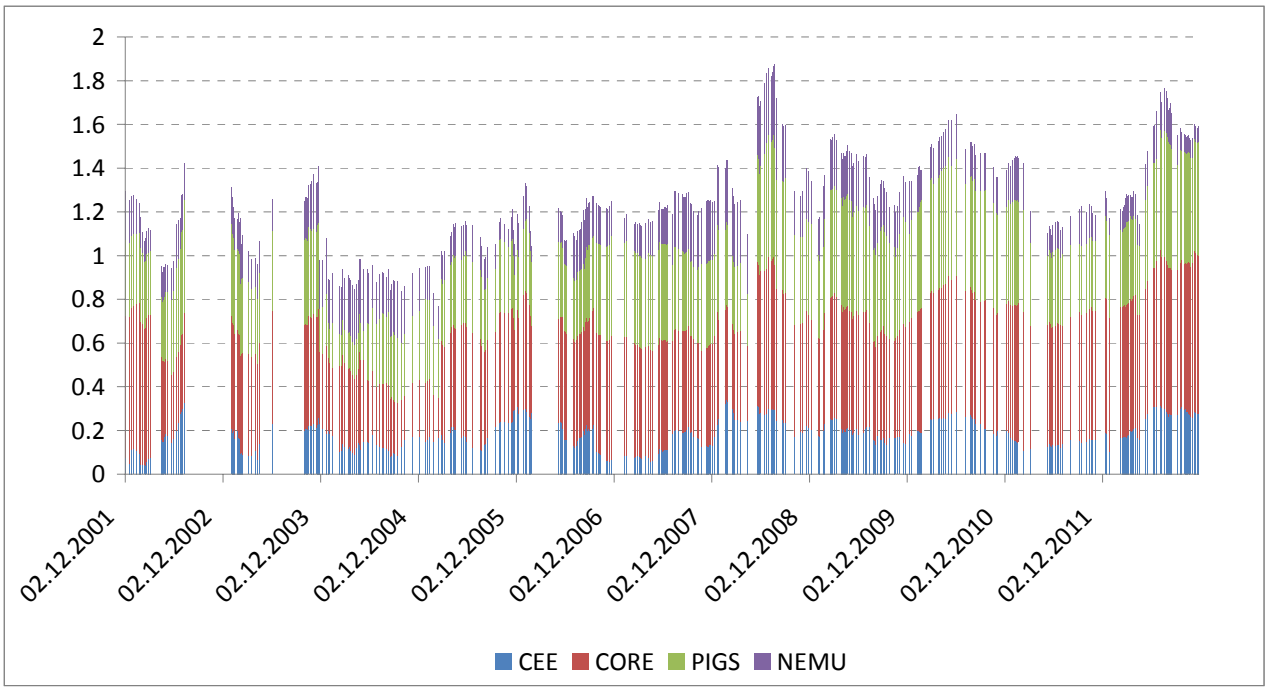


Figure 4b. Decomposition by countries of the total spillover absorption, full sample (May 2000- February 2012)



3.3 The Fiscal Crisis

The time-varying plot of the total spillover hides a lot of the changes in bilateral linkages across markets. We examine one particular case of the Fiscal Crisis in the eurozone, namely the probable spillover of Greek fiscal problems to European bond markets. Since Greece has been the first EMU country to run into fiscal trouble and has set off a series of events, like fiscal bailouts and trouble in the balance sheet of banks, we look in more detail at the consequences of shocks to the Greek sovereign bond spreads on other markets.

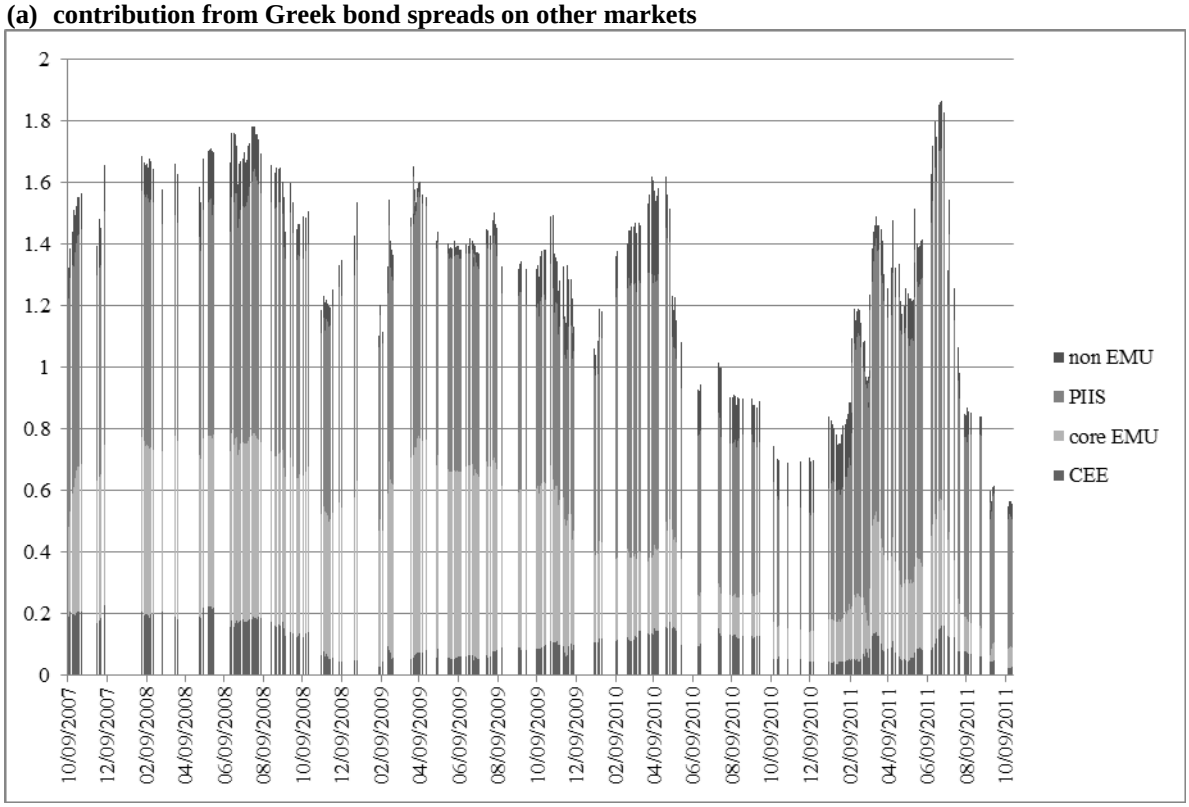
In Figure 5a, we decompose the total effect of shocks to the Greek bond spread on the spreads of the other EU countries. In order not to clutter the graph, we have grouped countries as in Figures 1 and 4 but Greece is excluded from PIIGS. A first observation is that the contribution of changes in sovereign spreads in Greece on other markets is fluctuating significantly over time, and it is quite different across groups. The spillover remains stable – albeit at a high level – up to the start of the Fiscal Crisis in May 2010. The CEE and non-EMU countries are barely affected, although there can be sporadic large changes in the spillover. Most of the effect goes to the PIIS and also the core EMU countries. The crisis immediately magnifies the spillover to other markets but does not change the structure of the spillover. The CEE and non-EMU remain rather decoupled whereas the PIIS and the core-EMU suffer most of the rise in Greek spreads. The spillover continues to rise till the agreement on the European rescue fund in July 2011, when it seems that domestic macroeconomic factors become much more important for the size of spreads and consequently for the importance of the spillover. Other studies argue that in 2010, investors started to put a higher weight on the domestic fiscal position and discerned the problems of Greece from other EU sovereigns (Manasse, 2010). This explains the slight fall in spillover over early 2011. But we can observe consequently a tremendous increase in spillover – both to the PIIS and core EMU – in June/July 2011. This likely reflects the contagion effect to Italy and Spain of fiscal problems. The rescue package of July 2011 seems to have separated the fiscal trouble in Greece from other bond markets, and halted the spread to other PIIS (at least until the end of the sample in October 2011). UPDATE HERE De Grauwe and Ji (2012) argue that the present surge in spreads is disconnected from the rise in public debt ratios and is sign of mispricing of sovereign risk. This makes spillover the main driver of sovereign bond spreads across the monetary union.

