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

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Abstract

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. We employ the VAR method by Diebold and Yilmaz (2009) to analyse the strength and direction of bilateral linkages between EU sovereign bond markets using daily data on sovereign bond yield spreads and a common factor. The forecast-error variance decomposition of this FAVAR indicates a lot of heterogeneity in the bilateral spillover sent and received between bond markets. Spillover is more important than domestic factors for all eurozone countries. The CE countries mostly affect each other. Only Denmark, Sweden and the UK are rather insulated from spillover. The spillover has increased substantially since 2007, despite starting from a high level. We use this framework to measure the impact of sovereign rating news and analyse the dynamic linkages between spreads and the ratings of the main credit rating agencies. We find a two-sided relation between rating news and sovereign risk premia. The spillover of rating news is very heterogeneous, and it is substantially stronger for downgrades at lower grades. The impact is often weaker domestically than on bond spreads of other sovereigns.

JEL classification: C14, E43, E62, G12, H62, H63
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Nontechnical Summary

Financial integration has increased the interdependence between asset markets, and in particular sovereign bond markets. The European debt crisis shows that fiscal trouble can transmit in unexpectedly fast ways even between sovereign bond markets. Such spillover is supposedly driven by conditions on global financial markets that reflect risk aversion. Empirical studies typically confirm the rising importance of external factors in determining the evolution of yields on domestic bond markets. However, as these studies proxy the global factor with some aggregate measure of international market developments we can infer little on the transmission channel behind the spillover, and it is hard to explain the feedback between different sovereign bond markets. The spillover should not be equally strong between all markets simultaneously.

In this paper we analyse the bilateral linkages between EU sovereign bond markets over time using forecast-error variance decompositions from a VAR with daily data since 2000 on the sovereign bond yield spreads of the EU countries. The method allows us to measure the spillover from shocks to a specific sovereign bond market to all other markets. The specific control for common factors and the time-varying framework are viable for uncovering spillover of a contagious nature.

Our results indicate the presence of significant spillover between the sovereign bond markets of EU countries over the whole previous decade. This should not come as a surprise given financial and economic integration in the EU. However, the spillover has increased substantially and permanently since the start of the financial crisis, which arguably indicates the presence of contagion. Moreover, there is a lot of heterogeneity in the bilateral spillover sent and received between specific sovereign bond markets. While spillover is more important than domestic factors for all EMU countries, the CE countries affect only each other, and Denmark, Sweden and the UK are insulated from the impact of other EU countries.

We then check whether sovereign rating news is responsible for this increased spillover and analyse the dynamic linkages between sovereign spreads and sovereign rating actions in our VAR framework. In line with existing evidence from event studies, we find that the overall effect of rating news on sovereign risk premia is limited, which is consistent with the claim that most rating actions do not come as a surprise for the markets. However, the rating spillover is again very heterogeneous across the types of rating action and across countries. In particular, the impact and the spillover are stronger for downgrades, especially at the lower end of the rating scale. The impact is often even stronger on the bond spreads of other sovereigns than domestically.

1. Introduction

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 in both 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. This financial-fiscal crisis is characterised by the speed of transmission and the strength of the feedback linkages across borders and financial markets. The sovereign debt crisis in the eurozone is the latest chapter in this financial crisis. Rising sovereign credit risk not only reflects structural imbalances and economic divergences, but also has a common component because of monetary policy and linkages in the banking market.

The potency of spillover across sovereign bond markets should 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). Integration has not been limited to capital and stock markets. Bond markets have become more interconnected too. Whereas in the past, only countries with high levels of domestic savings and developed financial systems (based on bank financing) could issue debt, many governments can now tap into international capital markets (Caballero and Krishnamurthy, 2004). In the eurozone, integration has made bond portfolios increasingly internationally diversified (De Santis and Gérard, 2009). Issuance in a common currency has motivated debt managers to compete for investors from other countries willing to diversify their portfolio by increasing the volume of new debt issues. Improved transparency and the elimination of some technical obstacles (such as trading systems and tax differences) has further reduced home bias and promoted integration of bond markets (Baele et al., 2004; Pagano and Von Thadden, 2004). As a consequence, EU governments have diversified around half of their debt to a pool of mostly European creditors (BIS, 2011). However, the recent debt crisis has reversed the trend, triggering withdrawal of foreign investors and increasing the home bias again (Andritzky, 2012).

Empirical studies confirm the rising importance of external factors in determining the evolution of yields on domestic bond markets. Sovereign bond yield spreads should compensate investors for default risk, transaction costs (liquidity premium) and exchange rate fluctuations. If investors are able to distinguish markets, the spread should depend only on these idiosyncratic variables.

However, their explanatory power is rather limited for European sovereign bond yield spreads. Instead, conditions on international financial markets may largely explain its dynamics (Codogno et al., 2003; Sgherri and Zoli, 2009; Schuknecht et al., 2011; Bernoth et al., 2006; Favero and Missale, 2012). This so-called ‘common factor’ is argued to reflect generalised risk aversion on international markets. Global investors adjust their bond portfolios when worldwide economic conditions change. This is what happened early in the financial crisis: a surge in global risk aversion (Mody, 2009) and risk of contagion (Caceres et al., 2010) were significant factors behind the increase in 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 et al., 2011; Attinasi et al., 2010; Gerlach et al., 2010). Investors seem to have been particularly sensitive to such bad fundamentals and dropped bonds quickly at times of increased turbulence on financial markets (Favero and Missale, 2012). Once the financial crisis turned into an economic crisis, the initially expansionary fiscal policy response revealed the cost to already burdened government budgets. As a consequence, default risk and liquidity risk started to rise and the fiscal position became the main determinant of changes in bond spreads (Haugh et al., 2009; Sgherri and Zoli, 2009; Barrios et al., 2009; Schuknecht et al., 2011). However, problems on some sovereign markets, such as Greece, Portugal and Ireland, then started to spread to other eurozone countries via the debt holdings of the large European banks. The feedback from sovereign to banking trouble transmitted internationally to affect all large European banks (Merler and Pisani-Ferry, 2012). A heated discussion in the literature debates if bond spreads are determined by purely domestic elements or if spillover drives them. In the former case, markets correctly appraise the fundamental drivers of spreads (Manasse and Trigilia, 2011). In the latter situation, there is mispricing and markets are susceptible to be pushed towards bad equilibria (Broto and Perez-Quiros, 2011; De Grauwe and Ji, 2012). Policy responses would also need to be dramatically different in both cases.

