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 losses on some subprime loans in US banks have had global consequences as uncovered debt positions consequently created a snowball debt effect that brought down major financial institutions both in the US and Europe. The ensuing financial crisis called for policy intervention, not just by central banks, but also out of the deep pockets of the tax payer. Massive public aid provided to the financial sector together with falling tax revenues and spending on recovery plans to withstand the economic fall out of the financial collapse, unleashed a feedback loop between banking and sovereign debt crisis. The sovereign debt crisis of the eurozone is so far the last chapter in this financial crisis. Rising sovereign credit risk reflects not just structural imbalances and economic divergences, but also has a common component because of monetary union and linkages in the banking market. The Eurozone fiscal crisis is characterized both by the cross-country dimension of fiscal trouble and its potential international spillover. This combined financial-fiscal crisis is characterised by the speed of transmission and the strength of the feedback linkages across borders and financial markets.

The potency of spillover across sovereign bond markets does not come as a surprise. Financial and economic integration has been a gradual process, stimulated by several rounds of capital account liberalisation, financial deregulation and innovation, and the introduction of the euro (Lane and Milesi-Ferretti, 2008). Sovereign bond markets have become more interconnected too. Whereas in the past, only countries with high domestic savings and developed financial systems based on bank financing could issue public bonds, many governments can now tap into international capital markets (Caballero and Krishnamurthy, 2004).

Empirical studies have confirmed the rising importance of global factors in determining the evolution of domestic bond markets. Sovereign bond yield spreads should compensate investors for default risk, transactions costs (liquidity premium) and exchange rate fluctuations. If investors are able to distinguish markets, the spread should depend only on these idiosyncratic variables. Most empirical studies find that their explanatory power is rather limited for European sovereign bond yield spreads. Instead, conditions on international financial markets can largely explain the dynamics of European sovereign spreads (Codogno *et al.*, 2003; Sgherri and Zoli, 2009; Schuknecht *et al.*, 2010; Bernoth *et al.*, 2006; Favero and Missale, 2011). This so-called 'common factor' is argued to reflect generalised risk aversion on international markets. Global investors

adjust their portfolio of bonds when worldwide economic conditions change. 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). Despite the initial success of this expansionary policy, rapidly rising debt has revealed the cost to already burdened government budgets. As a consequence, default risk and liquidity risk have risen and the fiscal position determines the changes in bond spreads (Haugh et al., 2009; Sgherri and Zoli, 2009; Barrios et al., 2009; Schuknecht et al., 2010). Problems on some sovereign markets have also spread to other Eurozone countries via the debt holdings of the large European banks.

Most of these studies proxy the global factor with some measure of international market developments, but as a consequence, cannot detail the source and the direction of the transmission channels behind the spillover.[4] In this paper, we aim to detail the strength and direction of bilateral linkages between EU sovereign bond markets. The spillover measure is based on the forecast error variance decomposition of a VAR model including sovereign bond spreads (Diebold and Yilmaz, 2009, 2011). Shocks to one market contribute to explaining the variance in the other markets some periods ahead. This percentage contribution represents the spillover. Hence, we do not just link the evolution of sovereign bond spreads to idiosyncratic events but also detail the origin of the global factor affecting the domestic market. Moreover, we can infer from the strength of the bilateral links the source of the global factor and how it transmits across markets.

We estimate a VAR including EU sovereign bond yield spreads relative to the German 10 year bond yield controlling for a common factor, and generalized market volatility or short-term market liquidity using daily data on bond spreads since 2000. We track the magnitude and direction of spillover between each pair of markets over time, and the changes that occurred after the onset of the financial and the European debt crisis in countries both inside and outside the Eurozone.

One particular source of instability on sovereign bond markets is the rating decision by the main credit rating agencies (S&P, Moody's and Fitch). The reason that rating changes can spillover

[4] 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. 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.

across markets 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 changes in bond returns around the date of rating changes. We revisit the importance of rating announcements by analysing the dynamic linkages between these discrete events and sovereign yield spreads. We include in the VAR model different definitions of rating decisions (downgrades v upgrade, rating v revision changes) by different rating agencies (S&P, Moody's, Fitch) to identify whether the rating action is really 'news' or is already incorporated in bond market prices, and whether there is spillover effect of rating actions across countries.

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 spillover with a VAR

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:

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

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.

The method allows us to study the general spillover between different asset markets, and dissect the strength and direction of the spillover between any two markets. 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. In particular, we can compute the percentage contribution of a change in daily quoted asset prices on the variation in asset prices of each particular market included in the VAR model. The matrix Λ of all λ_{ij} contains all bilateral linkages to and from two different markets.[5] The column for a market A contains λ_{Aj} and can be read as the contribution from a shock to that market A to asset prices in other markets. The entry λ_{AA} is the percentage contribution of a shock in explaining the movement of the market's asset price. The row for some market B contains λ_{iB} and can be read as the spillover market B receives from a shock to the spreads in other markets. The dimensions of Λ grow quickly when adding new markets, so we need some summary statistics.

A first group of statistics measures the degree of spillover. Using the forecast decomposition of this VAR, *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.:

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

[5] It is like the weight matrix measuring distance spatial econometrics.

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:

$$DS^h_{\rightarrow i} = 100.\sum_{j \neq i}^{n} \lambda^h_{ij} \Big/ \sum_{i,j=1}^{n} \lambda^h_{ij} \tag{4}$$

Measure (4) is the sum of the row-elements of the matrix Λ. Similarly, we can measure the spillover a market *i* transmits to all other *n-1* markets by

$$DS^h_{\leftarrow i} = 100.\sum_{j \neq i}^{n} \lambda^h_{ji} \Big/ \sum_{i,j=1}^{n} \lambda^h_{ji} \tag{5}$$

Measure (5) is the sum of each column of the matrix Λ, not including the own contribution of each market.[6] 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. $NS^h = DS^h_{\rightarrow i} - DS^h_{\leftarrow i}$. 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:

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

Since this is a gross measure, two markets may have the same net spillover, but this would be relatively more important for a market that exerts or experiences little spillover. We therefore define the *net index* of market A as the absolute value of NS^h over the own contribution of a market. A number larger than 1 indicates the spillover effect dominates the domestic effect, implying that this market is well-connected since flows from and to that market exceed the idiosyncratic effect of a shock to that market.

The spillover index is a measure of interdependence between financial markets. The approach of Diebold and Yilmaz (2009, 2011) improves over partial equilibrium approaches that proxy a global factor with some measure of risk aversion on markets (typically US corporate bond spreads, or US stock market volatility) 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, and its feedback. Prices move contemporaneously on

[6] Alternatively, one may include the own effect of the shock.

different financial markets, and this spillover is stronger between markets that are more closely connected. This is a general equilibrium effect of idiosyncratic shocks to different markets.

2.2 Fundamentals or contagion: a FA-GVAR

The source of the spillover cannot be identified in the VAR; and it can either reflect the co-movement of fundamentals or be due to contagion. Fundamental linkages between markets like trade or finance explain the co-movement of asset prices and determine the strength of spillover. Kaminsky and Reinhart (2000) separate both channels to isolate contagion. Forbes and Rigobon (2002) argue that contagion is a sudden significant increase in cross-market linkages after a shock to one market (conditional on market volatility). Both approaches require additional identifying assumptions on the relations between markets.

We use high-frequency (daily) data whose dynamics are by their nature not affected by macroeconomic fundamentals nor by news related to these fundamentals, which have a lower frequency. However, idiosyncratic shocks to a sovereign bond market do have stronger spillover to markets when their mutual fundamental linkages are stronger (Favero and Missale, 2011). So the contemporaneous correlation between markets reflects both channels, with an important interaction between contagion and fundamentals.

This contemporaneous correlation between asset markets is not accounted for in a simple VAR like (1). The reason is that the variance decomposition depends on the ordering of variables in the VAR. I.e., the cholesky identification of the VAR imposes diagonal block restrictions on the contemporaneous feedback effect of markets to the markets that are ordered first. Diebold and Yilmaz (2011) therefore adopt the generalized VAR (or G-VAR) framework of Koop *et al.* (1996) and Pesaran and Shin (1998) that allows shocks to 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.

We additionally control for the existence of contemporaneous correlations across sovereign bond markets by including common factors in the VAR. Empirical studies have argued that bond spreads in EMU move together and that the spread variability of individual countries is driven by these common factors (Codogno *et al.*, 2003; Sgherri and Zoli, 2009; Schuknecht *et al.*, 2010; Bernoth *et al.*, 2006). Since this is a common development, it may not be tracked to any specific market. We extend the VAR approach of Diebold and Yilmaz (2009, 2011) and include a common factor in the

factor-augmented VAR (or FA-VAR). Following Bernanke *et al.* (2005), we use a two-step strategy. In the first step, we use factor analysis to extract the common factors driving a significant part of the yield spreads. The factor model assumes that the observable multivariate k-vector X_t is generated by:

$$X_i - \mu = LF_i + \varepsilon_i \tag{7}$$

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 represents a vector of error terms or unique factors. Therefore, the idea is to express *k* 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 partial (MAP) method to determine the number of factors. The principal factor method is used to estimate the factor loadings.

In the second step, we estimate the GVAR that besides the original *n* variables x_t contains additional *k* factors F_i. We can then compute the FEVD and use this decomposition to dissect the strength and direction of the spillover between any two markets, and the common factors. 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 the common factors.

2.3 Specification

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).[7] Figure 1 shows the spreads for four 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).

[7] The main source for the data is Thomson Reuters Datastream. For reasons of data availability we did not include Luxembourg or smaller CEE countries that quote bond yields only in recent years. For the same reason, we do not use sovereign CDS quotations as they were popularized around the onset of the crisis in 2007 and their market is still rather illiquid for many sovereigns.

The MAP-method shows that three factors drive the bond spreads of EU countries. The evolution of all three factors is very smooth until the onset of the financial crisis in 2008, but then spike to diverge later on (Figure 2). The first factor starts to increase over 2008 as the global financial crisis hit the EU and there was a significant increase of yield spreads, notably in the Eurozone. The second spike appears at in late 2011 during the latest acute phase of the debt crisis. The second factor reaches a peak in late 2008 and early 2009 alike the first factor and since then its value declines steadily. The third factor reaches a minimum in 2008/09 and has been rising since.

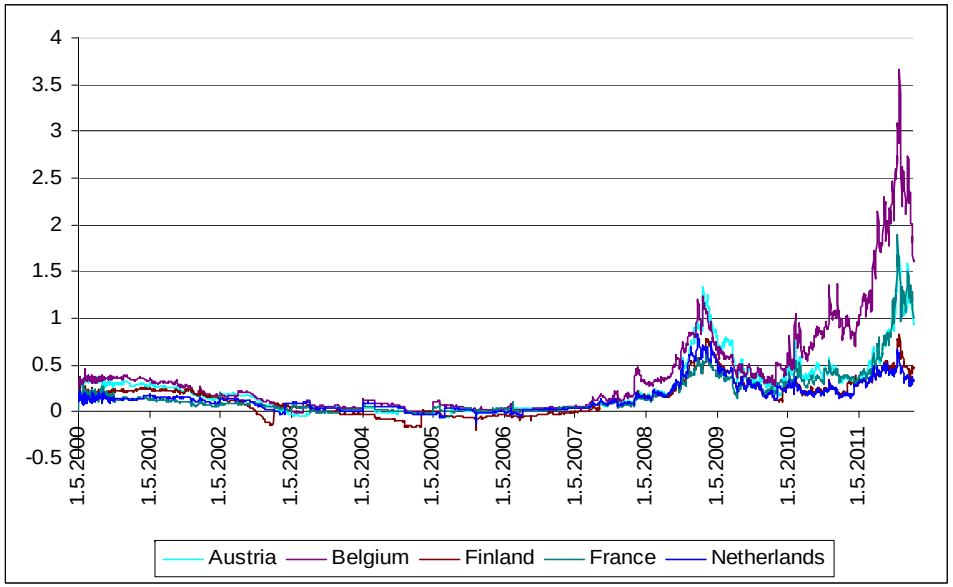
The principal factor method shows that the first of these principal factor is able to explain over 70% of the variance of spreads (Table 1). The factor loadings are close to unity for the Eurozone countries, which suggests this factor is mostly identifying common developments to the EMU. Non-EMU countries have substantially lower loadings. The second and third factor explain much less of the overall variance. In addition, their loadings do not seem to have any logical interpretation.[8] This might be related to the fact that Eurozone commonalities are well tracked by the first factor and non-EMU countries represent a rather heterogeneous group. Consequently, we consider the first factor as the reliable measure of common factor in Eurozone sovereign spreads. [9] We further test the sensitivity of the results when more factors are included in a set of robustness checks.