In a similar fashion we can calculate the time-varying effect of shocks in all other markets' spreads on the spreads of the Greek bond market (Figure 5b). The overall effect is stable, and again there are stronger links from the core EMU and other PIIS to Greece. This implies strong bilateral linkages. The PIIS seem to exert a slightly stronger effect since the start of the Fiscal Crisis. Since Greece has stronger effects on other markets than it receives from other bond markets implies a positive net spillover of Greek sovereign bond markets. Greek fiscal trouble contribute to spread movements in other PIIS and the core EMU countries.

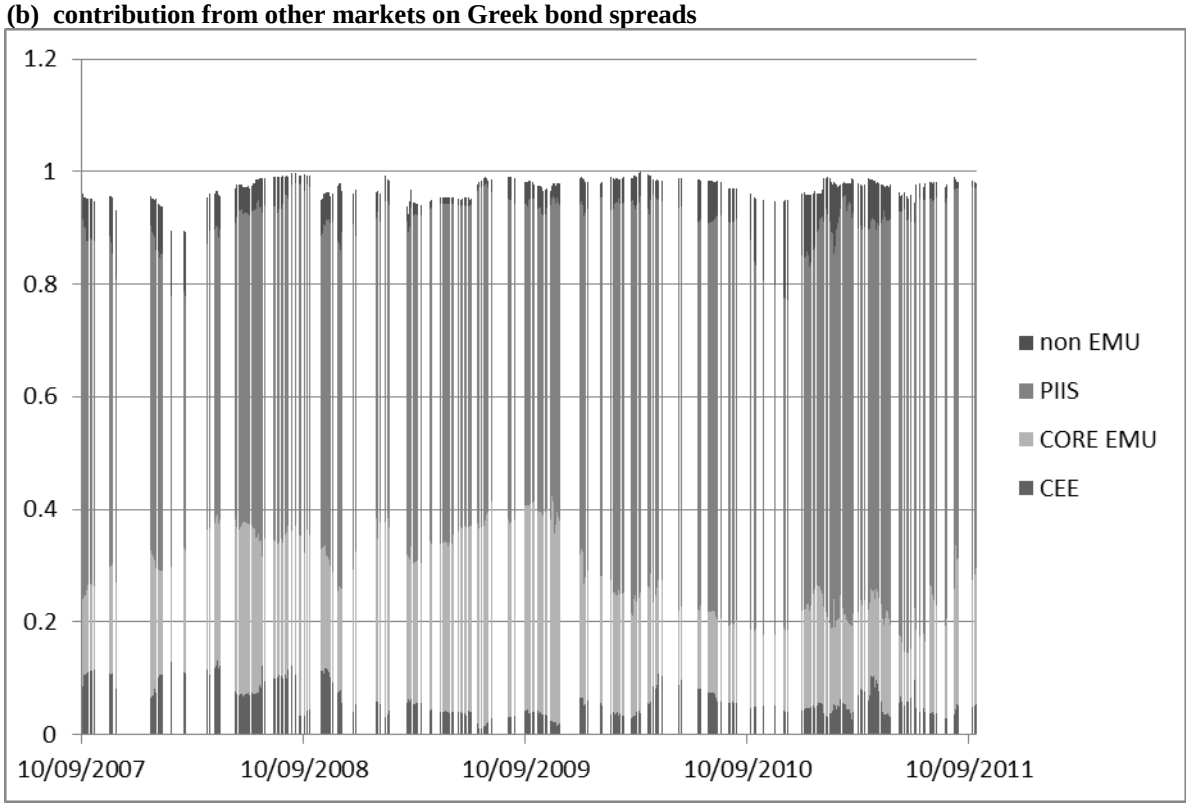
While the effect of other sovereign bond markets on Greek spreads is rather stable during the Financial Crisis, the magnitude of Greek spillover to other sovereigns varies widely and the fluctuations have sometimes a very high frequency. One plausible explanation is that it is related to the frequency of news related to Greece, One particular example of such news are rating actions.

Figure5. Decomposition of the effect of Greek bond spreads on other markets, and vice versa.