Most empirical studies cannot detail the transmission channels behind the spillover, as they typically proxy the global factor with some aggregate measure of international market developments.[1] However, the spillover should not be equally strong between all markets simultaneously. In this paper, we aim to detail the strength and direction of the bilateral linkages between EU sovereign bond markets. The spillover measure is based on the forecast error variance decomposition of a VAR model (Diebold and Yilmaz, 2009, 2011). Shocks to one market contribute to explaining the variance in the other markets some periods ahead. This percentage

[1] 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 joint probabilities of distress extracted from CDS credit default swap spreads. Claeys et al. (2011) proxy the 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.

contribution represents the spillover. We extend the VAR to include both sovereign bond spreads and a common factor. With this FAVAR, we not only measure the importance of domestic and international events in the evolution of sovereign bond spreads, but additionally detail the bilateral linkages between all markets. Moreover, we can infer from the strength of the bilateral links the source of the global factor and how it transmits across markets. Using daily data since May 2000, we can also track the changes in spillover between each pair of markets over time.

We estimate a VAR including EU sovereign bond yield spreads relative to the German 10-year bond yield controlling for a common factor, and generalised market volatility or short-term market liquidity using daily data on bond spreads. The forecast-error variance decomposition of this FAVAR indicates a lot of heterogeneity in the bilateral spillover sent and received between bond markets. Spillover is more important than domestic factors for all EMU countries. The CE countries mostly affect each other. Only Denmark, Sweden and the UK are rather insulated from spillover. The spillover has increased substantially since 2007, despite starting from a high level.

The sources of this increased spillover can be varied. Public opinion has accused in particular the three main credit rating agencies (S&P, Moody's and Fitch) of destabilising sovereign bond markets with unjustified and untimely rating decisions. Rating downgrades during the crisis seem to have provoked turbulence on asset markets and higher financing costs for all sovereigns (Afonso et al., 2011). This spillover is a consequence of increased financial integration. Banking regulation, collateral rules, credit default swap contracts and investment mandates force domestic and foreign investors to relocate their savings towards higher rated bonds in response to rating revisions or adjustments (Sy, 2009). 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 FAVAR different definitions of rating decisions (downgrades versus upgrades, rating versus revision changes) by the main three rating agencies to identify whether the rating action is really 'news' or is already incorporated in bond market prices, and whether there is a spillover effect of rating actions across countries. We find a two-sided relation between rating news and sovereign risk premia. However, the spillover running from spreads towards rating decisions seems to be stronger. The spillover of rating news is very heterogeneous and it is substantially stronger for downgrades at lower grades. The impact is often weaker domestically than on bond spreads of other sovereigns.

The paper is structured as follows. In section 2, we review our empirical approach to measuring 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), which 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):

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

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:

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

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 is due 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-steps-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*-steps-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*-steps-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:[2]

$$\Lambda = \begin{pmatrix} \lambda_{AA} & \lambda_{AB} & \cdots & \lambda_{AZ} \\ \lambda_{BA} & \lambda_{BB} & \cdots & \lambda_{BZ} \\ \vdots & & \ddots & \vdots \\ \lambda_{ZA} & \cdots & \cdots & \lambda_{ZZ} \end{pmatrix} \tag{3}$$

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.

The matrix Λ measures the bilateral interdependence between financial markets. The method of Diebold and Yilmaz (2009, 2011) improves over partial equilibrium (regression) approaches since it does not suppose that the bond market is affected only by some exogenous financial conditions, without any feedback. Instead, the decomposition of the VAR provides a general equilibrium effect that measures the transmission from one market to another. In particular, 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, but measures the importance of an idiosyncratic shock in a market onto other markets, and its feedback. Prices move contemporaneously on different financial markets, and this spillover is stronger between markets that are more closely connected.

We condense the information on all bilateral spillovers into a few summary statistics. Using the forecast decomposition of this VAR, the *total spillover* index measures the contribution of the

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

spillover of shocks between all the 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.:

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

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

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

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

$$DS_{\leftarrow i}^h = 100.\sum_{j \neq i}^{n} \lambda_{ji}^h \Big/ \sum_{i,j=1}^{n} \lambda_{ji}^h \tag{6}$$

Measure (5) is the sum of each column of the matrix Λ, not including the own contribution of each market.[3] 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. $NS^h = DS_{\to i}^h - DS_{\leftarrow i}^h$. This measures how much each variable *i* contributes to all other *n-1* markets in net terms. It is also possible to calculate then the *net pairwise spillover*, which shows how much each market *i* contributes to another market *j* in net terms. For this, we need to obtain:

$$NS_{i \leftrightarrow j}^h = 100.\left[\lambda_{ij}^h \Big/ \sum_{k=1}^{n} \lambda_{ik}^h - \lambda_{ji}^h \Big/ \sum_{k=1}^{n} \lambda_{jk}^h \right] \tag{7}$$

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 *share in spillover absorption* as the share of the spillover that a particular market *i*

[3] Alternatively, one can include the own effect of the shock.

receives from all other *n-1* markets $DS^{h}_{\leftarrow i}$ in the total spillover TS^{h}. Likewise, the *share in spillover transmission* is the share of the spillover that a particular market *i* transmits to all other *n-1* markets $DS^{h}_{\rightarrow i}$ in the total spillover TS^{h}. The sum of the two statistics demonstrates the share of a market in the overall spillover and is therefore a measure of the connectedness of the market.

2.2. Measuring Contagion with a Time-Varying FAVAR

The correlation of asset prices can either reflect the co-movement of economic fundamentals or be due to the transmission of idiosyncratic shocks across markets. This transmission may pass through real channels – which may be explained by trade or financial links – or be due to contagion (Kaminsky and Reinhart, 2000). In general contagion is hard to define, and its measurement is fraught with difficulties.[4] 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 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 should be understood as a sudden significant increase in cross-market co-movement after a shock to one market (conditional on market volatility).

The forecast error variance decomposition-based method of Diebold and Yilmaz (2009) does not allow explicit identification of whether the co-movement of asset prices is due to one channel or the other. However, we can use matrix Λ as an implicit measure of contagion between markets in the VAR framework once we (i) use high frequency (daily) data, (ii) estimate a time-varying model, and (iii) control for common factors. How does this identification function?

By using high-frequency (daily) data, whose dynamics are by nature not affected by macroeconomic fundamentals, we can detect from the time-variation in the spillover from some specific market to another whether there is a sudden change in transmission. Idiosyncratic shocks to a sovereign bond market have stronger spillover to markets when their mutual fundamental linkages are stronger (Favero and Missale, 2012). The contemporaneous correlation between markets reflects both channels, and contagion is a departure from the usual spillover between markets.

[4] See Pericoli and Sbracia (2003) for an overview.