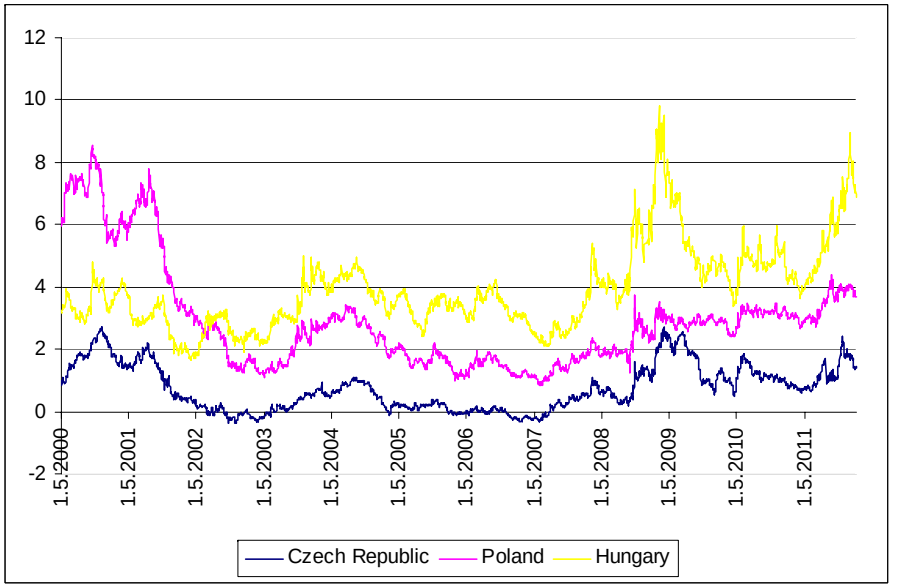
The basic FA-GVAR model contains two lags of the domestic bond spread of 16 EU countries and the common factor obtained in the first step. We compute the forecast error variance decomposition at a horizon of 10 days (one week and a half) which should be sufficient to capture the horizon at which spillover across markets occurs. We additionally include in the VAR a short-term interest rate (EONIA) to control for the possible effects of monetary policy on the short end of the term structure. Another control variable is the Chicago Board Options Exchange index (VIX) to control for overall volatility on markets outside Europe. This index is often used to measure risk aversion on global markets. Both variables are assumed to be exogenous.

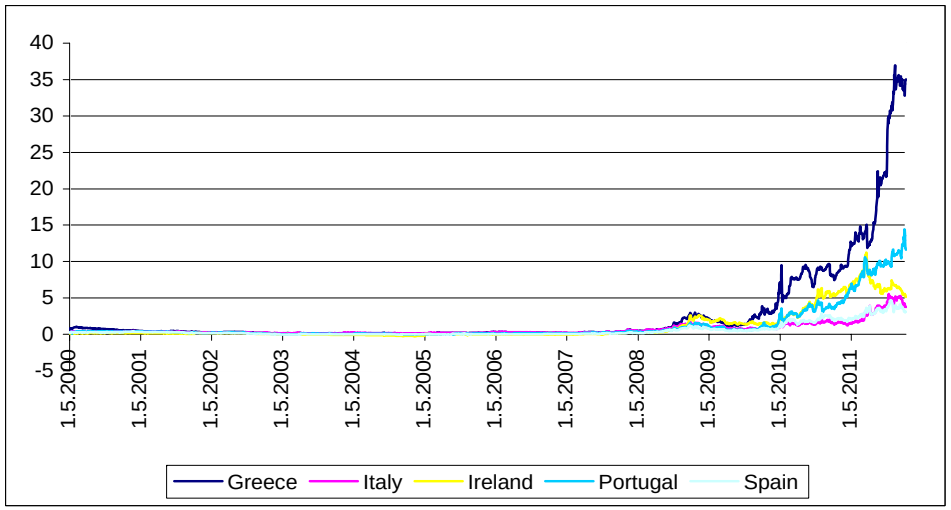
[8] The use of limited number of series from which the factors are extracted as well as the fact that all the series are represent the same variable (sovereign bond yield) simplifies the interpretation of the extracted factors.

[9] We used alternative methods to determine the number of factors and estimate their loadings and these provide similar results. 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 a breakdate in 2009. Although the results pointed to some differences between the two periods, the first factor consistently explains at least 65% of the variance and its factor loadings did not vary notably. The loading and time evolution of the other factors did vary somewhat.

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







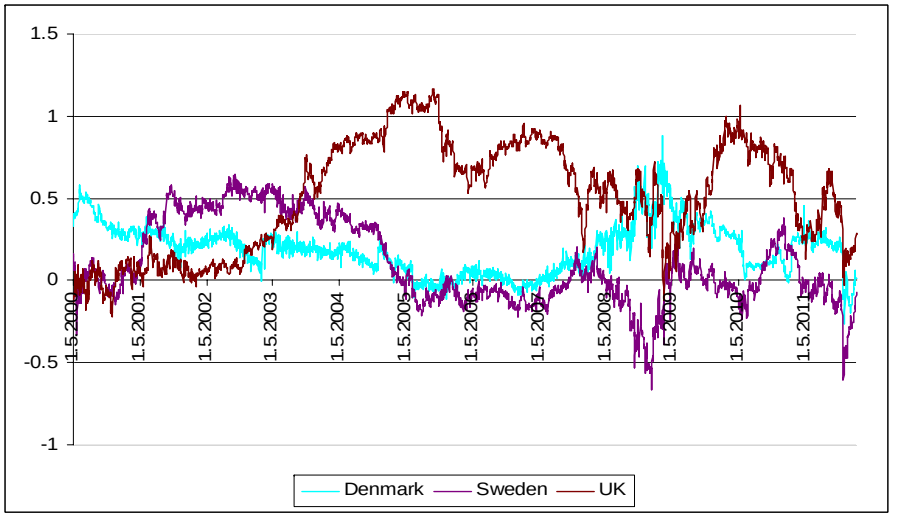


Figure 2. Time evolution of factors.

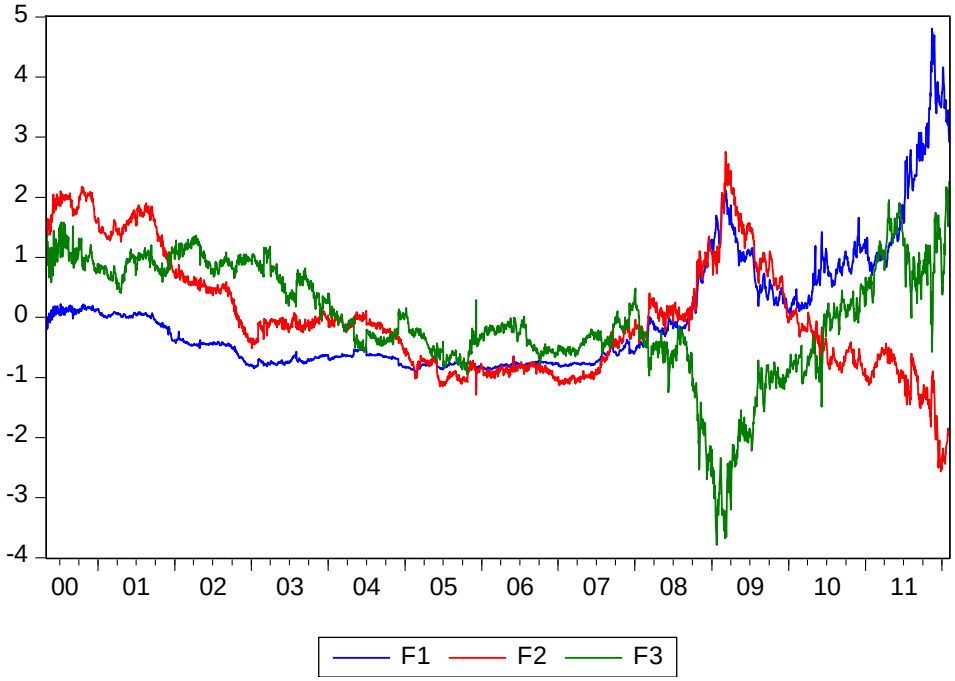


Table 1. Factor loadings

	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	

3. Sovereign bond yield spillover in Europe

3.2 Spillover and linkages across markets

Figure 1 suggests there are important interlinkages between sovereign bond markets, but that these linkages are not equally strong between all markets, and also vary over time. We first look at the spillover between all 16 EU sovereign bond markets using the GVAR model including all bond prices. We first look at the spillover between all 16 EU sovereign bond markets. Table 2 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 market *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 all spreads yields representing the common effect. The column (*row*) of the common factor represents again the spillover the common factor sends to (*receives from*) individual bond markets.[10]

Table 2 summarises this directional spillover over the full sample May 2000- February 2012. 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 spillover between individual bond markets and common factors. The total spillover amounts to 59%, meaning that more than half of the variation in sovereign bond spreads can be explained by shocks to bond spreads in other countries. The remaining 41% of all movements are caused by a purely domestic factor, i.e. idiosyncratic dynamics of the domestic spread in the past. This finding is 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 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.

[10] There are no decompositions from the exogenous variables (EONIA and VIX) and these are simple control variables. The results do not change significantly when we include both variables as endogenous.
[11] Claeys *et al.* (2011) find that about 60% of a change in long term interest rates spills over across markets.

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	59%
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	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	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

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 ranges between one half and two thirds. By contrast, the idiosyncratic change amounts to just one fourth for the EMU countries (with a 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 common factor affects – and is affected by – all bond markets. Shocks to the factor do have some persistence on the factor itself, but most of its impact flows to EMU countries.

The bilateral linkages between countries are quite distinct between non-EMU, CEE and EMU countries. The common factor has its source mainly in Belgian, Italian and Spanish bond markets. The factor has its strongest impact on Austrian, Finnish, French and Dutch bonds. 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 its 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.[12]

Among EMU countries, we can identify three groups of countries by the strength of their bilateral spillover: (i) a core of EMU countries (Austria, Finland, France and the Netherlands) where

[12] 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 spillover than the Hungarian forint, whose exchange rate is managed.

domestic factors are of minor importance, and countries affect 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 the domestic factor is also subdued in favour of mutual bilateral effects as well as the effect of common factor; and (iii) Portugal, Ireland and Greece, where domestic dynamics are slightly more important and the common factor slightly less.

The Belgian, Italian and Spanish bond markets seem to create a systemic link on European bond markets. Belgium and Italy stand out due to their relatively higher levels of public debt. Moreover, Belgium and Spain have (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. The negative value of the net spillover demonstrates the systemic importance of Belgium. The net index is the highest of all markets: the net spillover to other markets is about 1.6 times as large as the effect of a shock on its own market. This underlines the importance of shock transmission between EMU countries. By contrast, non-EMU countries are completely separate from this transmission.

3.2 Time variation

The analysis based on the 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-movement 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.

A Bai-Lumsdaine-Stock (1998) test on the overall structural stability of the VAR model for the central 70% part of the sample (between February 6th, 2002 and May 4th, 2011) shows that a significant break occurs between April 16th and April 22nd 2010 for the homoskedastic version. This break corresponds to the first crisis meeting of the Eurogroup on the Greek fiscal situation. The heteroskedastic version has a wider confidence interval between July and September 2009 and indicates the switch from a global Financial Crisis to the Eurozone debt crisis starting with Greece. The results are robust to using smaller trimming percentages at 1 and 5% respectively. 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 3 summarises the evolution of total spillover. We can see that the interdependence between 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 spillover for global stock markets (1995-2007) between 40 and 55%.[13] The total sovereign bond spillover oscillates between 55 and 70% till the end of 2007 when it significantly increases a minimum of 55% to a substantially higher level of about 80 %. We can observe some specific spikes in spillover over the 2001-2007 period, 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 overall high level of spillover confirms the evidence of other studies that movements in bond rates were driven by the similar factor. Around half of the evolution in bond rates can be explained by external factors. The decline in overall spillover since 2006 indicates a period in which investors on bond markets started to perceive sovereign issuers as distinct.

The start of the Financial Crisis in mid-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 4 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.

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

Figure 3. Total spillover plot, 200-day window, 10 steps ahead forecast, full sample (May 2000- February 2012).