(a) contribution from Greek bond spreads on other markets



(b) contribution from other markets on Greek bond spreads

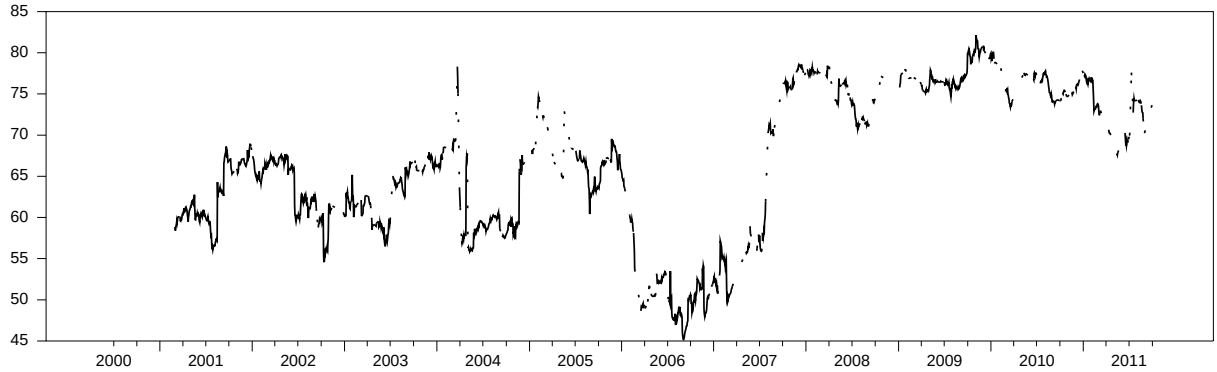


3.4 Robustness checks

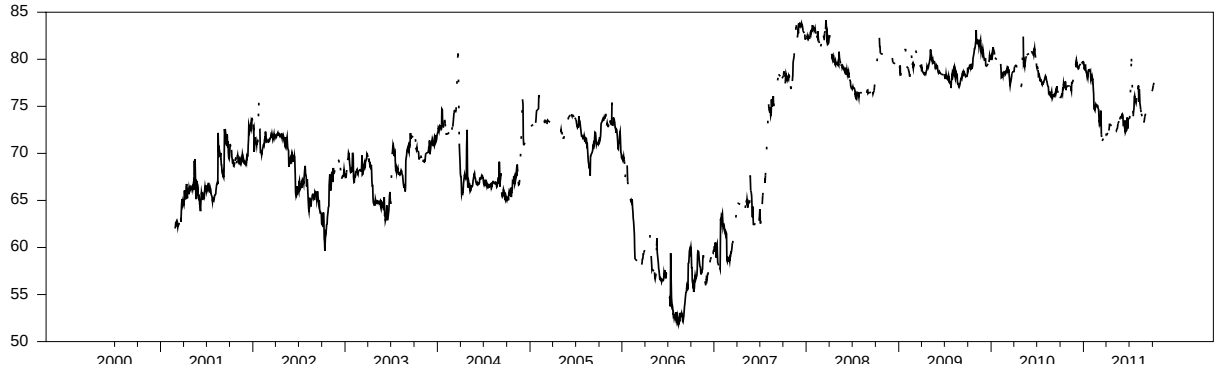
The results of the VAR model are robust to changes in the number of lags included in the VAR, the number of steps ahead when making the forecast, and the sample window. A VAR model with 4 lags (instead of 2), a 20-days (instead of 10-days) ahead forecast or a 400-day (instead of 200-day) rolling window respectively, all depict a similar evolution of the spillover over time (Figures 6a-c).

Figure 6. Robustness checks on VAR model.

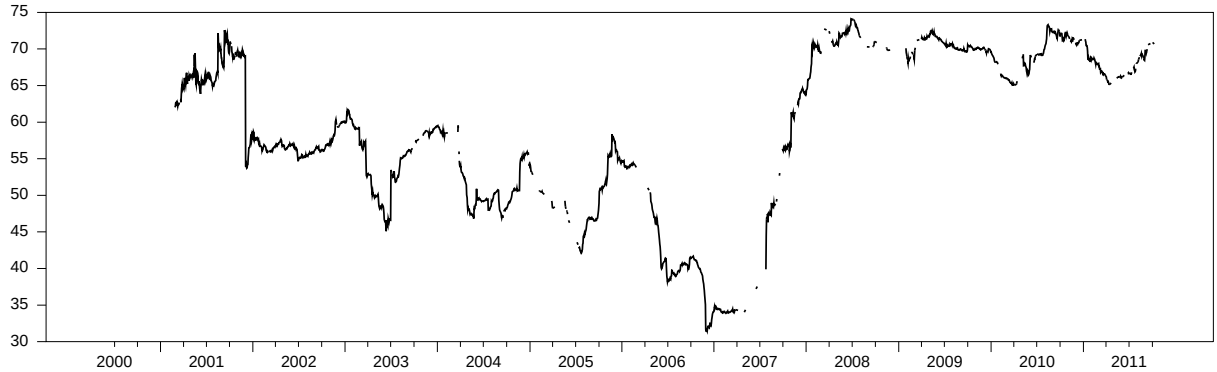
(a) 4 lags



(b) 20 step ahead forecast



(a) 400 day window



4. Impact of sovereign rating news

The high frequency movements in the spillover index suggest that spillover is not only caused by mutual linkages between bond markets, but that macroeconomic news that changes the outlook for public finances in some country triggers the sale of government bonds and raises the spread to a

benchmark bond. One particular event that has sparked quite some controversy is rating news. Announcements by the main credit rating agencies of degrading the bonds of some EU countries, or the revision of the rating outlook seem to have caused quick reactions in the bond markets. Rating news and revisions have been deemedto cause a chain reaction in other sovereign bond markets.

However, banking regulation, collateral rules, credit default swap contracts or investment mandates force domestic and foreign investors to relocate their savings towards higher qualified bonds in response to the rating revision or adjustment (Sy, 2010). Studies that employ event study techniques or VAR models find that a rating downgrade in country A reduces the sovereign bond spreads of other countries (Gande and Parsley, 2005), although most of this effect could have been anticipated in the bond market already (González-Rozada and Levi Yeyati, 2005). For the Eurozone, Arezki *et al.* (2011) finds that the strength of the spillover both across countries and financial markets depends on the type of announcement, the country suffering the downgrade and the rating agency. A negative chain reaction could only happen if there are systematic spillover effects across EMU countries. Arezki *et al.* (2011) argue that these systematic linkages are responsible for the diffusion of negative rating news.