A methodological problem with using a VAR with daily asset prices is the contemporaneous (intraday) correlation between markets. The variance decomposition depends on the ordering of the variables in the VAR, and the Cholesky identification of the VAR imposes diagonal block restrictions on the contemporaneous feedback effect of markets to the markets that are ordered first. Exogeneity assumptions that allow some asset markets to react to others but do not allow for simultaneous feedback are not realistic when testing spillover between daily asset prices. Following Diebold and Yilmaz (2011) we adopt the generalised VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), which allows shocks to all markets to be correlated, but this is accounted for by using the historically observed distribution of the shocks. As a consequence, these VAR estimates are invariant to ordering.

Co-movement of asset prices may only reflect similar responses to a common shock. Empirical studies have argued that bond spreads in EMU move together and that most of the variability of spreads on individual markets is driven by these common factors (Codogno et al., 2003; Bernoth et al., 2006; Favero 2012). Since this is a common development, it cannot be tracked in a VAR to any specific market. We therefore additionally control for the existence of these common changes in sovereign bond market behaviour by including common factors in the VAR. Following Bernanke et al. (2005), we use a two-step strategy for estimating this factor-augmented VAR (FAVAR). 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 for a set of n observable random variables xi can be written:

$$x_i - \mu_i = l_{i1}F_1 + \ldots + l_{ik}F_k + \varepsilon_i \tag{7}$$

where μi is a variable mean, lij are coefficients (factor loadings) corresponding to k unobservable random variables (common factors) Fij, and ε_i represents error terms, which are assumed to be independently distributed with zero mean and finite variance. The idea is to express n observable variables in terms of k unobservable common factors. The coefficients lij represent the factor loadings that link unobserved common factors to observed data. The model can be estimated after additional moment and covariance restrictions are imposed. We impose the common assumption that factors are orthogonal and use the minimum average partial (MAP) method to determine the number of factors Fij.[5] The principal factor method is then used to estimate the factor loadings. In the second step, we estimate the VAR, which, besides the original n variables xi, contains an additional k factors Fij. We can then compute the FEVD and use this decomposition to dissect the strength and direction of the spillover between any two markets, and

[5] The factor loadings l_{ij} and the number of factors k vary over time. However, a factor defined over the full sample better reflects the co-movement for different markets over time.

the common factors. In particular, we can compute the percentage contribution of a change in daily quoted government bond prices on the variation in the 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 to February 2012 (closing price).[6] The use of the yield spread over the reference yield, which is usually taken to be the risk-free rate, is common in this literature (e.g. Favero and Giavazzi, 2002). The idea is to analyse only the part of the domestic yield that is not driven by changes in the risk-free rate. However, this approach has a caveat as it does not allow us to assess the spillover to and from the reference country. This may be particularly relevant if the reference country enjoys safe haven status (as Germany arguably does) when investors fly to quality bonds. However, the use of alternative benchmarks such as the US Treasury bond yield is not feasible given that it is not a natural benchmark for EU sovereigns as perceived by investors, and it could overstate the role of common developments in EU bond markets and does not allow us to distinguish between common and idiosyncratic sovereign bond dynamics.[7] Alternative measures, such as credit default swaps (CDS), arguably provide a closer measure of sovereign credit risk. However, prior to the crisis, sovereign CDS markets were often not liquid and for some sovereign issuers in Europe practically non-existent. Figure 1 shows the spreads for four different groups of countries: the core EMU (Austria, Belgium, France, Finland and the Netherlands), where the spreads are moderate but have nonetheless risen a lot since the start of the financial crisis and again since the start of the debt crisis, the GIIPS countries (Greece, Ireland, Italy, Portugal and Spain), where spreads have boomed, the Central European (CE) countries (Czech Republic, Hungary and Poland) and the eurozone opt-outs (Denmark, the UK and Sweden).

[6] The main source for the data is Thomson Reuters Datastream. For reasons of data availability we did not include Luxembourg or smaller CE countries, which have quoted bond yields only in recent years. For the same reason, we do not use sovereign CDS quotations as they were popularised only around the onset of the crisis in 2007.
[7] As a robustness check, we did the FAVAR analysis also using sovereign yield spreads over the US Treasury (in this case also including Germany). The results (available upon request) confirmed our previous hypothesis that the common EU factor is dominant.

The MAP-method selects three factors as common drivers of the bond spreads of EU countries. The evolution of all factors is very smooth until the onset of the financial crisis in 2008, but then spikes to diverge later on (Figure 2). The first factor started to increase in 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 during the latest acute phase of the debt crisis in the autumn of 2011. The second factor reaches a peak in late 2008 and early 2009, like the first factor, and since then has steadily declined. 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 factors is able to explain over 70% of the variance of the spreads (Table 1). The factor loadings are close to unity for the eurozone countries, which suggests that this factor mostly identifies developments common to the EMU.[8] Non-eurozone countries have substantially lower loadings on this factor. Instead, the second and third factors explain much less of the overall variance and their loadings are high for the non-eurozone countries only. This again suggests that eurozone commonalities in sovereign spreads are well tracked by the first factor and non-eurozone countries represent a rather heterogeneous group. Therefore, in our benchmark case we use only the first factor, but also test the sensitivity of the results when more factors are included.[9]

The basic FAVAR model contains two lags of the domestic bond spreads of 16 EU countries and the common factor obtained in the first step. In line with Diebold and Yilmaz (2009) we compute the forecast error variance decomposition at a horizon of 10 days (one and a half weeks), 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 by which we also capture the role of global bond markets is the Chicago Board Options Exchange Index

[8] The countries are grouped in this order across all tables: CE countries (Czech Republic, Hungary, Poland), core eurozone (Austria, Finland, Netherlands, France), Belgium (as will become obvious later, this country stands between the core eurozone and GIIPS), GIIPS and eurozone opt-outs (Denmark, Sweden, UK).

[9] We used alternative methods to determine the number of factors and estimate their loadings and these checks all provide similar results. A particular restriction is that the factor analysis assumes fixed loadings over time. Given the significant changes in European sovereign debt markets, we performed the factor analysis on two subsamples with a break date of January 1st 2010. Although the results pointed to some differences between the two periods, the first factor consistently explains at least 65% of the variance and the factor loadings did not vary notably, i.e. the loadings for EMU countries were close to one, the loadings for CE countries smaller and the loadings for Denmark, Sweden and the UK small or even negative. Evidence that the relative importance of different factors varies over time, albeit not greatly, is also reported in Broto and Perez-Quiros (2011) and ECB (2012).