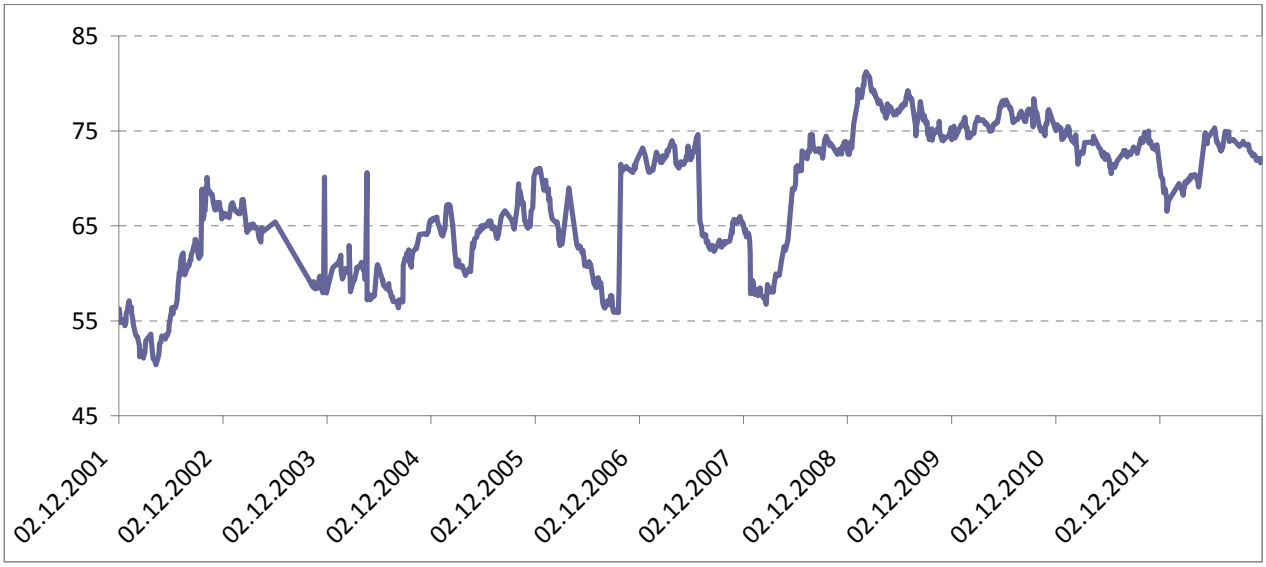
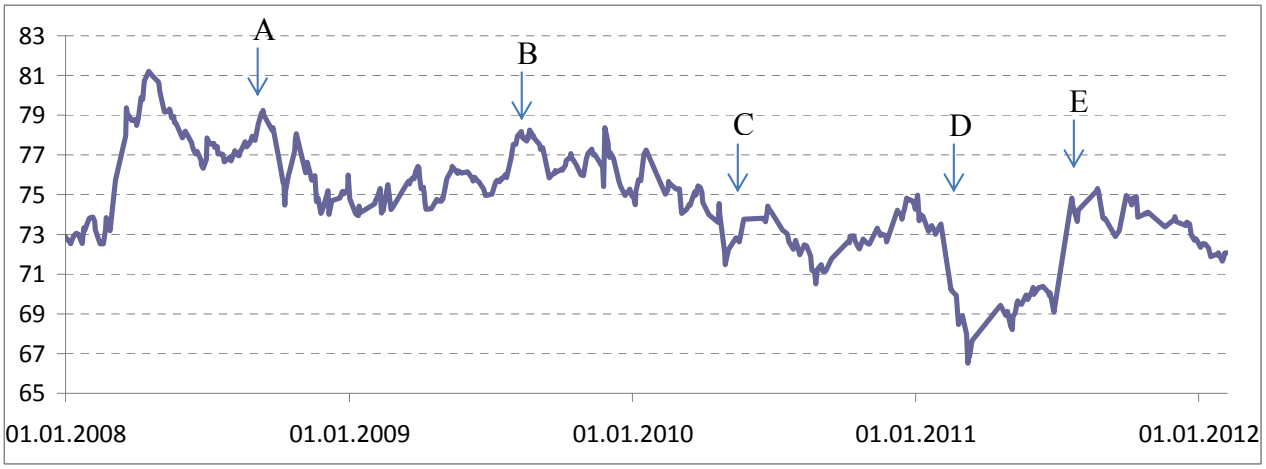


Figure 4. Total spillover plot, 200-day window, 10 steps ahead forecast, sample 2008-2011



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 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

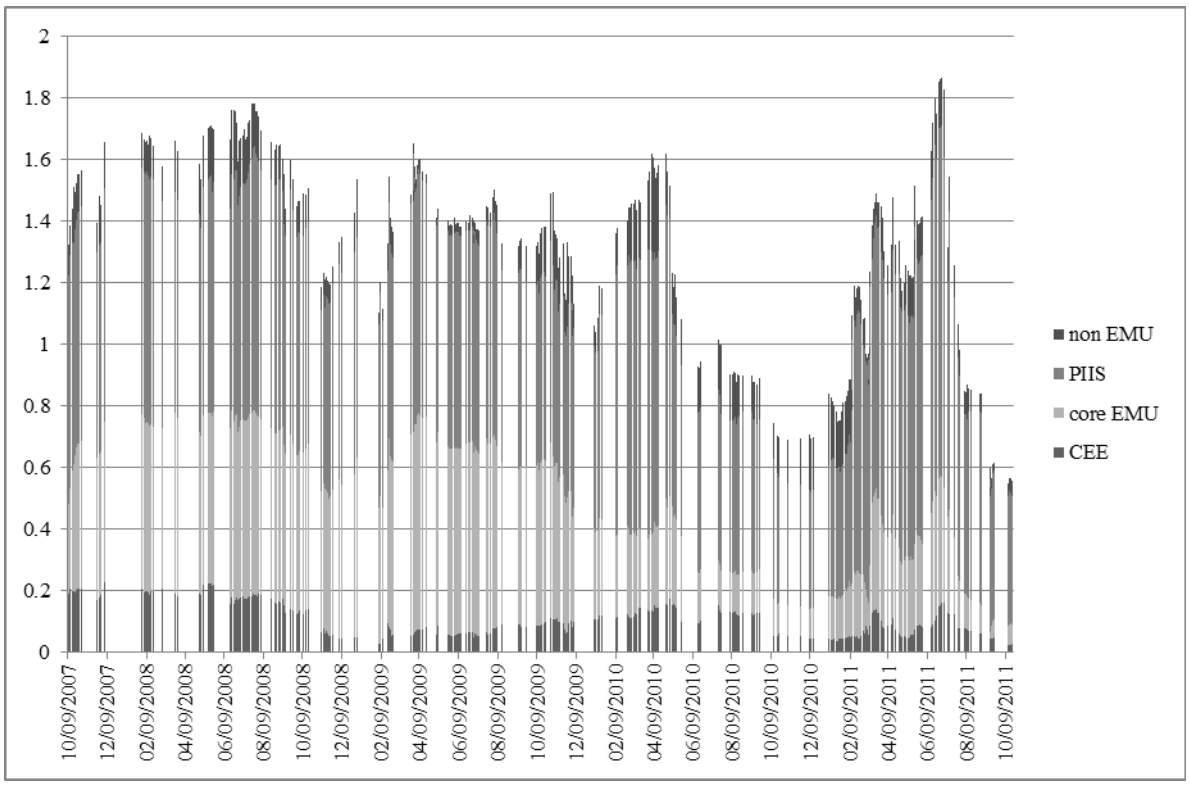
sovereign spreads in Greece on other markets is fluctuating significantly over time, and it is quite different across groups. The spillover remains stable – albeit at a high level – up to the start of the Fiscal Crisis in May 2010. The CEE and non-EMU countries are barely affected, although there can 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). 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 troubles contribute to spread movements in other PIIS and the core EMU countries.

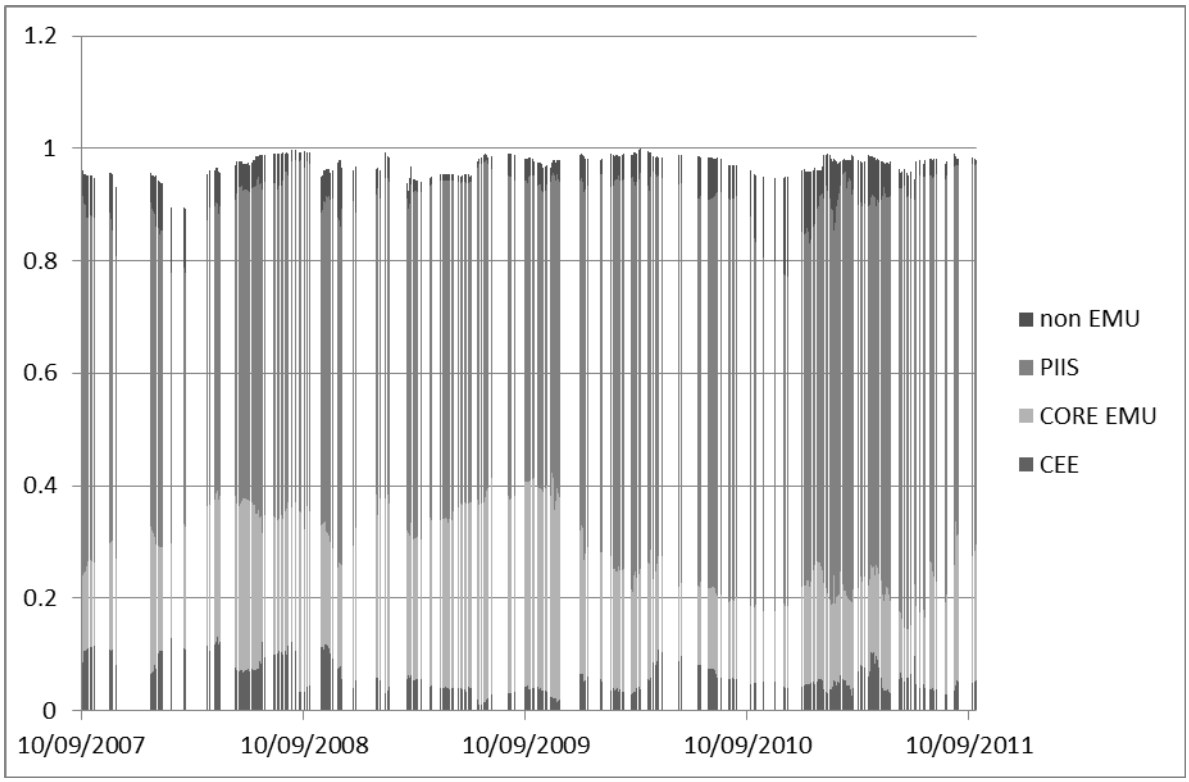
While the effect of other sovereign bond markets on Greek spreads is rather stable during the Financial Crisis, the magnitude of Greek spillover to other sovereigns varies widely and the fluctuations have sometimes a very high frequency. One plausible explanation is that it is related to the frequency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

Figure 5. 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 Alternative specifications of the FA-GVAR model

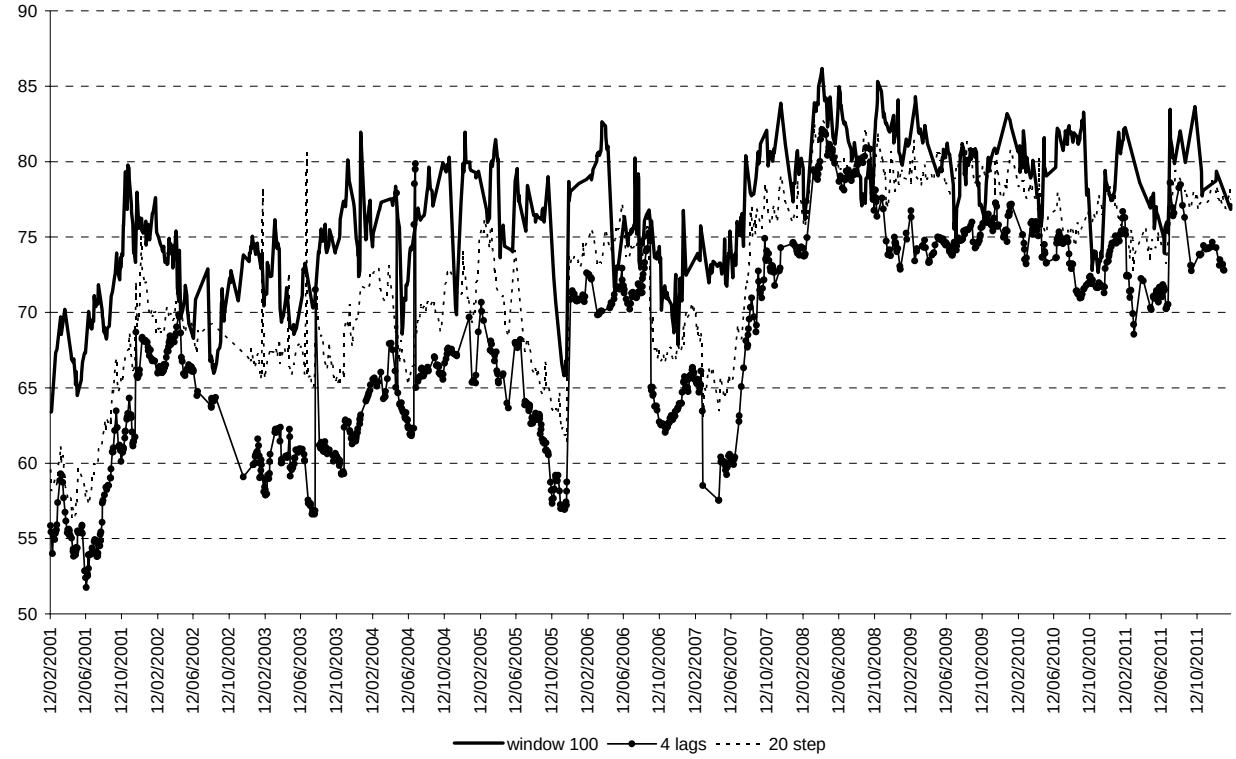
The importance of the common factor as driving total spillover across markets is shown by the evidence from a GVAR model. If the common factor is removed (see Table A.1 in Appendix), the main difference is that the total spillover decreases given as own variable shares (i.e. the diagonal elements) increase. 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.