4.1 Impact of rating news

We first estimate the impact effect of a rating change on the bond spread. Figure 7a shows the 90% bands around the bond spread movement of all 16 EU markets after a shock to the step-dummy of the overall rating in EU16 countries,[16] i.e., it is the response to a 1 level rating change in any of the EU16 bond markets (see upper left panel in Figure 2).. The plot shows that a rating change significantly increases the spread for the PIIS countries, for whom agencies have most often changed ratings. After 10 days, the spread rises by 4 to 20 basis points. The rise in spreads does not only occur in the PIIS, but also in Belgium. For the other core-EMU countries and the CEE, the response is not significant, and there is just a small tendency for spreads to fall in Austria. The response of the non-EMU countries is more clear-cut as spreads fall. We can reach two conclusions from this: (i) rating changes have an impact on spreads, and (ii) this rating change affects all eurozone countries, so the Fiscal Crisis seems to be an EMU problem, as Denmark, Sweden or the UK do not suffer a similar change in spreads.

The effect of rating news can be asymmetric since there have been both upgrades and downgrades. We obtain similar results if we consider only downgrades, albeit the effects are slightly stronger.[17]

Since rating actions have happened in the PIIS countries, and by now also in a couple of core EMU countries, our measure is perhaps contaminated by contemporaneous rating moves by the 'Big 3' agencies in other countries. It seems logical given that the number of rating action varies greatly. For instance, while the S&P sovereign rating of Germany has not changed during the whole period of analysis (it is AAA since 1983), Greece was subject to 13 rating actions (including the outlook revisions), Portugal and Ireland to 9 etc. As in section 3.4, we therefore look into the effects of rating changes of Greece only. Our step-dummy thus reflects the gradual downgrading of Greek

[16] We present the result for rating changes by Fitch only. The results for the other 2 agencies are similar and available upon request

[17] Results are available upon request.

bond by Fitch. Most of the rating actions occur since 2009 and our result is driven by this period. Figure 7b shows a very similar image of the impulse responses, and the different effects across countries resume the findings of Figure 5. Also, a time varying plot of the total spillover does not undergo large changes relative to Figure 3. Changes in Greek ratings affect mostly the PIIS. The core EMU is to some extent linked to Greece (via Belgium) but CEE and non-EMU countries are decoupled from developments in Greece. This again confirms that the Greek fiscal trouble have spread to other EMU countries and that the Fiscal Crisis is an EMU problem.

4.2 Rating news and spillover

We now replicate the same VAR model and test for the spillover between bond markets and the overall EU step-dummy for the rating change. Table 2a reports the bilateral linkages for the full sample, and with the rating variable included as an additional variable (as a step dummy). The total spillover is not affected much by the inclusion of the rating (it falls to 53%). Together with the evidence from Figure 6, we might conclude that rating news transmits in the same way as any other movement in the spread. The results for a VAR including an impulse dummy are rather similar (Figure 2b).

Another finding is that the spillover runs rather from bond yields to rating actions than vice versa. The bottom row of Table 2 shows a spillover of 3.21 from all 16 EU bond markets, whereas it is just 0.88 from ratings to all bond markets. Therefore, it seems that the spillover of rating news to sovereign bond market is itself rather limited. This discards two widespread opinions. First, rating actions do reply to developments in the economy or in bond markets, but ratings are hardly affected by shocks to bond spreads, and nearly 100% of the change is explained by the change in the rating itself. Rating news is really new. Second, the chain reaction that rating changes trigger are not specific to rating news, but reflect general spillover on bond markets. Rating news, as do other factors, have an impact on spreads and these spill over to other bond markets. The findings are similar for downgrades and revisions, or a combination of both.

A further look at Table 2a shows some interesting findings: the country most affected by overall rating actions is Portugal, followed by the other PIIGS. On the contrary, the changes in spreads in PIIGS do, in turn, seem to trigger a rating change. But changes in Belgium, France or the Netherlands affect the rating change too. The rating decision mostly moves further changes in the rating but given the step values in this series, the numbers are hard to interpret. We can nevertheless see that rating changes mostly affect the spreads for core EMU and PIIGS, and of course mostly so in the countries whose ratings have been regularly been adjusted since the start of the Fiscal Crisis.

Figure 7a. VAR model: sovereign spread response to change in rating (overall level of rating of 16 EU countries), May 2000- February 2012