(VIX). This index is often used to measure risk aversion on global markets. Volatility on markets outside Europe, especially the US, is argued to be a main driver of bond spreads. Both control variables are assumed to be exogenous.[10]

To recap, our aim is to measure bilateral and overall spillover among sovereign bond markets of EU countries. We do this by (i) eliminating the common risk-free rate (i.e. the German bund yield), (ii) augmenting the VAR structure by the common factor of the resulting sovereign yield spreads, and (iii) controlling in the VAR for other common factors such as monetary policy and global risk aversion. On the contrary, we do not aim at explicitly decomposing the yield spread into a default (credit risk) premium and a liquidity (risk) component. The reason is that we analyse the spillover across markets as perceived by financial markets. For the same reason, exchange rate risk (for the non-eurozone countries) can be an additional factor of divergence of sovereign bond yields. However, we do not find it plausible to adjust for exchange rate risk (e.g. using asset swap spreads) since investors effectively bear this exchange rate risk and it affects the effective level of the return of the non-eurozone spread yield.

[10] In this way, we implicitly benchmark the spillover between EU bond markets also on the evolution of global bond markets. We included other control variables such as the US bond yield, but this did not modify the results.

Figure 1: Bond Spreads on the German 10-Year Bond Yield

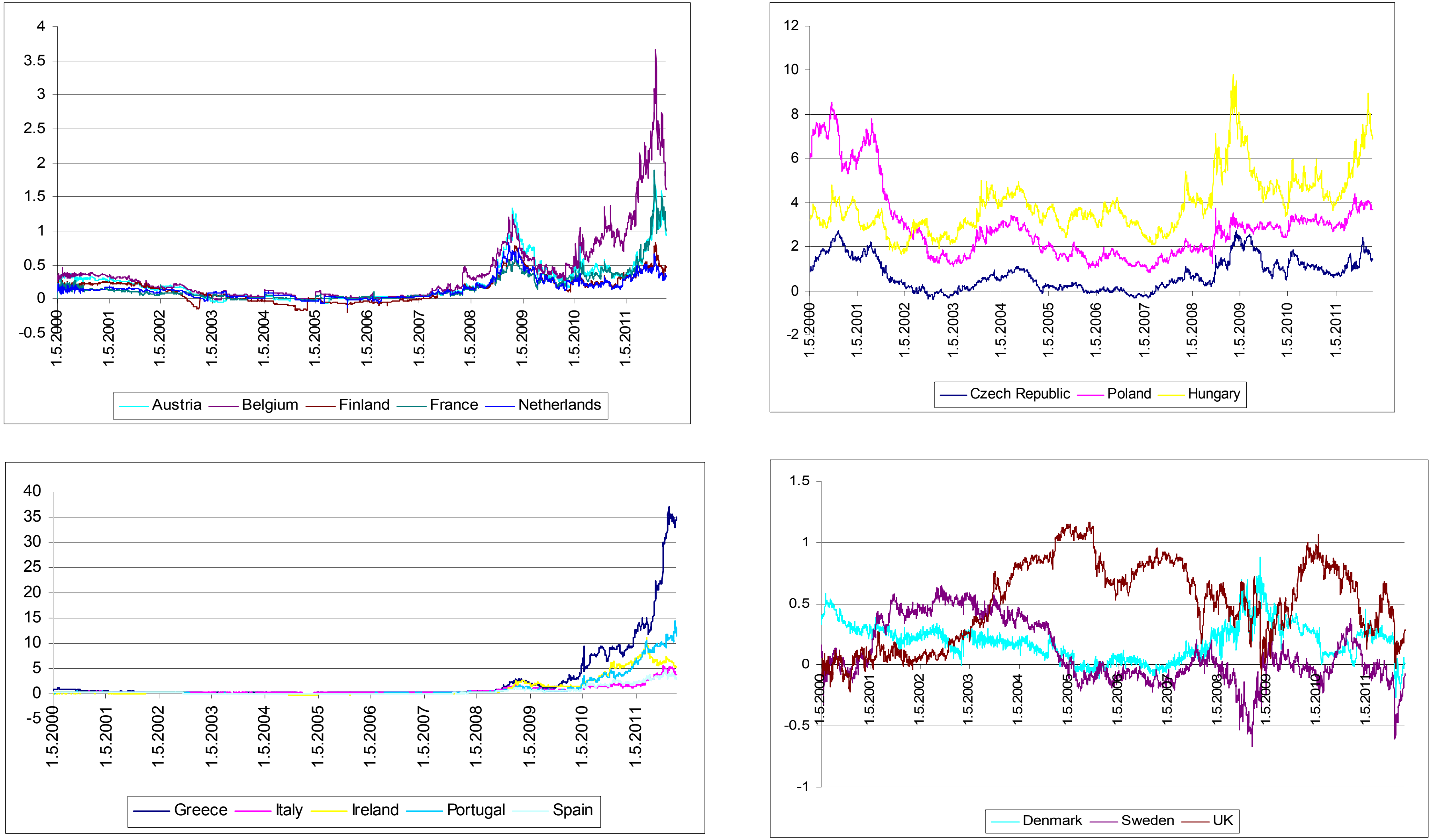


Figure 2: Time Evolution of Factors

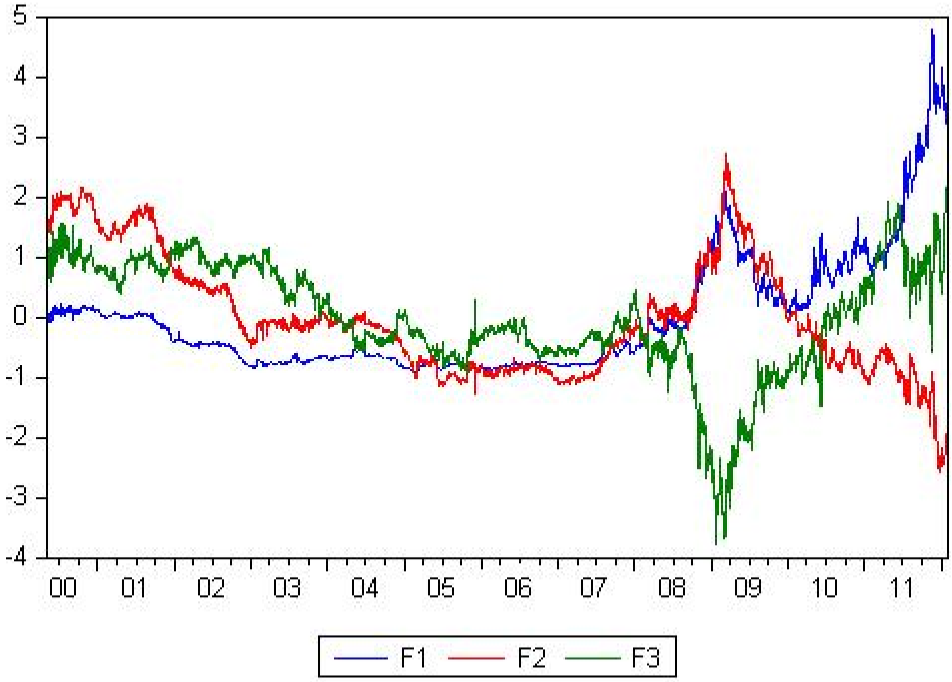


Table 1: Factor Loadings

	F1	F2	F3	Communality	Uniqueness
CZE	0.64	0.58	-0.08	0.75	0.25
POL	0.33	0.66	0.37	0.69	0.31
HUN	0.75	0.06	-0.45	0.78	0.22
AUT	0.94	0.18	-0.15	0.94	0.06
FIN	0.87	0.37	-0.12	0.91	0.09
NLD	0.84	0.29	-0.32	0.90	0.10
FRA	0.96	-0.11	0.00	0.94	0.06
BEL	0.97	-0.14	0.08	0.97	0.03
ESP	0.92	-0.28	0.17	0.96	0.04
ITA	0.95	-0.28	0.07	0.98	0.02
GRC	0.86	-0.39	0.24	0.96	0.04
PRT	0.88	-0.37	0.25	0.97	0.03
IRE	0.85	-0.29	0.15	0.84	0.16
DNK	0.29	0.79	-0.11	0.72	0.28
SWE	-0.37	0.21	0.44	0.38	0.62
GBR	-0.26	-0.64	-0.47	0.70	0.30
	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.60	9.60	6.92	0.72	0.72
F2	2.68	12.28	1.58	0.20	0.92
F3	1.10	13.38	---	0.08	1
Total	13.38	35.25		1	

3. Sovereign Bond Yield Spillover in Europe

3.1. Spillover and Linkages across Markets

Figure 1 suggests that there are important interlinkages between sovereign bond markets, but that these linkages are not equally strong between all markets. We first look at the spillover between all 16 EU sovereign bond markets using the FAVAR model including all bond prices and the factor. 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. We sum the effect of shocks to market *A* on all others (either including the own effect or not) in the two rows following the country effects. The right-hand column sums the effect country *B* receives from all other markets. In addition, we include the first factor of all spread 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.[11] The two bottom rows measure the share of spillover absorption and transmission.

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 the 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. the 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 is determined not by domestic factors but by international bond markets.[12] In contrast to previous studies, our result is not derived from a partial equilibrium assumption, in which global conditions cause domestic changes, but it fully accounts for the feedback of domestic markets to international markets.

[11] 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.
[12] Claeys et al. (2011) find that about 60% of a change in long-term interest rates spills over across markets.

This total spillover is the aggregate of all the spillover between different markets, but it does not reflect the large variety of spillover effects between bond markets. We can observe from the bilateral entries in Table 2 that the country-specific effect of spillover is not alike for each country. For the eurozone opt-outs (Denmark, Sweden and the UK) the domestic factor accounts for over two-thirds of the changes in the bond spread, and for the CE countries (the Czech Republic, Hungary and Poland) it ranges between one-half and two-thirds. By contrast, the idiosyncratic change amounts to just one-quarter for the eurozone countries (with a slightly higher share for Greece, Portugal and Ireland). Hence, the eurozone 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 eurozone countries. This is not surprising given that the eurozone countries achieved the highest factor loadings in the estimation of the factor model (Table 1). 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. Commonalities in the EU sovereign bond market are mostly common developments within the eurozone.