An alternative way to take the common factor into account is to de-factorize the spread series for each country by subtracting the common factor from the spread. The series can be interpreted as the idiosyncratic spread of each country. The analysis with the defactorized series (see Table A.2 in Appendix) now has higher own variance shares, and this reflects the fact that we are looking at the idiosyncratic parts of the spread only. If the total spillover is higher than in the baseline model, this is the consequence of remaining spillover between markets, once the common factor does not absorb all these cross variance shares. The table also confirms the previous results on the direction of the bilateral spillover. Nonetheless, 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 but on the other hand, the non-EMU countries represent the shocks unrelated to core-EMU developments.

3.5 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.



4. Impact of sovereign rating news

The high frequency movements in the spillover index suggest that spillover might not be only caused by mutual linkages between bond markets. Macroeconomic news changing the outlook for public finances can trigger the sale of respective government bonds with consequence of raising its yield spread vis-à-vis a benchmark rate. One particular event that has sparked quite some controversy is rating news. Announcements by the main credit rating agencies of changing the credit rating or revising the rating outlook of a certain sovereign issuer seem to provoke quick reactions in the bond market. Moreover, rating news seems to have triggered similar reactions in bond markets of other sovereigns. 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).

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.

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). However, the situation of the EU countries is very specific as their economies are very interconnected and sovereign debt of one country cannot be simply understood as a substitute for another. Afonso *et al.* (2011) extend this evidence on sovereign bond and CDS spreads of EU countries and find a 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 VAR with sovereign CDS spreads but the effects depend on which country suffers the downgrade and which rating agency gives its verdict. A negative chain reaction could only happen if there are systematic spillover effects across EMU countries. They argue that these systematic linkages are responsible for the diffusion of negative rating news.

However, the dynamic relationship between spreads and rating news is rather complex because the anticipation by markets of rating news, and hence sovereign risk premia might look like triggering a rating decision but the latter can in turn affect the sovereign risk premia. Moreover, the horizon of the impact is rather uncertain, as is the scope of any single rating revision. Rating decisions by some agency overlap with the decisions of the other two agencies. Much other macroeconomic news occurs that further contaminates the sample.

4.1 Measuring the impact and spillover of sovereign rating news

To deal with these points, we further extend the previous analysis and include a dummy for rating adjustments as in 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.

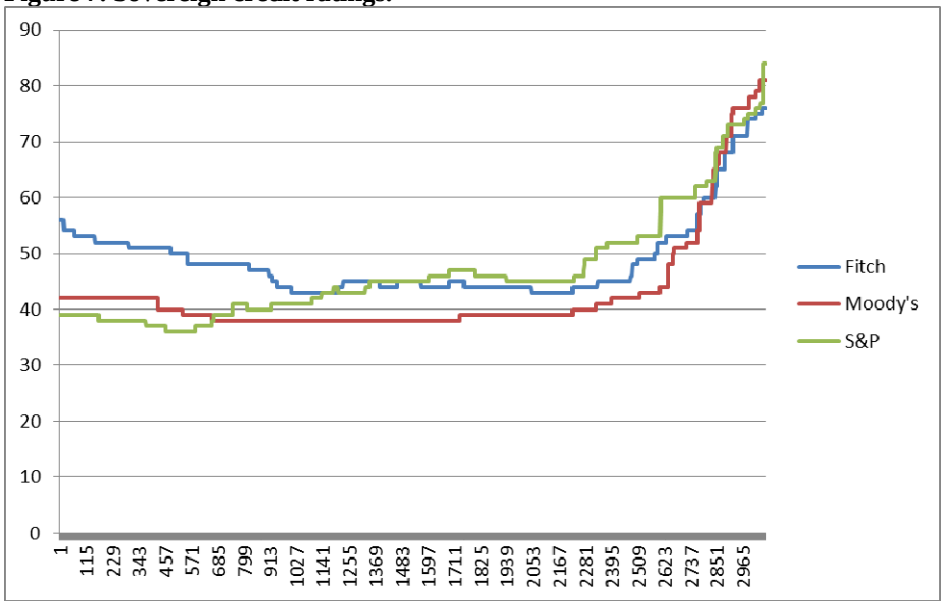
We track the effect on the sovereign rates following a 'dummy shock', as in (8) where z_t include the bond yields spreads x_t as in (1) as well as the dummy for rating news:

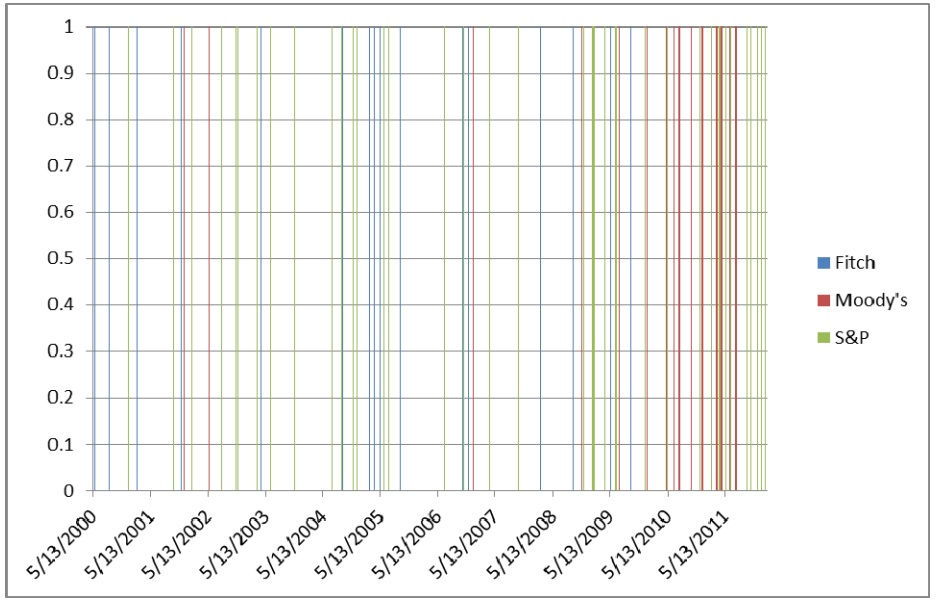
$$z_t = \sum_{i=1}^{p} \Phi_i z_{t-i} + \varepsilon_t \tag{8}$$

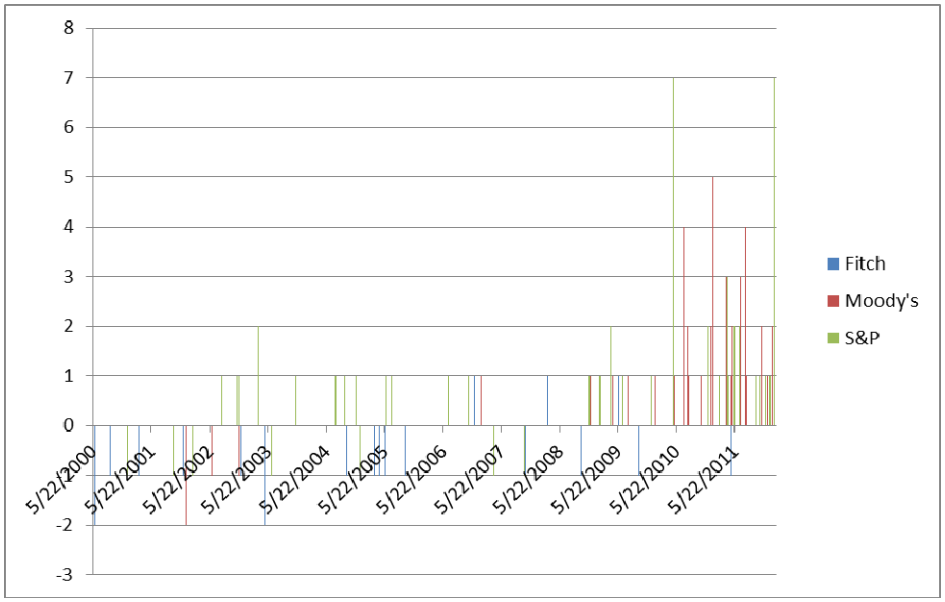
These dummies corresponding to the dates for the rating changes and we use both (i) *a step-dummy* where each rating category is assigned a particular numerical values on selected scale of all countries (going from a maximum of AAA to a minimum of D as in Arezki *et al.* (2011), or (ii) *an impulse dummy* 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.

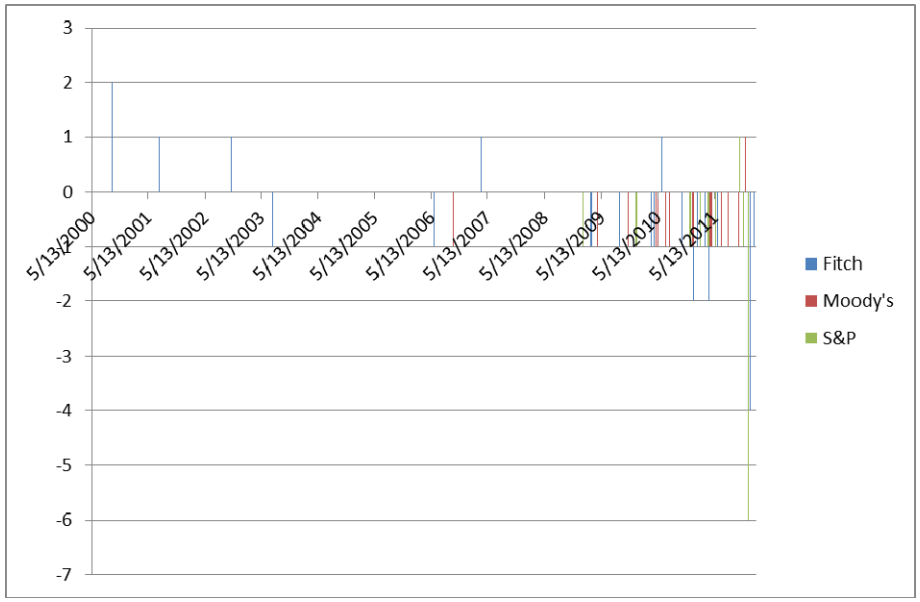
The sovereign ratings are local currency long-term debt for each country from the main credit rating agencies (S&P, Moody's, Fitch). As noted before, there are different possible ways to create variable tracking the rating actions. Figure 7 demonstrates this. Panel a) tracks the overall evolution of 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 real news.

Figure 7. Sovereign credit ratings.









4.2 Rating news and spillover

We now replicate the same FA-GVAR model and test for the spillover between bond markets and the overall EU step-dummy for the rating change (see the upper left panel in Figure 7). Table 2a reports the bilateral linkages for the full sample and with the rating variable included as an additional endogenous variable. The total spillover is not affected much by the inclusion of the rating (it falls to 55%) given that the rating variable absorbs a lot of its own dynamics. The results for a VAR including an impulse dummy (see the upper right panel in Figure 2) are rather similar (Table 2b). Therefore, rating actions do not have a major impact on the overall spillover within the sovereign bond market, which implies that rating news by itself has not been driving the spillover across markets. However, the Tables 2a and 2b provide some finer details on the dynamic relationship between the sovereign rating news and sovereign bond yield spreads.