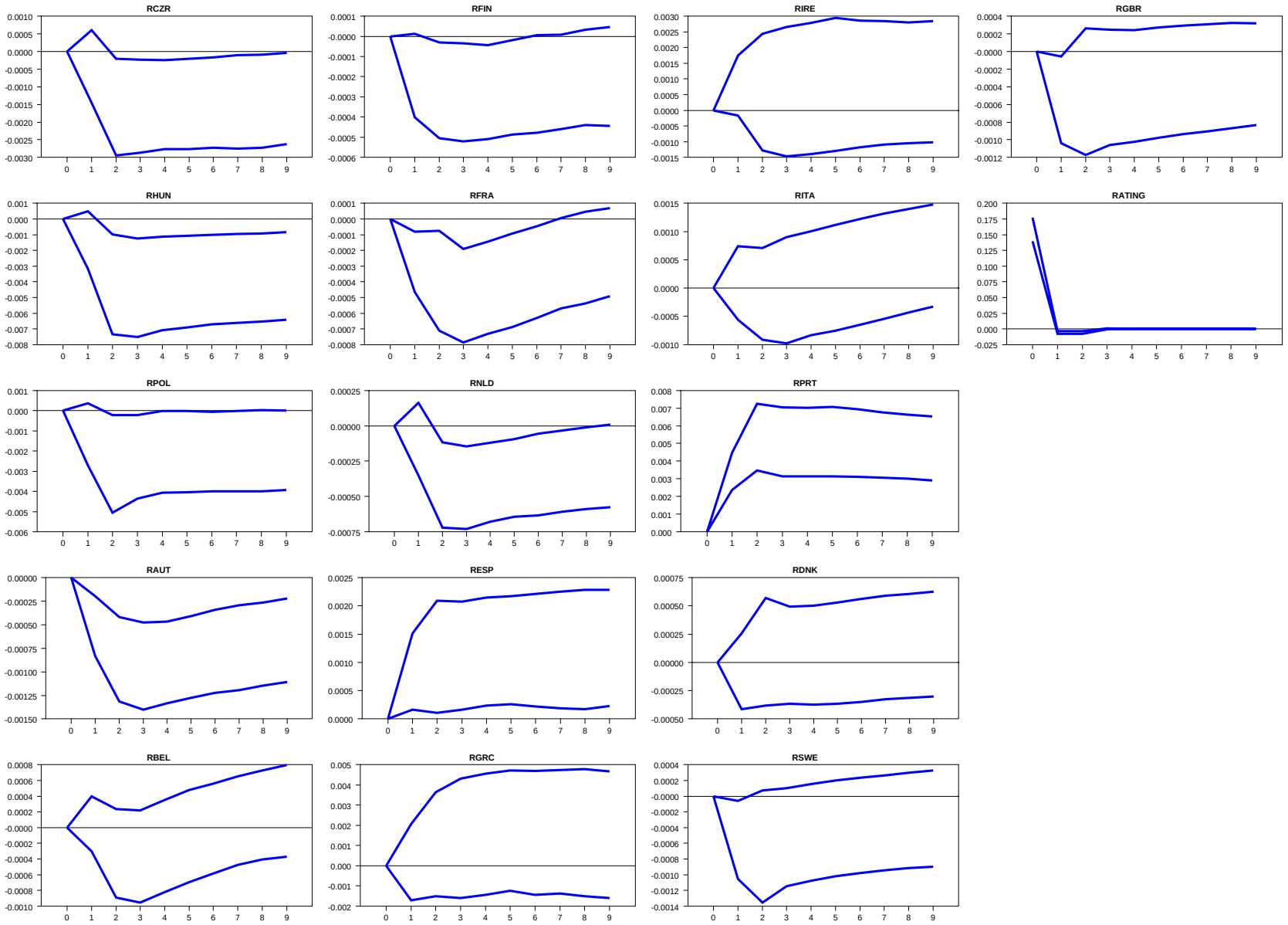


Figure 7b. VAR model: sovereign spread response to change in rating (change rating of Greece), May 2000- February 2012

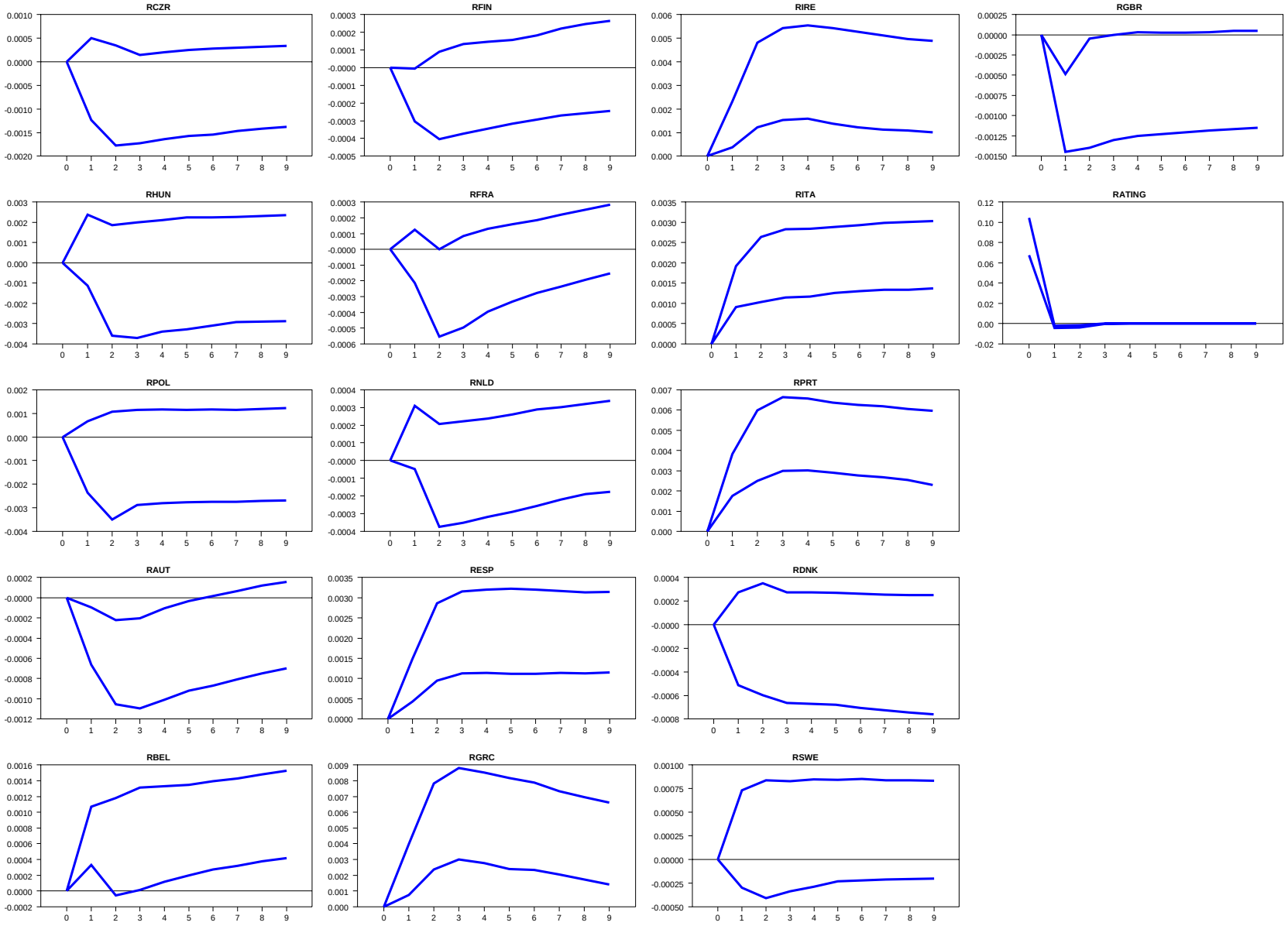


Table 2. Spillover, of VAR model including ratings.