As Table 2 suggests, the bilateral linkages between countries are quite distinct between countries inside and outside the eurozone. For the three opt-out countries, the 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 these countries receive. The three countries are relatively insulated from bond markets in the eurozone. Nonetheless, Denmark and Sweden are substantially more linked to the eurozone because of strong trade linkage to the core countries, and Denmark also through its participation in ERM2. A similar explanation holds for the CE countries, 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 Austria's economic proximity and the importance of its banking sector, Austrian bond prices do not affect the CE spillover much, nor are they influenced very much by the CE bond markets.[13] The separation of the non-eurozone sovereign bond markets might be driven

[13] For the CE group, Ebner (2009) and Alexopoulou 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 bond market vis-à-vis the eurozone bond market. Bubák et al. (2011) look at volatility spillover in CE stock markets, confirming increased shock transmission during periods of market uncertainty but also that the Czech and Polish currencies, which float freely, are subject to more volatility spillover than the Hungarian forint, whose exchange rate is managed.

by exchange rate differences relative to the euro area. However, this result also applies to Denmark, yet the Danish kroner participates in ERMII with a narrow ±2.25% fluctuation band. This finding suggests that there is a distinct feature of spillover in the eurozone and exchange rate risk alone cannot explain the importance of idiosyncratic factors. Markets more likely perceive the eurozone as distinct due to the spillover of default and liquidity risk across EMU markets, or to the likely collapse of the eurozone.

Among the eurozone countries, we can identify three groups of countries by the strength of their bilateral spillover: (i) the core eurozone (Austria, Finland, France and the Netherlands), where 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 also be listed in the former group), where the domestic factor is also subdued in favour of mutual bilateral effects as well as the effect of the common factor, and (iii) Portugal, Ireland and Greece, where domestic dynamics are slightly more important and the common factor slightly less so.

Table 2: 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 in 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 in spillover absorption	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 in spillover overall	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

The overall statistics listed in the rows below suggest that Belgian, Italian and Spanish bond markets seem to create a systemic link on European bond markets. As we can see in the last row, the joint share of these countries on the overall spillover transmission and absorption is more than 50%. The results for Italy and Spain are probably not surprising given the size of those countries, and other studies also find that both countries are crucial transmitters of shocks on bond markets to other countries. For example, using CDS series, Broto and Perez-Quiros (2011) find that both Italy and Spain are more affected by events on other EMU markets than by domestic events. By contrast, the Belgian bond market is not typically considered crucial. We find that Belgium is actually the most open bond market in Europe: it is the biggest receiver of shocks abroad as well as the country that affects the other EU countries the most (in relative terms). The negative value of the net spillover and the share in total spillover demonstrate the systemic importance of Belgium. The reason is that in terms of size, even if Belgian debt is high as a ratio to GDP, its volume is small relative to the debt issues of Italy and, more recently, Spain. At the same time, Belgium economically belongs to the core EMU countries, and despite its high public debt it pays a subdued credit risk. But moreover, all three countries have an internationally grown banking system that is mainly exposed to the GIIPS countries. For example, the Belgian banks Fortis and Dexia were among those with the highest exposure to US subprime loans and Greek public debt respectively (BIS, 2011). Spanish banks are exposed to problems in the domestic financial sector. Belgian, Italian and Spanish banks also mutually hold large portions of public debt (Merler and Pisani-Ferry, 2012; Claeys and Vašíček, 2012). Other papers also show how closely linked bank and sovereign credit risk are (Acharya et al., 2011). This underlines the importance of shock transmission between the eurozone countries through the banking channel. By contrast, non-eurozone countries are rather separate from this transmission.