First, it seems that the spillover runs both from bond yield spreads towards rating actions and vice versa. The bottom row of Table 2a shows a spillover of 7.42 transmitted by the step-dummy rating variable to the bond markets, whereas the spillover absorbed from the bond markets is just 4.76. A similar finding is visible also in Table 2b, with the difference that spillover transmitted and absorbed by the impulse-dummy rating variable is almost negligible. A further look at Tables 2 shows some interesting findings: the country most affected by overall rating actions is Portugal and Ireland. On the contrary, it is not just the changes in spreads in PIIGS that trigger a rating change. Other countries affecting the rating change too are France and Belgium. The finding for Belgium seems to corroborate on the result in Table 1 that the country has a systemic importance in European sovereign bond markets. 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.

As noted above, with respect to decisions of credit rating agencies it is not obvious what event represent proper news that might trigger but also be triggered by sovereign yield spread dynamics. In what follows we explore alternative ways of tracking the ratings action that than an overall rating level / changes by three rating agencies along different dimensions: (i) distinguishing between rating downgrades and upgrades (Table 3), (ii) testing effect of rating outlook changes rather then rating changes itself (Table 4), (iii) separating the rating changes of different rating

agencies, and (iv) separating the rating actions on different sovereigns. In what follows we report the results using rating impulse-dummy variable as in Table 2b.

Table 2a. Spillover table rating step-dummy variable, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	RATING	From Others
CZE	53.74	7.59	6.96	2.50	0.49	0.74	1.53	2.51	3.13	3.75	0.65	0.55	1.60	4.22	1.07	0.03	8.91	0.01	46.26
POL	6.95	62.36	6.69	1.06	0.19	0.22	0.69	1.57	2.14	2.73	0.93	0.88	1.65	5.50	0.92	0.03	5.49	0.01	37.64
HUN	6.75	8.58	51.02	2.37	0.51	0.43	0.76	3.45	3.57	4.05	2.02	2.02	3.77	3.37	0.07	0.06	7.13	0.06	48.98
AUT	1.68	1.53	2.88	22.86	3.87	6.77	9.62	10.82	6.97	8.88	1.78	1.20	3.24	0.42	0.15	0.10	17.18	0.05	77.14
FIN	1.49	0.93	0.96	8.90	27.92	11.46	8.74	7.52	3.77	4.58	1.08	0.82	2.92	0.97	0.62	0.71	16.59	0.01	72.08
NLD	1.58	0.81	1.79	7.99	8.61	26.79	8.36	7.41	4.99	4.99	1.38	1.85	3.87	1.45	0.60	1.08	16.39	0.05	73.21
FRA	1.52	1.32	1.89	10.22	3.93	7.03	19.75	11.52	7.39	11.12	1.96	0.88	2.57	1.12	0.49	0.33	16.96	0.01	80.25
BEL	1.68	1.42	2.20	7.66	2.59	4.89	8.13	21.47	12.77	13.50	1.54	1.58	4.86	0.27	0.31	0.11	14.92	0.10	78.53
ESP	1.36	1.04	1.52	5.72	1.41	3.83	6.35	10.48	27.91	15.13	2.40	2.50	6.79	0.17	0.35	0.40	12.51	0.13	72.09
ITA	1.77	1.41	1.72	4.14	1.23	2.79	4.11	12.23	17.49	27.35	2.65	2.99	5.96	0.22	0.14	0.11	13.63	0.06	72.65
GRC	1.09	0.78	1.24	2.88	1.60	2.23	4.63	8.59	8.23	7.20	40.94	3.42	7.64	0.01	0.11	0.23	8.77	0.43	59.06
PRT	0.68	0.68	1.58	2.55	0.22	1.01	1.02	7.85	8.55	6.16	4.65	37.53	15.44	0.02	0.02	0.02	7.44	4.57	62.47
IRE	1.03	0.79	1.30	3.48	1.84	2.72	3.53	7.41	8.98	4.74	4.72	8.69	39.96	0.01	0.01	0.05	9.33	1.41	60.04
DNK	3.99	4.11	4.83	1.23	2.16	2.24	2.20	0.53	0.28	0.32	0.30	0.23	0.30	64.23	5.30	0.18	7.56	0.02	35.77
SWE	1.48	1.18	0.48	0.17	0.69	0.91	0.43	0.20	1.10	0.41	0.18	1.32	0.50	4.58	83.43	0.58	1.99	0.38	16.57
GBR	0.22	0.16	0.12	0.32	0.83	1.91	0.52	0.26	2.29	0.99	0.35	1.27	0.96	0.13	1.07	86.52	2.08	0.01	13.48
FACTOR	3.25	2.34	3.12	9.42	4.61	6.84	8.12	11.36	9.40	11.33	2.47	2.75	5.93	1.36	0.48	0.36	16.74	0.11	83.26
RATING	0.03	0.01	0.01	0.17	0.07	0.08	0.25	0.27	0.08	0.04	0.29	0.06	3.02	0.03	0.15	0.02	0.21	95.24	4.76
To others	36.56	34.68	39.31	70.79	34.84	56.08	68.99	103.97	101.12	99.92	29.35	33.01	71.02	23.85	11.86	4.40	167.07	7.42	994.25
To others (+ own)	90.31	97.05	90.34	93.64	62.77	82.87	88.74	125.44	129.03	127.26	70.29	70.54	110.98	88.08	95.29	90.91	183.81	102.66	55.2%
From others	46.26	37.64	48.98	77.14	72.08	73.21	80.25	78.53	72.09	72.65	59.06	62.47	60.04	35.77	16.57	13.48	83.26	4.76	
Net spillover	9.69	2.95	9.66	6.36	37.23	17.13	11.26	-25.44	-29.03	-27.26	29.71	29.46	-10.98	11.92	4.71	9.09	-83.81	-2.66	

Table 3b. Spillover table, rating impulse-dummy variable, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	RATING	From Others
CZE	52.56	7.48	6.62	2.48	0.52	0.74	1.65	2.72	3.49	4.00	0.81	0.89	1.95	4.02	0.91	0.03	9.12	0.02	47.44
POL	6.96	61.01	6.37	1.07	0.20	0.22	0.76	1.75	2.47	2.94	1.15	1.31	1.99	5.26	0.78	0.02	5.71	0.03	38.99
HUN	6.87	8.75	54.36	2.31	0.45	0.41	0.63	2.97	3.01	3.57	1.72	1.46	3.14	3.57	0.09	0.06	6.64	0.01	45.64
AUT	1.71	1.52	2.58	21.64	3.77	6.43	9.51	10.94	7.48	9.13	2.11	1.80	3.80	0.37	0.08	0.07	17.03	0.02	78.36
FIN	1.54	0.95	0.79	8.44	26.15	10.69	8.75	7.91	4.48	5.03	1.46	1.64	3.66	0.84	0.40	0.59	16.57	0.10	73.85
NLD	1.60	0.83	1.61	7.75	8.37	25.48	8.37	7.66	5.43	5.28	1.61	2.46	4.38	1.34	0.46	0.97	16.36	0.02	74.52
FRA	1.55	1.32	1.56	9.51	3.78	6.48	18.82	11.72	8.19	11.45	2.43	1.62	3.34	0.95	0.27	0.25	16.73	0.02	81.18
BEL	1.68	1.40	1.78	7.06	2.51	4.46	8.01	20.82	13.33	13.53	1.96	2.60	5.73	0.21	0.13	0.07	14.68	0.03	79.18
ESP	1.36	1.04	1.15	5.25	1.43	3.45	6.40	10.64	27.07	14.83	2.90	3.72	7.78	0.13	0.13	0.27	12.37	0.08	72.93
ITA	1.75	1.37	1.40	3.89	1.24	2.59	4.20	12.26	17.59	26.15	3.07	4.04	6.72	0.17	0.06	0.07	13.39	0.01	73.85
GRC	1.11	0.79	0.74	2.61	1.59	1.91	4.87	9.32	9.64	7.80	35.35	5.98	8.96	0.01	0.01	0.11	9.03	0.16	64.65
PRT	0.74	0.67	0.88	2.25	0.32	0.87	1.41	8.57	9.78	6.57	5.46	36.05	15.92	0.01	0.13	0.03	7.62	2.71	63.95
IRE	1.04	0.80	0.96	3.27	1.83	2.46	3.75	7.79	9.59	4.98	5.08	9.91	37.82	0.01	0.04	0.03	9.37	1.26	62.18
DNK	4.02	4.11	4.79	1.22	2.16	2.24	2.23	0.56	0.24	0.32	0.33	0.32	0.35	64.07	5.21	0.18	7.59	0.06	35.93
SWE	1.26	1.00	0.58	0.15	0.57	0.83	0.37	0.22	0.47	0.30	0.04	0.16	0.10	4.66	86.95	0.63	1.43	0.28	13.05
GBR	0.20	0.15	0.14	0.33	0.83	1.89	0.52	0.25	1.96	0.84	0.31	0.93	0.80	0.13	1.14	87.63	1.94	0.01	12.37
FACTOR	3.15	2.25	2.62	8.73	4.39	6.27	8.00	11.48	10.02	11.46	2.91	3.86	6.75	1.16	0.28	0.28	16.39	0.02	83.61
RATING	0.10	0.01	0.13	0.33	0.09	0.10	0.17	0.87	0.22	0.39	0.17	0.24	1.12	0.03	0.09	0.02	0.29	95.61	4.39
To others	36.65	34.45	34.69	66.66	34.06	52.05	69.61	107.63	107.40	102.44	33.51	42.94	76.49	22.88	10.21	3.67	165.87	4.86	1006.08
To others (+ own)	89.21	95.45	89.05	88.30	60.22	77.53	88.43	128.45	134.46	128.59	68.86	78.99	114.31	86.95	97.17	91.30	182.26	100.47	55.9%
From others	47.44	38.99	45.64	78.36	73.85	74.52	81.18	79.18	72.93	73.85	64.65	63.95	62.18	35.93	13.05	12.37	83.61	4.39	
Net spillover	10.79	4.55	10.95	11.70	39.78	22.47	11.57	-28.45	-34.46	-28.59	31.14	21.01	-14.31	13.05	2.83	8.70	-82.26	-0.47	

Tables 3a and 3b report results when we use the impulse dummy for rating actions as in Table 2b but separate the downgrades and upgrades (by any of the three rating agencies). The results suggest that distinguishing the direction of a rating action matters. In particular, the rating downgrades both receive and transmit more spillover to the sovereign bond markets. The impact of and from individual sovereign bond markets is somewhat weaker than in the previous case and it seems that rating downgrades follow more the developments in sovereign bond markets (spillover absorbed is 4.88) than vice versa (spillover transmitted is 2.58). The latter holds when we consider rating downgrades (Figure 3b) but the overall interrelation with bond markets is weaker.

Table 4 report the result when we use an impulse dummy for outlook changes (but in this case we do not separate the positive and negative outlook assignments). This evidence seem to suggest quite more spillover across markets (as compared to Table 2b). But it also seems that rating agencies react stronger to sovereign bond markets when deciding on changing rating outlook than changing the rating itself (8.25 vs. 4.39). On the contrary, the response of bond markets to changes in rating outlook is weaker (2.42 vs. 4.86). This can come a bit as a surprise given that outlook changes signalize future rating changes and as such can be deemed to represent more news that actual change of rating. Yet, it seems that bond markets might not be convinced until the change is actually carried out.

Table 5 disaggregates the impact of rating changes according to the rating agency. Although the sovereign rating grades assigned by different rating agencies need not coincide, the rating decisions – especially for downgrades – often do. This is evident from the step-dummy for rating changes reported in upper left panel of Figure 7. Still, there are some interesting differences. In the pre-crisis period, we can see while the overall level of rating of EU sovereign has been rather improving (decrease of overall value of step dummy) according to Fitch, and it has been worsening according to the S&P, Moody's took very few rating actions at all. Since the onset of the crisis in 2008/09 all three agencies have been very active. Consequently, Table 5 reports the rating spillover when actions by each rating agency are considered separately. This allows us to evaluate additionally the spillover between the rating dummies.

Unlike the evidence in Table 2b (and consistently with the step-dummy approach in Table 2a) it seems that there is more effect of spreads on rating decisions than vice-versa. In Table 5 we can see that it is mainly due to result for S&P where the spillover absorbed substantially exceeds spillover transmitted. Second, there seems to be some kind of interplay between the rating decision of S&P and Fitch, while Moody's is rather detached from the rating decisions of the other two

agencies. Third, it seems that that Portugal and Ireland are the two countries whose bond yield spreads absorbs the most spillover from rating decisions. On the contrary, the spillover from spreads towards rating decisions is driven mainly by spread dynamics of core-EMU countries such as Austria, Belgium or France.