(a) level of rating

	CZR	HUN	POL	AUT	BEL	FRA	FIN	NLD	ESP	GRC	IRE	ITA	PRT	DNK	SWE	GBR	RATING	From Others
CZR	54.66	7.83	6.49	3.17	2.64	1.09	1.59	2.66	4.03	0.79	2.60	4.74	1.56	3.91	2.05	0.17	0.01	45.34
HUN	5.56	52.12	6.31	3.31	4.24	0.91	1.36	2.33	6.30	2.12	3.56	7.08	2.66	0.67	1.39	0.02	0.06	47.88
POL	5.16	5.69	69.17	1.67	2.22	0.85	0.76	1.13	3.07	0.76	1.97	3.76	1.17	1.27	1.26	0.07	0.01	30.83
AUT	1.84	2.75	1.31	29.30	8.98	7.12	7.74	10.44	8.48	2.12	4.38	10.23	3.48	0.75	0.86	0.23	0.00	70.70
BEL	1.65	1.72	0.97	5.04	18.74	5.45	8.99	6.85	15.62	3.27	7.16	16.61	6.23	0.60	0.88	0.22	0.02	81.26
FRA	1.24	0.93	0.99	6.76	8.47	28.76	9.55	13.21	7.60	2.05	4.03	9.11	3.31	2.12	1.58	0.26	0.03	71.24
FIN	1.76	2.18	1.04	6.63	10.44	6.86	19.97	11.10	11.23	2.08	5.63	13.97	5.19	0.78	0.81	0.29	0.02	80.03
NLD	1.58	2.01	0.96	7.66	9.06	9.34	10.58	29.90	7.46	1.56	3.73	10.50	3.11	1.58	0.79	0.14	0.03	70.10
ESP	1.78	1.36	0.87	3.49	9.30	3.71	6.50	4.43	26.60	5.00	9.61	18.97	7.08	0.30	0.60	0.33	0.07	73.40
GRC	0.70	1.25	0.47	1.55	7.82	2.73	4.70	2.48	11.89	31.31	11.57	11.09	11.55	0.07	0.14	0.53	0.15	68.69
IRE	1.08	1.28	0.80	2.56	6.08	3.06	6.54	3.59	10.67	8.01	35.73	7.70	12.38	0.10	0.26	0.08	0.10	64.27
ITA	1.92	1.66	1.06	3.41	9.60	3.66	6.64	4.95	20.40	4.05	8.09	25.60	7.34	0.60	0.74	0.27	0.01	74.40
PRT	1.03	0.98	0.44	2.55	6.52	2.75	5.46	3.65	11.27	10.80	16.62	9.55	27.47	0.13	0.19	0.27	0.33	72.53
DNK	2.75	2.11	1.60	2.35	1.07	3.71	2.50	1.72	0.87	0.37	0.80	1.93	0.73	75.40	1.91	0.14	0.03	24.60
SWE	0.86	0.54	0.69	0.73	0.69	1.31	0.30	0.97	1.25	0.01	0.43	1.71	0.09	1.61	88.59	0.21	0.01	11.41
GBR	0.21	0.05	0.03	0.46	0.75	0.54	0.79	0.54	2.04	1.60	0.83	1.52	1.13	0.06	1.34	88.08	0.00	11.92
RATING	0.12	0.20	0.02	0.07	0.37	0.14	0.04	0.12	0.15	0.29	1.27	0.21	0.03	0.00	0.13	0.03	96.79	3.21
Contribution to others	29.23	32.53	24.06	51.40	88.25	53.22	74.07	70.16	122.34	44.89	82.30	128.68	67.05	14.56	14.93	3.26	0.88	901.80
Contribution incl. own	83.89	84.65	93.23	80.70	106.99	81.98	94.04	100.06	148.94	76.20	118.02	154.28	94.52	89.96	103.52	91.34	97.68	53.0%

(b) change in rating

	CZR	HUN	POL	AUT	BEL	FRA	FIN	NLD	ESP	GRC	IRE	ITA	PRT	DNK	SWE	GBR	RATING	From Others
CZR	54.23	7.54	6.54	3.16	2.75	1.10	1.61	2.66	4.17	0.87	2.70	4.85	1.72	3.85	2.02	0.15	0.06	45.77
HUN	5.60	55.01	6.07	3.24	3.83	0.87	1.28	2.34	5.82	1.67	3.16	6.70	2.14	0.74	1.41	0.02	0.11	44.99
POL	5.13	5.18	68.20	1.69	2.48	0.88	0.80	1.13	3.38	0.98	2.18	4.00	1.49	1.19	1.23	0.04	0.03	31.80
AUT	1.84	2.57	1.35	28.88	9.09	7.07	7.70	10.31	8.64	2.26	4.49	10.31	3.68	0.73	0.85	0.20	0.05	71.12
BEL	1.64	1.46	1.05	4.92	18.69	5.33	8.81	6.63	15.73	3.58	7.34	16.54	6.69	0.54	0.85	0.17	0.02	81.31
FRA	1.24	0.86	1.02	6.71	8.55	28.48	9.50	13.08	7.71	2.15	4.11	9.18	3.45	2.08	1.57	0.24	0.06	71.52
FIN	1.76	2.08	1.06	6.58	10.49	6.83	19.83	11.02	11.31	2.15	5.69	13.99	5.32	0.76	0.80	0.26	0.07	80.17
NLD	1.58	1.96	0.97	7.61	9.09	9.33	10.55	29.80	7.51	1.58	3.75	10.52	3.17	1.57	0.79	0.13	0.09	70.20
ESP	1.76	1.15	0.94	3.45	9.43	3.65	6.41	4.31	26.39	5.33	9.76	18.81	7.46	0.27	0.59	0.27	0.02	73.61
GRC	0.71	0.82	0.61	1.54	8.18	2.62	4.58	2.33	12.11	30.82	11.71	11.08	12.38	0.05	0.13	0.33	0.01	69.18
IRE	1.08	1.20	0.83	2.55	6.14	3.04	6.51	3.56	10.73	8.11	35.57	7.73	12.48	0.10	0.26	0.07	0.06	64.43
ITA	1.90	1.45	1.12	3.35	9.71	3.61	6.56	4.83	20.38	4.32	8.23	25.32	7.70	0.56	0.72	0.22	0.01	74.68
PRT	1.02	0.66	0.56	2.49	6.85	2.65	5.29	3.43	11.44	11.43	16.53	9.58	27.50	0.10	0.18	0.16	0.13	72.50
DNK	2.72	2.33	1.49	2.30	0.93	3.66	2.42	1.70	0.73	0.25	0.68	1.76	0.52	76.47	1.93	0.11	0.00	23.53
SWE	0.87	0.50	0.72	0.73	0.73	1.32	0.31	0.98	1.32	0.00	0.46	1.77	0.11	1.59	88.35	0.20	0.02	11.65
GBR	0.20	0.07	0.03	0.44	0.68	0.53	0.77	0.54	1.90	1.42	0.75	1.42	0.97	0.07	1.33	88.89	0.00	11.11
RATING	0.08	0.05	0.00	0.08	0.31	0.08	0.06	0.09	0.21	0.03	0.24	0.12	0.40	0.01	0.09	0.03	98.11	1.89
Contribution to others	29.12	29.88	24.36	50.85	89.23	52.58	73.17	68.95	123.08	46.14	81.80	128.36	69.68	14.19	14.73	2.62	0.73	899.46
Contribution incl. own	83.35	84.88	92.57	79.73	107.93	81.05	93.00	98.75	149.47	76.97	117.36	153.68	97.18	90.65	103.08	91.51	98.84	52.9%