3.2. Time Variation in the Total Spillover

The analysis based on the full sample estimates might not fully uncover the change over time in all these bilateral linkages. Indeed, as the entries track the average spillover for a rather long and heterogeneous time period, some results might not seem intuitive from today's perspective.[14] The financial crisis starting in 2007 is commonly believed to have significantly increased co-movement across asset markets and the European debt crisis specifically the co-movements across sovereign bond markets since 2010. Figure 1 shows how the spreads of all EU countries have been moving closely together since early 2002, and how the GIIPS have diverged from the German 10-year bond rate since 2010.

A Bai-Lumsdaine-Stock (1998) test on the overall structural stability of the FAVAR 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 16 and April 22 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 the 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. Rather than aiming at two (still arguably heterogeneous) subsamples we follow Diebold and Yilmaz (2009) and 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, which varies between 50% and 80%, with Diebold and Yilmaz (2009), who estimate such spillover for global stock markets (1995–2007) at between 40% and 55%.[15] Caporin et al. (2012) use sovereign CDS data and argue that the channels by which shocks on European CDS markets propagate have been rather similar over time during the turbulent post-2009 period.

The total sovereign bond spillover oscillates between 55% and 70% until the end of 2007. We observe some specific spikes in spillover over the 2001–2007 period, for example after September 11th 2001, the application of the Excessive Deficit Procedures to some EU countries

[14] For example, the overall contribution of Greece is very small. Indeed, it seems that Greece is no bigger a shock transmitter than, for instance, the Czech Republic.
[15] While our total sovereign bond spillover from the whole sample analysis is 56%, their stock market spillover index is 35%.

and the revision of the Stability and Growth Pact in March 2005. The high overall level of spillover confirms the evidence of other studies that 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 again raised the co-movement of sovereign bond spreads. The spillover index shoots up to 75% and remains 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 show the fluctuations since the financial crisis, Figure 4 shows a close-up image of Figure 3 starting in January 2008.

Figure 3: Total Spillover Plot, 200-Day Window, 10-Steps-Ahead Forecast, Full Sample (February 2001–February 2012)

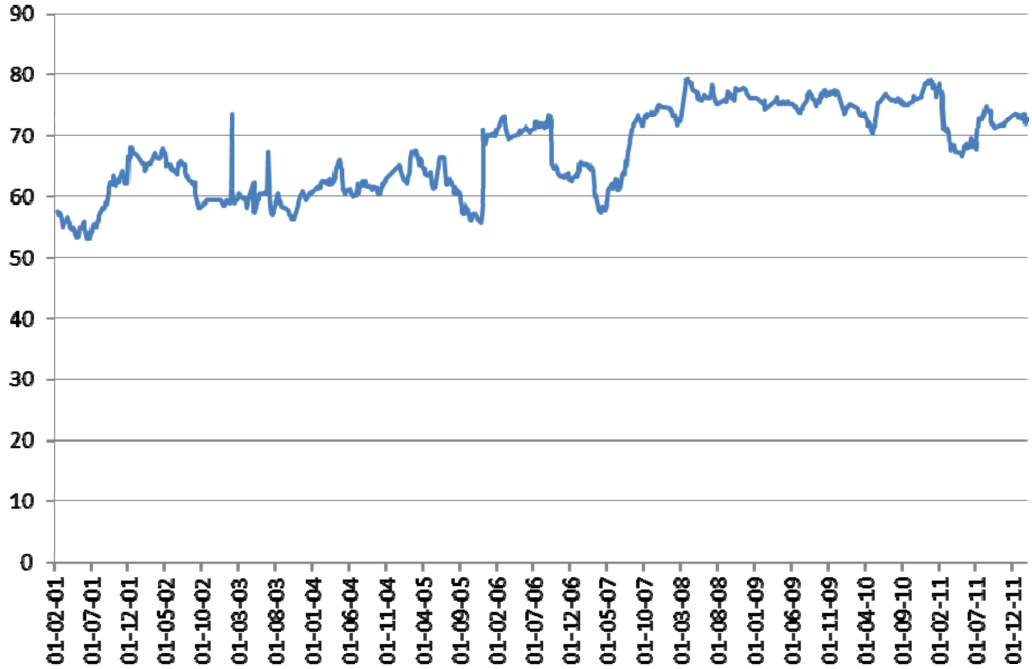
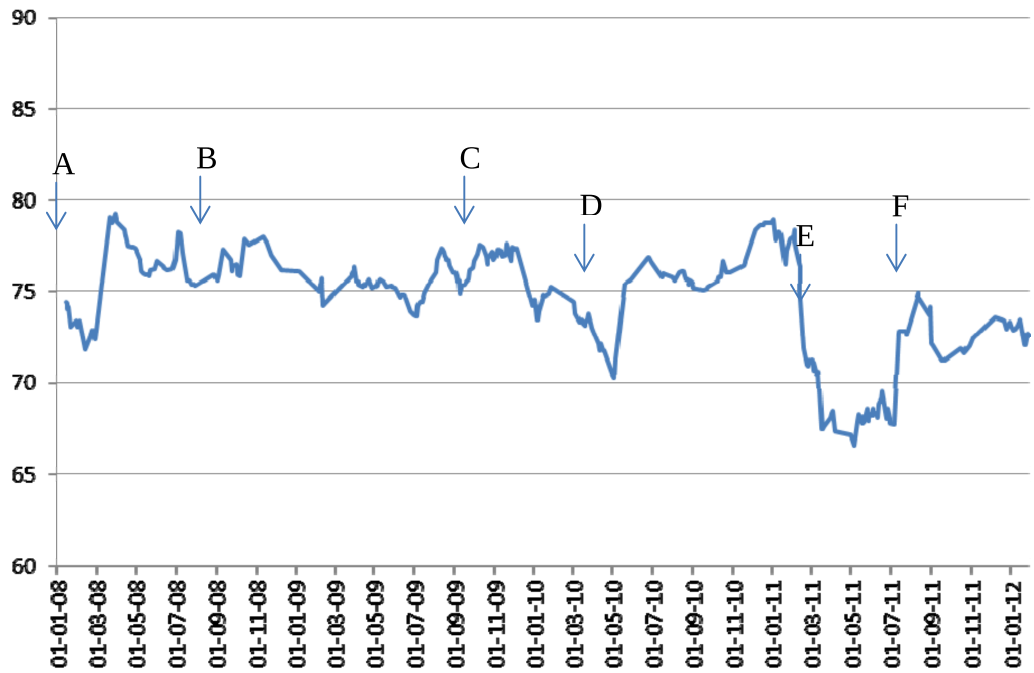


Figure 4: Total Spillover Plot, 200-Day Window, 10-Steps-Ahead Forecast, (January 2008 – February 2012)



The time-varying estimation of our FAVAR provides some implicit indication of contagion in EU sovereign bond markets in recent years. First, although we do not provide confidence bands around the total spillover plot, the post-2008 level is arguably an abnormal shift, i.e. the level of spillover is significantly higher than the full sample mean (58%). Second, the events around the peaks on the spillover plot do not represent news about fundamentals in a large group of countries.