Finally, to evaluate the potential international spillover of the rating actions it seems useful to separate rating actions on individual sovereigns given that the severity of rating actions is concentrated to a few sovereigns. For instance, Greece was for instance subject to 13 rating actions (including the outlook revisions) by S&P, Portugal and Ireland to 9 etc. These rating actions are heavily concentrated in the later part of the sample from 2008 onwards. When including the three rating series, we confirm the previous finding that rating changes are more affected by sovereign bond markets than vice versa. When tracking the spillover of a rating decision on a single sovereign, the impact of a country's rating change - in particular a downgrade – affects more sovereign spreads of other countries than it is own. For instance, a Greek downgrade affects spreads of Portugal and Ireland, while the impact on Greek spread is very limited. Similarly, the Portuguese and Irish sovereign spreads imply major spillover towards the Greek rating variable than the dynamics of Greek sovereign spreads themselves.

4.3 Impact of rating news

The results of analysis reported in Table 6 suggest international spillover of rating decisions. All of the previous analysis was based on FEVD from the FA-GVAR. We can also look at the effect of a rating action on domestic and foreign sovereign bond spreads (and vice versa). Yet, it is of importance to learn the impact effect of a rating change on the bond spread in the FA-GVAR. Figure 7a-c show the 90% bands around the bond spread movement of all 16 EU markets after a shock to the impulse-dummy of Greece, Portugal and Ireland respectively (considering the action of all three rating agencies jointly). Figure 7a shows that a rating change, i.e. downgrade, of Greek sovereign bonds significantly increases the spread for all PIIGS countries while the spread of almost all other countries decreases. Similar findings can be observed in Figures 7b and 7c for Portugal and Ireland. We can also see that most of the impact can be observed rather quickly, i.e. within around 5 days After 10 days, the spread rises by 4 to 20 basis points. We obtain similar results if we consider only downgrades, albeit the effects are slightly stronger.

Table 3a. Spillover table, rating impulse-dummy variable for rating downgrades, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	RATING	From Others
CZE	52.42	7.47	6.61	2.45	0.51	0.74	1.63	2.71	3.51	3.99	0.85	0.91	1.98	4.03	0.90	0.03	9.11	0.16	47.58
POL	6.90	61.09	6.34	1.06	0.20	0.23	0.76	1.76	2.46	2.95	1.15	1.21	1.98	5.31	0.78	0.02	5.72	0.08	38.91
HUN	6.83	8.76	54.36	2.31	0.45	0.42	0.62	2.98	3.01	3.59	1.72	1.38	3.13	3.60	0.09	0.05	6.66	0.04	45.64
AUT	1.66	1.51	2.52	21.61	3.79	6.50	9.54	10.94	7.48	9.13	2.10	1.64	3.78	0.38	0.08	0.08	17.03	0.21	78.39
FIN	1.50	0.94	0.77	8.42	26.20	10.76	8.77	7.90	4.47	5.02	1.44	1.48	3.64	0.86	0.40	0.62	16.56	0.25	73.80
NLD	1.60	0.83	1.60	7.75	8.38	25.51	8.39	7.66	5.44	5.28	1.62	2.34	4.37	1.35	0.47	0.97	16.37	0.06	74.49
FRA	1.51	1.31	1.51	9.47	3.80	6.54	18.90	11.71	8.19	11.44	2.42	1.46	3.32	0.97	0.27	0.27	16.73	0.19	81.10
BEL	1.65	1.39	1.74	7.05	2.53	4.51	8.06	20.87	13.37	13.56	1.97	2.39	5.70	0.22	0.14	0.08	14.70	0.05	79.13
ESP	1.35	1.03	1.14	5.22	1.42	3.45	6.38	10.61	27.18	14.82	2.99	3.68	7.80	0.13	0.13	0.27	12.37	0.02	72.82
ITA	1.74	1.38	1.39	3.92	1.26	2.62	4.24	12.31	17.65	26.24	3.06	3.75	6.68	0.18	0.06	0.07	13.45	0.01	73.76
GRC	1.15	0.81	0.79	2.69	1.59	1.88	4.89	9.39	9.66	7.84	35.26	5.85	8.95	0.01	0.01	0.09	9.11	0.03	64.74
PRT	0.83	0.69	1.01	2.32	0.30	0.82	1.35	8.64	9.96	6.63	5.87	37.15	16.16	0.01	0.14	0.04	7.74	0.35	62.85
IRE	1.08	0.80	1.00	3.28	1.80	2.43	3.72	7.80	9.73	5.00	5.36	10.22	38.08	0.01	0.05	0.02	9.43	0.21	61.92
DNK	3.97	4.12	4.74	1.23	2.18	2.25	2.24	0.56	0.24	0.32	0.30	0.25	0.34	64.14	5.23	0.18	7.59	0.12	35.86
SWE	1.22	0.98	0.55	0.14	0.56	0.84	0.37	0.23	0.47	0.31	0.04	0.16	0.10	4.64	86.64	0.65	1.41	0.68	13.36
GBR	0.22	0.15	0.15	0.33	0.84	1.89	0.53	0.25	1.97	0.86	0.30	0.86	0.77	0.13	1.17	87.56	1.96	0.06	12.44
FACTOR	3.13	2.25	2.60	8.72	4.40	6.31	8.02	11.49	10.05	11.47	2.93	3.67	6.73	1.18	0.28	0.28	16.42	0.06	83.58
RATING	0.17	0.04	0.14	0.50	0.47	0.33	0.45	0.37	0.27	0.13	0.67	0.10	0.14	0.15	0.25	0.12	0.57	95.12	4.88
To others	36.53	34.46	34.59	66.87	34.50	52.51	69.97	107.31	107.92	102.33	34.81	41.34	75.56	23.16	10.46	3.86	166.50	2.58	1005.25
To others (+ own)	88.95	95.55	88.95	88.47	60.70	78.02	88.87	128.18	135.10	128.57	70.07	78.49	113.64	87.29	97.10	91.42	182.92	97.70	56%
From others	47.58	38.91	45.64	78.39	73.80	74.49	81.10	79.13	72.82	73.76	64.74	62.85	61.92	35.86	13.36	12.44	83.58	4.88	
Net spillover	11.05	4.45	11.05	11.53	39.30	21.98	11.13	-28.18	-35.10	-28.57	29.93	21.51	-13.64	12.71	2.90	8.58	-82.92	2.30	

Table 3b. Spillover table, rating impulse-dummy variable for rating upgrades, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	RATING	From Others
CZE	52.47	7.50	6.63	2.52	0.52	0.75	1.66	2.75	3.48	4.02	0.79	0.83	1.94	4.03	0.90	0.03	9.15	0.02	47.53
POL	6.99	61.08	6.38	1.10	0.21	0.22	0.77	1.78	2.44	2.96	1.09	1.10	1.96	5.34	0.79	0.02	5.74	0.01	38.92
HUN	6.88	8.78	54.40	2.35	0.46	0.42	0.64	3.00	2.99	3.60	1.65	1.30	3.11	3.60	0.09	0.06	6.68	0.01	45.60
AUT	1.68	1.54	2.57	21.78	3.83	6.50	9.60	11.00	7.44	9.17	2.01	1.51	3.70	0.39	0.09	0.08	17.09	0.01	78.22
FIN	1.53	0.97	0.79	8.52	26.29	10.77	8.82	7.95	4.45	5.05	1.38	1.38	3.58	0.87	0.41	0.60	16.62	0.02	73.71
NLD	1.61	0.84	1.62	7.77	8.38	25.55	8.39	7.67	5.44	5.29	1.60	2.30	4.36	1.36	0.47	0.96	16.38	0.01	74.45
FRA	1.52	1.34	1.54	9.57	3.83	6.56	18.97	11.76	8.16	11.49	2.34	1.37	3.25	0.97	0.28	0.26	16.78	0.01	81.03
BEL	1.67	1.42	1.77	7.12	2.55	4.51	8.10	20.93	13.34	13.59	1.90	2.29	5.64	0.22	0.14	0.07	14.74	0.01	79.07
ESP	1.35	1.04	1.15	5.24	1.43	3.46	6.40	10.64	27.19	14.85	2.93	3.62	7.78	0.13	0.13	0.27	12.39	0.00	72.81
ITA	1.75	1.39	1.40	3.93	1.26	2.62	4.25	12.33	17.64	26.28	3.02	3.69	6.66	0.18	0.06	0.07	13.46	0.00	73.72
GRC	1.12	0.79	0.76	2.59	1.56	1.89	4.82	9.29	9.69	7.78	35.49	6.04	9.02	0.01	0.01	0.11	9.02	0.00	64.51
PRT	0.80	0.66	0.98	2.20	0.27	0.81	1.30	8.52	9.99	6.53	5.93	37.65	16.46	0.01	0.15	0.04	7.63	0.08	62.35
IRE	1.05	0.80	1.00	3.23	1.78	2.45	3.69	7.78	9.77	4.98	5.34	10.36	38.25	0.01	0.05	0.03	9.41	0.03	61.75
DNK	3.97	4.13	4.74	1.25	2.21	2.28	2.27	0.57	0.24	0.33	0.29	0.23	0.33	64.12	5.23	0.19	7.62	0.02	35.88
SWE	1.24	1.01	0.56	0.15	0.58	0.85	0.38	0.23	0.46	0.31	0.03	0.13	0.09	4.68	87.11	0.65	1.44	0.09	12.89
GBR	0.23	0.15	0.15	0.33	0.82	1.85	0.52	0.25	1.96	0.84	0.31	0.90	0.81	0.14	1.16	87.61	1.93	0.05	12.39
FACTOR	3.14	2.27	2.62	8.78	4.42	6.32	8.05	11.53	10.03	11.50	2.87	3.57	6.69	1.18	0.29	0.28	16.46	0.00	83.54
RATING	0.26	0.07	0.21	0.12	0.04	0.06	0.09	0.26	0.03	0.01	0.02	0.01	0.18	0.03	0.04	0.14	0.04	98.40	1.60
To others	36.80	34.69	34.87	66.76	34.16	52.31	69.75	107.31	107.53	102.30	33.51	40.66	75.55	23.15	10.28	3.84	166.12	0.36	999.95
To others (+ own)	89.27	95.77	89.26	88.55	60.45	77.86	88.71	128.24	134.72	128.58	69.00	78.31	113.81	87.28	97.39	91.45	182.57	98.76	56%
From others	47.53	38.92	45.60	78.22	73.71	74.45	81.03	79.07	72.81	73.72	64.51	62.35	61.75	35.88	12.89	12.39	83.54	1.60	
Net spillover	10.73	4.23	10.74	11.45	39.55	22.14	11.29	-28.24	-34.72	-28.58	31.00	21.69	-13.81	12.72	2.61	8.55	-82.57	1.24	