5. Conclusion

The speed and depth by which fiscal problems have spread across Eurozone countries has come as a surprise. Although there is quite some evidence that sovereign risk premia are driven by a common or global factor, especially in emerging market economies, this kind of contagion was not expected to happen in the EU. Events since the start of the Fiscal Crisis in May 2010 with a very rapid rise in bond spreads and the downgrading of all EMU countries but Germany shows that Europe is not immune to contagion on sovereign bond markets.

In this paper, we analyse the bilateral linkages between sovereign bond markets in detail, using the forecast-error variance decompositions from a VAR with daily bonds spreads since 2000. Our results indicate that spillover has substantially increased since 2007 but that there is a lot of heterogeneity in the bilateral spillover sent and received between specific markets. Spillover is more important than domestic factors for all EMU countries, notably for the PIIGS, while other EU countries experience less spillover. The CEE countries affect each other mutually, but Denmark, Sweden, and the UK are insulated from the impact of other EU countries. Substantial spillover between EMU countries shows the Fiscal Crisis is a Eurozone crisis.

Our VAR-based evidence on rating announcement is in general consistent with previous studies using VAR methods. Alike Gande and Parsley (2005) and Arezki *et al.* (2011) we find that sovereign rating news really contains new information, and has a significant impact on spreads. Rating news in one country does not improve the spread for other countries because of a reallocation of investment. Instead, negative rating news worsens domestic and foreign spreads in the same way. Rating news affects spreads through the same transmission channel.

Solutions to the European sovereign debt crisis are mainly based on domestic solutions to tackle fiscal imbalance. But Eurozone sovereign bond markets are closely linked so that an EMU-wide solution is as important. This suggests that purely domestic solutions to restore fiscal imbalances are a necessary, but not a sufficient condition to restore calm on sovereign bond markets.

There are several extensions possible to the analysis on rating decisions in this paper. First, we might consider including different asset markets (sovereign bonds, corporate bonds, stock markets, banking sector) in a single VAR. Second, we examine the effect of rating decisions, but those arguably have important effects on sovereign bond prices onto other asset markets as well both domestically and abroad. Adjustments in sovereign ratings affect the financing cost of firms and banks (Kaminsky and Schmukler, 2002). The sovereign bond rate puts a floor under the bond market as it is usually considered to be the safest asset. Business financing on bond markets should suffer the consequences immediately since rises in the bond rate translate directly into increases in the risk free rate (price channel).

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Appendix

Table A.3 Spillover table, no factor, full sample (May 2000- February 2012)

	CZR	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	From others
CZR	57.80	8.26	7.32	2.76	0.57	0.81	1.81	3.02	3.83	4.42	0.88	0.91	2.13	4.45	1.00	0.03	42.20
POL	7.36	64.89	6.77	1.17	0.22	0.24	0.82	1.89	2.59	3.15	1.16	1.19	2.06	5.64	0.83	0.02	35.11
HUN	7.35	9.42	58.32	2.52	0.49	0.45	0.68	3.21	3.20	3.86	1.77	1.40	3.32	3.86	0.09	0.06	41.68
AUT	2.04	1.85	3.09	26.28	4.63	7.83	11.58	13.28	8.97	11.07	2.41	1.82	4.48	0.47	0.11	0.09	73.72
FIN	1.83	1.15	0.94	10.22	31.55	12.91	10.59	9.55	5.34	6.06	1.65	1.66	4.30	1.04	0.49	0.72	68.45
NLD	1.92	1.00	1.92	9.29	10.04	30.56	10.04	9.18	6.51	6.33	1.90	2.75	5.22	1.61	0.56	1.16	69.44
FRA	1.85	1.60	1.85	11.51	4.61	7.86	22.79	14.15	9.80	13.81	2.80	1.63	3.93	1.17	0.33	0.31	77.21
BEL	1.96	1.65	2.07	8.35	3.00	5.29	9.50	24.56	15.64	15.95	2.22	2.67	6.63	0.26	0.16	0.09	75.44
ESP	1.55	1.18	1.31	5.98	1.63	3.94	7.30	12.15	31.04	16.95	3.34	4.12	8.90	0.15	0.15	0.31	68.96
ITA	2.02	1.60	1.61	4.54	1.46	3.03	4.91	14.25	20.39	30.38	3.49	4.26	7.70	0.21	0.07	0.08	69.62
GRC	1.24	0.87	0.84	2.84	1.71	2.08	5.29	10.21	10.65	8.55	39.04	6.64	9.91	0.01	0.02	0.12	60.96
PRT	0.85	0.72	1.06	2.37	0.29	0.89	1.41	9.23	10.83	7.07	6.42	40.85	17.79	0.01	0.16	0.04	59.15
IRE	1.18	0.87	1.10	3.57	1.97	2.69	4.08	8.60	10.78	5.50	5.88	11.38	42.30	0.01	0.05	0.03	57.70
DNK	4.32	4.47	5.14	1.35	2.38	2.44	2.44	0.61	0.26	0.35	0.32	0.25	0.35	69.44	5.68	0.19	30.56
SWE	1.27	1.02	0.57	0.15	0.59	0.85	0.39	0.23	0.47	0.31	0.04	0.13	0.09	4.77	88.48	0.64	11.52
GBR	0.21	0.15	0.14	0.34	0.85	1.93	0.54	0.26	2.01	0.86	0.31	0.94	0.82	0.13	1.16	89.37	10.63
To others	36.95	35.83	35.74	66.98	34.44	53.23	71.37	109.81	111.27	104.24	34.59	41.74	77.63	23.79	10.86	3.88	852.35
To others (+own)	94.75	100.73	94.06	93.26	65.98	83.79	94.16	134.36	142.31	134.62	73.64	82.59	119.94	93.23	99.34	93.24	53.3%
From others	42.20	35.11	41.68	73.72	68.45	69.44	77.21	75.44	68.96	69.62	60.96	59.15	57.70	30.56	11.52	10.63	
Net spillover	5.25	-0.73	5.94	6.74	34.02	16.21	5.84	-34.36	-42.31	-34.62	26.36	17.41	-19.94	6.77	0.66	6.76	