We can discern the consequences of some major events on the co-movement of bond spreads – for example:

A. the collapse and subsequent sale of Bear Stearns to JP Morgan Chase (March 2008);
B. the collapse of Lehman Brothers (September 2008);
C. the bankruptcy of Dubai World (November 2009);
D. the fiscal trouble of Greece (May 2010);
E. the establishment of the European Stability Mechanism (February 2011);
F. the spread of the debt crisis to Spain and Italy (June 2011), and the measures adopted in August and September 2011 by the ECB.

The total spillover does not reflect the large variety of spillover effects between individual bond markets. We can learn more about the transmission across bond markets by looking deeper into the bilateral spillover across time.

3.3. The Time Variation in the Bilateral Spillover

Although the time-varying plot of the total spillover summarises numerous changes in bilateral linkages across markets, it is interesting to examine some particular cases. In particular, we provide evidence on the evolution over time of spillover within the GIIPS countries, in particular Greece, and CE countries.[16]

Since Greece was the first EMU country to run into fiscal trouble and set off a series of events, such as fiscal bailouts and trouble in the balance sheets of banks, we look in more detail at the consequences of shocks to Greek sovereign bond spreads on other markets. As we noted, the evidence based on the whole sample suggested that the spillover from Greece is very small, which seems rather counterintuitive given the political and economic events since 2009 (Mink and De Haan, 2011).

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 the countries as in Figure 1, but Greece itself is excluded from GIIPS (i.e. IIPS). The first observation is that the contribution of changes in sovereign spreads in Greece on other markets fluctuates significantly over time and is quite different across groups. The spillover remains stable until the onset of the global financial crisis in general and the Greek debt crisis in particular. The CE and other non-eurozone countries are barely affected, although there can be sporadic large changes in the spillover. Most of the Greek spillover goes both to IIPS and to the core eurozone countries.[17] The crisis immediately magnifies the spillover to other markets but does not change its structure. The CE and non-eurozone remain rather decoupled, whereas IIPS and the core-EMU suffer most of the rise in Greek spreads. The spillover is very strong in early 2008 as the global financial crisis hits Europe. We note that at that stage the eurozone sovereign yield spreads were still rather low, but doubts about the budgetary situation of Greece had started to rise. The spillover fluctuated at higher levels but decreased to almost the pre-2008 levels in early 2010. This finding is consistent with Manasse (2010) and Mink and De Haan (2011), who also 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. This reduced the spillover from Greece to the rest of the EU. However, we can observe subsequently several reversals in the degree of spillover – both to IIPS and to the core EMU. These reversals reflect the ongoing discussions at the EU level regarding the treatment of Greece. During the summer of 2011, the contagion to other IIPS, in particular

[16] The time-varying plot for any pair of countries can be obtained upon request.
[17] The groups of countries are of different size, but it is still instructive to observe the time evolution of transmission.

Italy and Spain, rises strongly. The rescue package of July 2011 does not seem to have separated the fiscal trouble in Greece from other bond markets. De Grauwe and Ji (2012) argue that the present surge in spreads is disconnected from the rise in public debt ratios and is a sign of mispricing of sovereign risk. This makes contagion the main driver of sovereign bond spreads across the eurozone.

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 eurozone. The IIPS seem to exert a significantly stronger effect since the onset of the debt crisis as compared to the core eurozone countries. The fact that Greece has stronger effects on other markets than it receives from other bond markets implies positive net spillover of Greek sovereign bond markets.

While the effect of other sovereign bond markets on Greek spreads is rather stable during the financial crisis, the magnitude of the Greek spillover to other sovereigns varies widely and the fluctuations sometimes have a very high frequency. One plausible explanation is that this is related to the frequency of news related to Greece (Mink and de Haan, 2011).