Table 4. Spillover table, rating impulse-dummy variable for rating outlook, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	REVISION	From Others
CZE	52.01	7.47	6.62	2.62	0.51	0.77	1.70	2.85	3.59	4.07	0.85	0.81	1.93	4.00	0.91	0.03	9.25	0.01	47.99
POL	6.91	61.01	6.37	1.12	0.21	0.23	0.78	1.81	2.47	2.98	1.11	1.12	1.94	5.30	0.79	0.02	5.79	0.02	38.99
HUN	6.89	8.78	54.35	2.36	0.46	0.42	0.63	3.01	2.99	3.59	1.66	1.31	3.09	3.60	0.09	0.06	6.70	0.01	45.65
AUT	1.69	1.53	2.64	21.82	3.79	6.41	9.56	10.87	7.31	9.30	1.90	1.59	3.80	0.41	0.09	0.07	17.13	0.10	78.18
FIN	1.49	0.96	0.81	8.52	26.19	10.75	8.81	7.91	4.41	5.11	1.34	1.41	3.62	0.88	0.41	0.60	16.64	0.15	73.81
NLD	1.59	0.83	1.67	7.64	8.30	25.55	8.30	7.50	5.30	5.36	1.49	2.40	4.44	1.40	0.46	0.97	16.34	0.47	74.45
FRA	1.52	1.33	1.58	9.54	3.78	6.48	19.01	11.69	8.07	11.61	2.26	1.41	3.32	1.01	0.28	0.25	16.81	0.06	80.99
BEL	1.67	1.41	1.81	7.07	2.52	4.46	8.07	20.90	13.25	13.72	1.82	2.35	5.73	0.24	0.13	0.07	14.76	0.05	79.10
ESP	1.37	1.03	1.17	5.19	1.40	3.41	6.36	10.56	27.11	14.92	2.86	3.68	7.85	0.14	0.13	0.26	12.37	0.20	72.89
ITA	1.78	1.38	1.39	3.90	1.27	2.61	4.23	12.30	17.57	26.29	2.99	3.72	6.68	0.18	0.06	0.07	13.47	0.11	73.71
GRC	1.12	0.78	0.80	2.46	1.50	1.78	4.71	9.09	9.51	7.90	35.59	6.27	9.21	0.01	0.02	0.10	8.95	0.19	64.41
PRT	0.79	0.66	0.95	2.23	0.28	0.85	1.32	8.57	9.99	6.45	5.99	37.23	16.20	0.01	0.15	0.03	7.64	0.65	62.77
IRE	1.07	0.79	1.00	3.24	1.77	2.43	3.69	7.79	9.74	4.98	5.33	10.33	38.26	0.01	0.05	0.02	9.42	0.06	61.74
DNK	3.95	4.11	4.77	1.25	2.16	2.25	2.25	0.56	0.24	0.33	0.29	0.23	0.33	63.99	5.22	0.18	7.60	0.28	36.01
SWE	1.26	1.01	0.57	0.15	0.58	0.84	0.38	0.23	0.45	0.31	0.03	0.13	0.09	4.71	87.21	0.63	1.43	0.01	12.79
GBR	0.21	0.15	0.14	0.32	0.82	1.85	0.51	0.23	1.90	0.83	0.28	0.95	0.81	0.13	1.13	87.82	1.90	0.02	12.18
FACTOR	3.15	2.26	2.66	8.76	4.38	6.28	8.03	11.47	9.95	11.59	2.80	3.64	6.76	1.20	0.28	0.28	16.48	0.02	83.52
REVISION	0.11	0.11	0.03	0.69	0.07	0.17	1.36	1.08	1.87	0.47	0.29	0.73	0.18	0.28	0.12	0.31	0.39	91.75	8.25
To others	36.58	34.58	34.99	67.05	33.82	51.97	70.72	107.50	108.61	103.51	33.29	42.07	75.97	23.51	10.31	3.95	166.60	2.42	1007.44
To others (+ own)	88.59	95.59	89.34	88.87	60.00	77.52	89.73	128.40	135.72	129.79	68.88	79.30	114.23	87.49	97.52	91.78	183.09	94.17	56.0%
From others	47.99	38.99	45.65	78.18	73.81	74.45	80.99	79.10	72.89	73.71	64.41	62.77	61.74	36.01	12.79	12.18	83.52	8.25	
Net spillover	11.41	4.41	10.66	11.13	40.00	22.48	10.27	-28.40	-35.72	-29.79	31.12	20.70	-14.23	12.51	2.48	8.22	-83.09	5.83	

Table 5. Spillover table, rating impulse-dummy variable, rating agencies separately

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	Fitch	Moodys	S&P	From Others
CZE	52.46	7.46	6.53	2.46	0.51	0.72	1.63	2.75	3.52	4.01	0.80	0.86	2.00	4.01	0.91	0.02	9.07	0.24	0.00	0.04	47.54
POL	6.95	61.13	6.37	1.05	0.19	0.21	0.75	1.76	2.44	2.95	1.12	1.25	1.92	5.27	0.78	0.02	5.65	0.16	0.01	0.01	38.87
HUN	6.82	8.72	54.23	2.29	0.44	0.40	0.62	3.00	3.03	3.58	1.69	1.42	3.19	3.55	0.09	0.06	6.60	0.17	0.02	0.09	45.77
AUT	1.71	1.51	2.58	21.56	3.75	6.39	9.48	10.93	7.47	9.13	2.11	1.80	3.82	0.37	0.08	0.08	16.98	0.12	0.01	0.10	78.44
FIN	1.55	0.94	0.80	8.44	26.12	10.68	8.76	7.93	4.46	5.04	1.45	1.62	3.62	0.85	0.41	0.59	16.55	0.17	0.00	0.01	73.88
NLD	1.59	0.83	1.60	7.73	8.34	25.38	8.34	7.68	5.45	5.30	1.61	2.45	4.44	1.35	0.47	0.97	16.32	0.01	0.00	0.13	74.62
FRA	1.56	1.32	1.57	9.48	3.76	6.46	18.76	11.69	8.17	11.43	2.43	1.64	3.37	0.96	0.27	0.25	16.70	0.10	0.01	0.04	81.24
BEL	1.70	1.40	1.81	7.05	2.50	4.45	7.99	20.72	13.28	13.49	1.99	2.65	5.76	0.22	0.14	0.07	14.65	0.02	0.01	0.10	79.28
ESP	1.37	1.03	1.18	5.25	1.42	3.44	6.41	10.64	27.02	14.88	2.90	3.73	7.70	0.14	0.14	0.26	12.36	0.00	0.08	0.05	72.98
ITA	1.78	1.38	1.44	3.90	1.24	2.60	4.21	12.23	17.52	26.12	3.09	4.10	6.69	0.18	0.06	0.07	13.39	0.00	0.01	0.02	73.88
GRC	1.12	0.78	0.75	2.60	1.58	1.91	4.89	9.34	9.57	7.80	35.48	5.98	8.86	0.01	0.01	0.10	9.00	0.01	0.15	0.06	64.52
PRT	0.72	0.65	0.85	2.21	0.31	0.84	1.39	8.62	9.75	6.57	5.36	36.10	15.91	0.01	0.13	0.04	7.53	0.22	1.46	1.33	63.90
IRE	1.07	0.77	1.01	3.27	1.80	2.44	3.79	7.82	9.48	5.04	5.05	9.87	37.57	0.01	0.04	0.02	9.35	0.30	1.11	0.20	62.43
DNK	4.03	4.11	4.80	1.22	2.16	2.24	2.23	0.56	0.25	0.32	0.33	0.31	0.34	64.08	5.20	0.17	7.58	0.02	0.03	0.02	35.92
SWE	1.26	0.99	0.57	0.15	0.56	0.83	0.37	0.23	0.46	0.30	0.04	0.15	0.09	4.65	87.01	0.62	1.42	0.12	0.12	0.07	12.99
GBR	0.20	0.14	0.13	0.33	0.83	1.89	0.52	0.26	1.96	0.83	0.30	0.91	0.79	0.12	1.13	87.58	1.92	0.03	0.08	0.03	12.42
FACTOR	3.16	2.24	2.63	8.71	4.37	6.25	8.00	11.48	9.99	11.47	2.90	3.86	6.73	1.17	0.28	0.27	16.36	0.03	0.01	0.07	83.64
Fitch	0.12	0.04	0.08	0.18	0.32	0.12	0.48	0.19	0.07	0.06	0.01	0.04	0.55	0.01	0.07	0.04	0.17	97.01	0.10	0.33	2.99
Moodys	0.07	0.01	0.05	0.05	0.04	0.07	0.05	0.31	0.07	0.12	0.08	0.05	0.10	0.05	0.19	0.31	0.02	0.08	98.23	0.04	1.77
S&P	0.03	0.04	0.19	1.13	0.02	0.39	1.06	1.73	0.60	0.95	0.18	0.37	0.82	0.08	0.13	0.06	1.05	0.32	0.10	90.75	9.25
To others	36.79	34.34	34.95	67.49	34.14	52.34	70.96	109.16	107.54	103.27	33.45	43.08	76.70	23.00	10.52	4.03	166.32	2.14	3.33	2.78	1016.32
To others (+ own)	89.24	95.47	89.18	89.05	60.26	77.72	89.73	129.88	134.56	129.39	68.93	79.18	114.27	87.08	97.53	91.61	182.68	99.15	101.56	93.53	50.8%
From others	47.54	38.87	45.77	78.44	73.88	74.62	81.24	79.28	72.98	73.88	64.52	63.90	62.43	35.92	12.99	12.42	83.64	2.99	1.77	9.25	
Net spillover	10.76	4.53	10.82	10.95	39.74	22.28	10.27	-29.88	-34.56	-29.39	31.07	20.82	-14.27	12.92	2.47	8.39	-82.68	0.85	-1.56	6.47	

Table 6. Spillover table, rating impulse-dummy variable for Greece, Ireland and Portugal separately, all rating agencies

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	FACTOR	RATING GRC	RATING IRL	RATING PRT	From Others
CZE	52.45	7.46	6.62	2.46	0.48	0.70	1.62	2.71	3.52	3.99	0.81	0.91	1.86	4.00	0.92	0.03	9.05	0.05	0.02	0.32	47.55
POL	6.88	61.09	6.36	1.08	0.19	0.21	0.76	1.78	2.47	2.95	1.10	1.21	1.95	5.27	0.79	0.02	5.70	0.03	0.02	0.12	38.91
HUN	6.82	8.78	54.56	2.29	0.41	0.38	0.61	2.94	3.01	3.56	1.71	1.40	2.99	3.58	0.09	0.06	6.57	0.00	0.18	0.06	45.44
AUT	1.65	1.52	2.55	21.78	3.74	6.38	9.58	10.99	7.51	9.18	2.05	1.65	3.59	0.38	0.10	0.08	17.03	0.06	0.01	0.16	78.22
FIN	1.50	0.95	0.77	8.46	26.27	10.67	8.82	7.95	4.51	5.06	1.42	1.52	3.50	0.85	0.43	0.59	16.59	0.07	0.01	0.06	73.73
NLD	1.58	0.83	1.60	7.75	8.34	25.55	8.39	7.66	5.48	5.28	1.63	2.44	4.26	1.34	0.48	0.98	16.37	0.02	0.00	0.02	74.45
FRA	1.50	1.32	1.54	9.56	3.78	6.47	19.00	11.75	8.20	11.46	2.37	1.47	3.13	0.97	0.29	0.27	16.74	0.01	0.01	0.18	81.00
BEL	1.65	1.41	1.77	7.12	2.52	4.46	8.10	20.96	13.41	13.58	1.93	2.39	5.46	0.22	0.15	0.08	14.73	0.00	0.00	0.07	79.04
ESP	1.34	1.04	1.16	5.25	1.42	3.41	6.38	10.56	27.20	14.75	2.97	3.72	7.55	0.14	0.14	0.29	12.35	0.04	0.02	0.27	72.80
ITA	1.72	1.39	1.40	3.95	1.26	2.59	4.24	12.30	17.69	26.24	3.05	3.79	6.50	0.18	0.06	0.08	13.45	0.02	0.01	0.07	73.76
GRC	1.11	0.79	0.77	2.61	1.58	1.92	4.82	9.31	9.69	7.75	35.32	6.02	9.01	0.01	0.01	0.11	9.05	0.08	0.01	0.03	64.68
PRT	0.83	0.69	0.98	2.26	0.30	0.87	1.34	8.54	9.92	6.56	5.86	36.79	16.44	0.01	0.15	0.03	7.73	0.33	0.01	0.36	63.21
IRE	1.03	0.79	1.00	3.19	1.74	2.37	3.63	7.64	9.71	4.88	5.40	10.62	37.58	0.01	0.04	0.03	9.28	0.96	0.02	0.08	62.42
DNK	3.97	4.10	4.76	1.24	2.17	2.25	2.26	0.58	0.24	0.33	0.29	0.26	0.35	64.09	5.25	0.17	7.63	0.01	0.02	0.04	35.91
SWE	1.24	1.00	0.56	0.15	0.59	0.86	0.38	0.23	0.47	0.31	0.03	0.12	0.09	4.68	86.96	0.64	1.44	0.01	0.01	0.24	13.04
GBR	0.21	0.14	0.12	0.32	0.80	1.82	0.52	0.25	2.01	0.85	0.32	0.96	0.84	0.12	1.16	87.43	1.91	0.06	0.14	0.03	12.57
FACTOR	3.11	2.26	2.62	8.77	4.37	6.25	8.04	11.52	10.10	11.49	2.91	3.73	6.55	1.18	0.30	0.28	16.43	0.00	0.01	0.07	83.57
RATING GRC	0.02	0.00	0.00	0.07	0.18	0.33	0.21	0.10	0.08	0.04	0.08	0.34	1.91	0.06	0.02	0.05	0.05	96.41	0.01	0.02	3.59
RATING IRL	0.04	0.01	0.20	0.07	0.09	0.10	0.08	0.03	0.06	0.01	0.01	0.02	0.05	0.02	0.12	0.13	0.05	0.01	98.89	0.02	1.11
RATING PRT	0.47	0.06	0.04	0.41	0.19	0.24	0.57	0.91	0.27	0.10	0.11	0.11	0.62	0.09	0.28	0.04	0.38	0.02	0.01	95.07	4.93
To others	36.65	34.53	34.82	67.02	34.16	52.29	70.34	107.76	108.37	102.12	34.06	42.68	76.65	23.11	10.79	3.97	166.12	1.80	0.50	2.20	1009.94
To others (+ own)	89.11	95.63	89.38	88.80	60.43	77.84	89.33	128.72	135.57	128.36	69.37	79.47	114.23	87.20	97.75	91.39	182.55	98.21	99.39	97.27	50.5%
From others	47.55	38.91	45.44	78.22	73.73	74.45	81.00	79.04	72.80	73.76	64.68	63.21	62.42	35.91	13.04	12.57	83.57	3.59	1.11	4.93	
Net spillover	10.89	4.37	10.62	11.20	39.57	22.16	10.67	-28.72	-35.57	-28.36	30.63	20.53	-14.23	12.80	2.25	8.61	-82.55	1.79	0.61	2.73	