Share on spillover transmission	4.33	4.20	4.19	7.86	4.04	6.25	8.37	12.88	11.15	10.45	3.47	4.18	7.78	2.38	1.09	0.39
Share on spillover absroption	4.95	4.12	4.89	8.65	8.03	8.15	9.06	8.85	8.09	8.17	7.15	6.94	6.77	3.58	1.35	1.25
Share on overall spillover	9.29	8.32	9.08	16.51	12.07	14.39	17.43	21.73	19.24	18.62	10.62	11.12	14.55	5.97	2.44	1.64

Table A.2 Spillover table, de-factorized spread series, full sample (May 2000- February 2012)

	CZR	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	From others
CZR	34.17	3.67	1.47	7.17	8.29	7.86	6.89	2.99	0.61	0.05	0.70	0.05	0.12	9.81	9.10	7.03	65.83
POL	6.20	52.08	2.63	3.88	4.84	4.34	3.76	1.63	0.40	0.03	0.13	0.03	0.05	9.21	6.26	4.53	47.92
HUN	4.96	8.34	82.36	0.23	0.24	0.10	0.01	0.01	0.04	0.15	0.04	0.01	0.07	2.91	0.36	0.17	17.64
AUT	1.85	0.33	0.01	16.39	13.88	14.00	13.68	8.03	1.45	0.14	0.60	0.02	0.09	8.05	10.63	10.87	83.61
FIN	2.20	0.38	0.03	12.65	15.77	14.37	13.25	7.66	1.46	0.10	0.54	0.03	0.10	8.81	11.09	11.57	84.23
NLD	2.23	0.36	0.01	12.53	14.42	15.42	13.17	7.63	1.62	0.11	0.50	0.07	0.11	9.01	11.10	11.72	84.58
FRA	1.89	0.33	0.03	12.75	13.72	13.82	15.64	8.30	1.75	0.37	0.46	0.01	0.06	8.69	10.93	11.23	84.36
BEL	1.15	0.16	0.06	10.86	11.51	11.76	12.66	19.25	5.55	1.90	0.80	0.05	0.19	5.59	9.37	9.13	80.75
ESP	0.59	0.05	0.37	6.94	7.21	8.00	8.96	8.10	33.68	6.27	0.03	0.59	1.54	3.31	6.77	7.62	66.32
ITA	0.59	0.08	0.32	4.38	6.15	6.35	5.44	9.77	17.27	33.91	0.02	0.52	0.63	2.87	5.64	6.06	66.09
GRC	1.61	0.59	0.30	6.30	5.26	5.73	3.97	0.87	0.20	0.05	55.60	2.08	2.37	6.09	5.03	3.95	44.40
PRT	0.09	0.11	0.05	0.04	0.04	0.05	0.10	1.99	4.37	0.47	4.39	71.12	16.79	0.22	0.10	0.08	28.88
IRE	0.08	0.18	0.20	0.30	0.73	0.63	0.53	1.36	3.70	1.74	3.29	12.77	73.61	0.20	0.23	0.46	26.39
DNK	2.90	0.86	0.09	11.44	13.42	13.18	12.23	6.35	0.84	0.03	0.55	0.02	0.03	15.40	11.91	10.77	84.60
SWE	2.71	0.67	0.02	11.26	12.91	12.84	11.70	6.82	1.89	0.19	0.43	0.10	0.09	9.60	17.96	10.82	82.04
GBR	2.32	0.46	0.01	11.22	12.98	13.21	11.79	6.98	2.36	0.31	0.39	0.17	0.16	8.27	10.89	18.49	81.51
To others	31.37	16.56	5.59	111.97	125.60	126.24	118.12	78.48	43.50	11.91	12.85	16.51	22.39	92.63	109.40	106.01	1029.14
To others (+ own)	65.55	68.64	87.94	128.35	141.37	141.67	133.76	97.73	77.19	45.82	68.45	87.63	96.00	108.03	127.36	124.50	64.3%
From others	65.83	47.92	17.64	83.61	84.23	84.58	84.36	80.75	66.32	66.09	44.40	28.88	26.39	84.60	82.04	81.51	
Net spillover	34.45	31.36	12.06	-28.35	-41.37	-41.67	-33.76	2.27	22.81	54.18	31.55	12.37	4.00	-8.03	-27.36	-24.50	

Share on spillover transmission	3.05	1.61	0.54	10.88	12.20	12.27	11.48	7.63	4.23	1.16	1.25	1.60	2.18	9.00	10.63	10.30	
Share on spillover absroption	6.40	4.66	1.71	8.12	8.18	8.22	8.20	7.85	6.44	6.42	4.31	2.81	2.56	8.22	7.97	7.92	
Share on overall spillover	9.44	6.27	2.26	19.00	20.39	20.48	19.67	15.47	10.67	7.58	5.56	4.41	4.74	17.22	18.60	18.22	