Figure 7a. VAR model: sovereign spread response to change in rating (change rating of Greece)

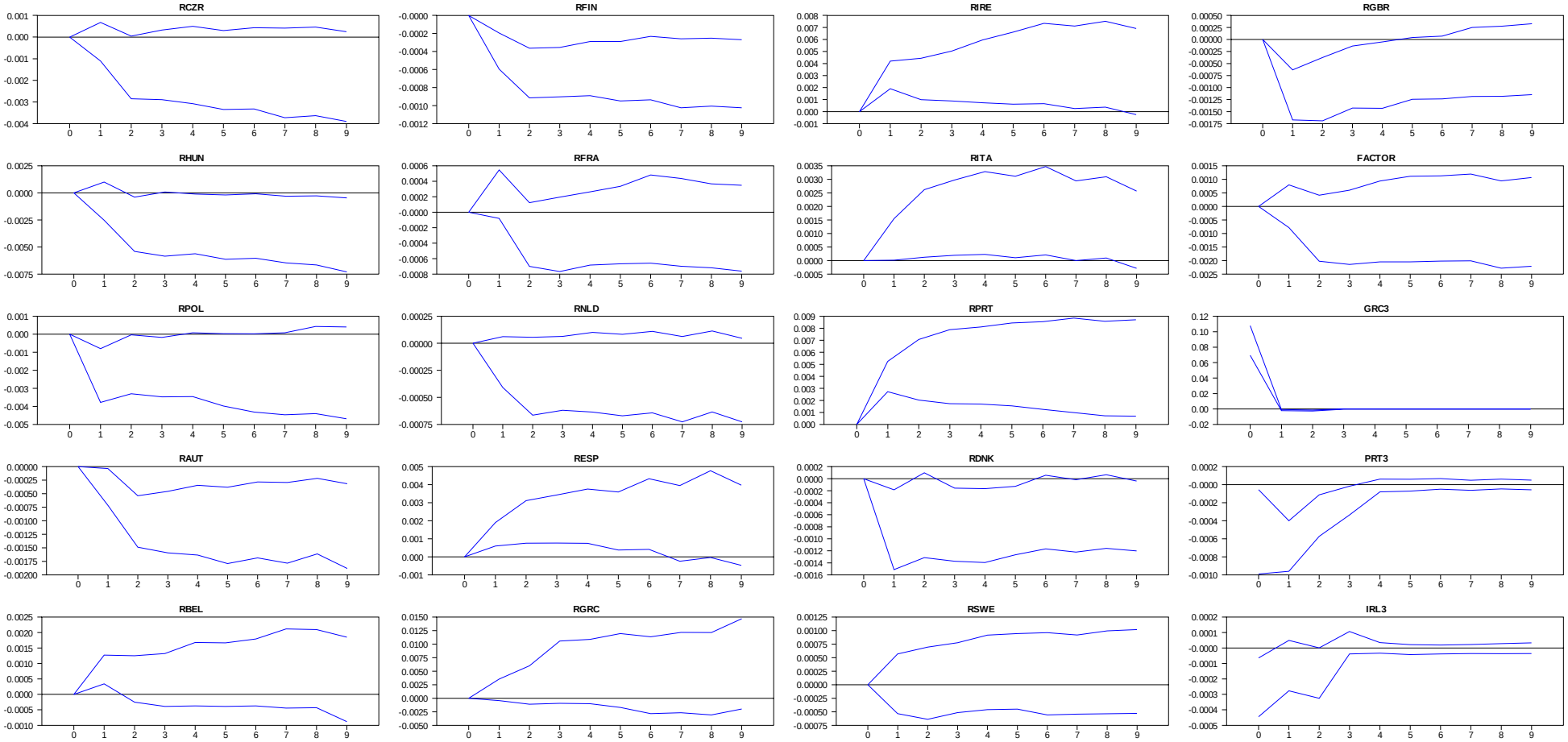


Figure 7b. VAR model: sovereign spread response to change in rating (change rating of Portugal)

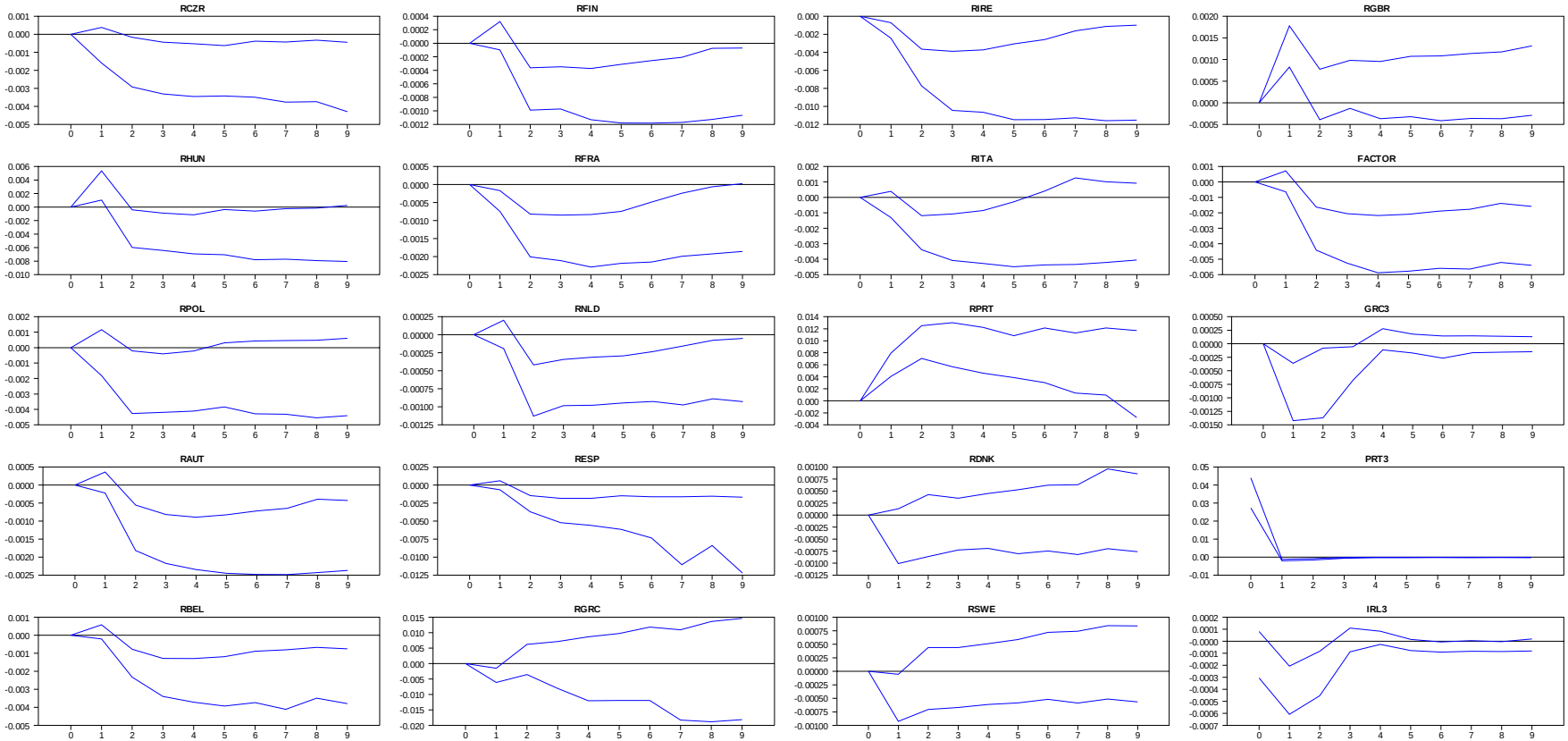
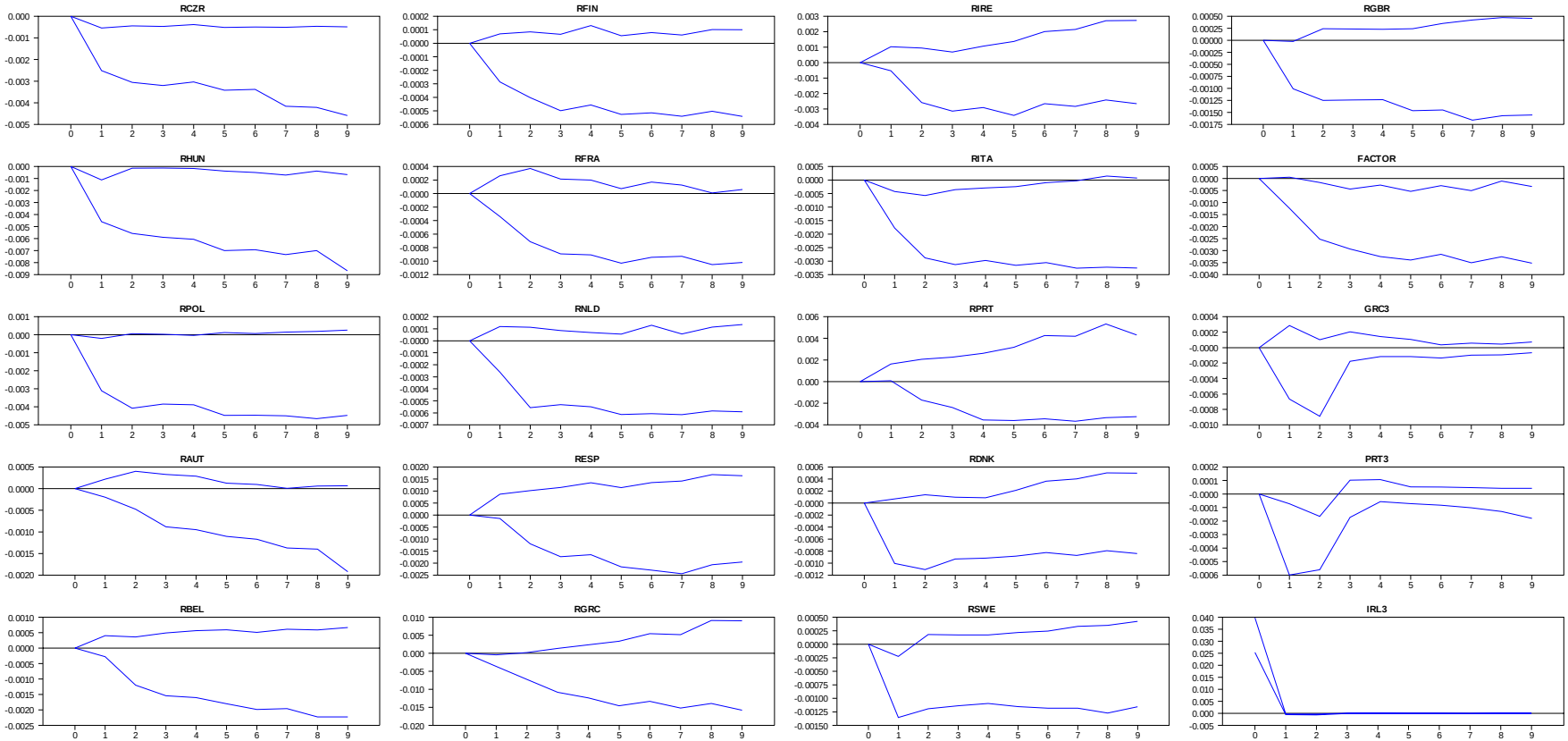


Figure 7c. VAR model: sovereign spread response to change in rating (change rating of Ireland)



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 sovereign bond spreads vis-à-vis Germany 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 due to the importance of a common factor as well as bilateral linkages. 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 on EMU countries. Alike Gande and Parsley (2005) and Arezki *et al.* (2011) we find that sovereign rating news contains some new information, and has a significant impact on spreads. However, the spillover running from spreads towards rating decision seem to be stronger. 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. However, our results support the view that Eurozone sovereign bond markets are closely linked so that an EMU-wide solution is more effective. Consequently, 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. This is important given that the markets interact, which holds in the European context especially for the sovereign bond markets and the banking sector. 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.4 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	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	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	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
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%
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	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	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	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	