Figure 5a: Decomposition of the Effect of Greek Bond Spreads on Other Markets

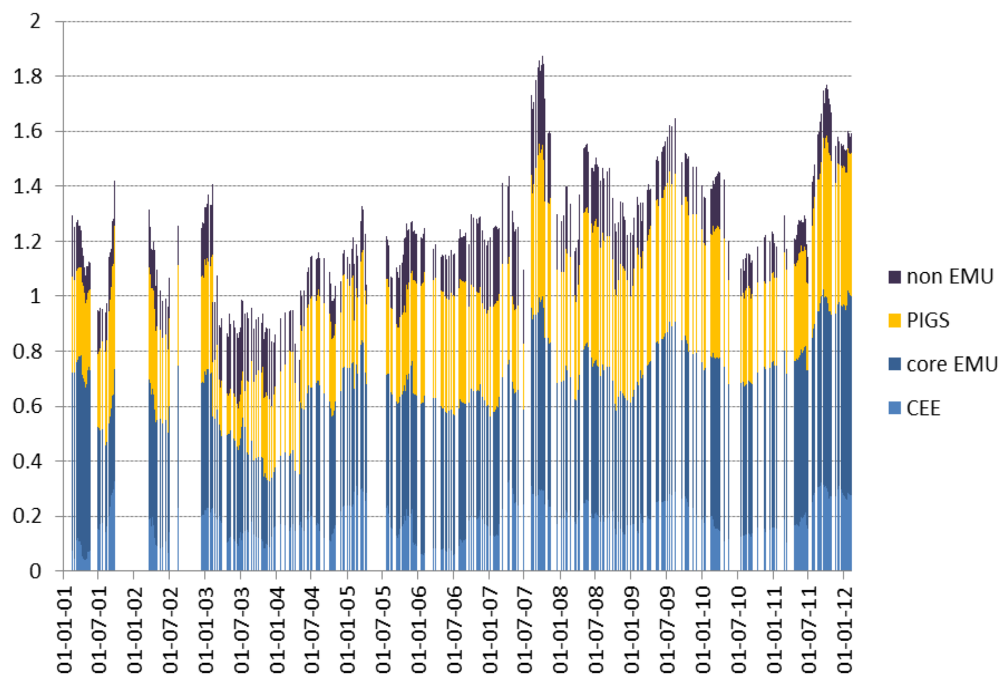
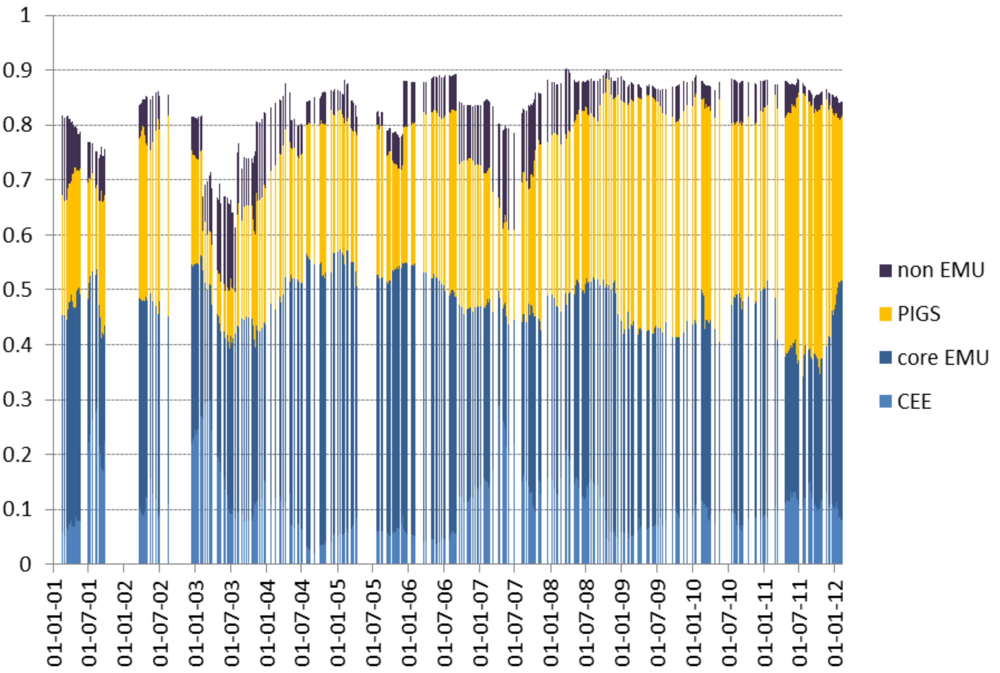


Figure 5b: Decomposition of the Effects of Other Bond Markets on Greek Bond Spreads



Another interesting example worth exploring concerns the central European countries, which according to Table 2 seem to have strong mutual linkages, but the time invariant result does not provide any indication of the direction of this spillover. In Figures 6a to 6c, we again decompose the total effect of shocks to Czech, Polish and Hungarian bond spreads on the remaining two EU countries. Unsurprisingly, the total spillover is much lower than for Greece and its size is more volatile, which corroborates the importance of time-varying analysis. The largest peaks in the spillover occur in all three countries during the global financial crisis, whose onset in the CE region is commonly dated to mid-2008 (cf. the peak for Greek spillover in late 2007). The spillover then fades quickly away only to increase again during the recent debt crisis.

However, there are some interesting differences between these three countries. The most notable is the very strong spike in the spillover transmitted from the Hungarian sovereign bond market in 2008. This is related to fiscal stress in Hungary, which was followed by a stand-by arrangement with the IMF in late 2008. This period could arguably be interpreted as contagion given that there was no fundamental similarity between Hungary and the other two CE countries (e.g. size and composition of sovereign debt), where most of the spillover went to. After the IMF intervention the spillover quickly returned to low levels. It increased again during the eurozone debt crisis, but more evenly across the three countries. Overall, it seems that the linkages between these countries have become gradually weaker over time. While the Polish and Hungarian sovereign bond spillover vis-à-vis the other two countries in the region represented more than half of the total transmitted spillover until the end of 2008, the mutual effect becomes much weaker afterwards. This gradual decline is also observable in the Czech Republic, but the spillover from its bond market has always been more closely linked to that of the other EU countries.

Figure 6a: Decomposition of the Effect of Czech Bond Spreads on Other Markets

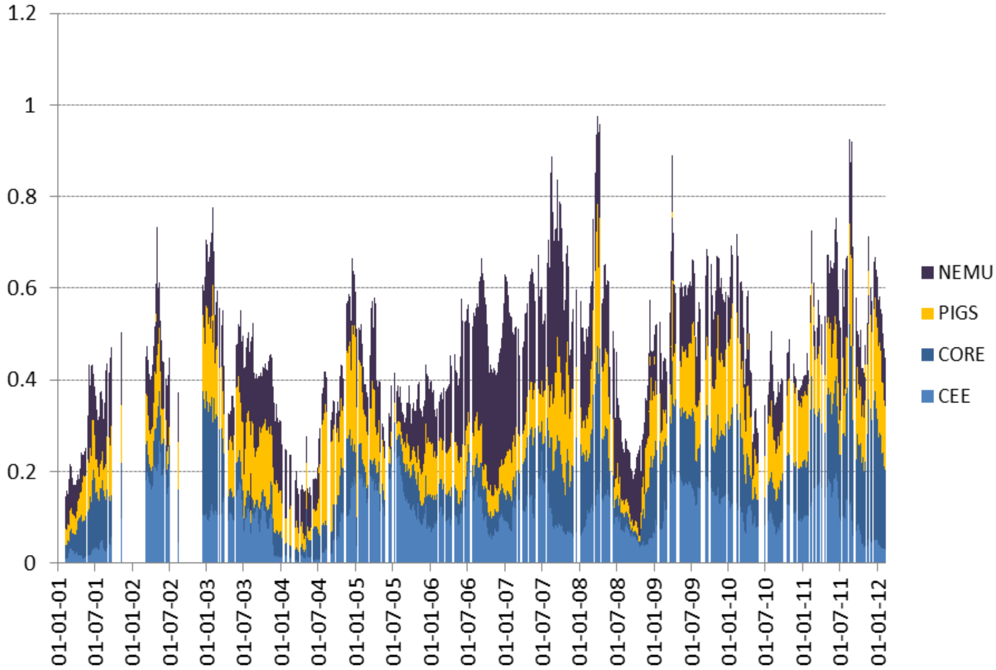


Figure 6b: Decomposition of the Effects of the Polish Bond Markets on Other Spreads

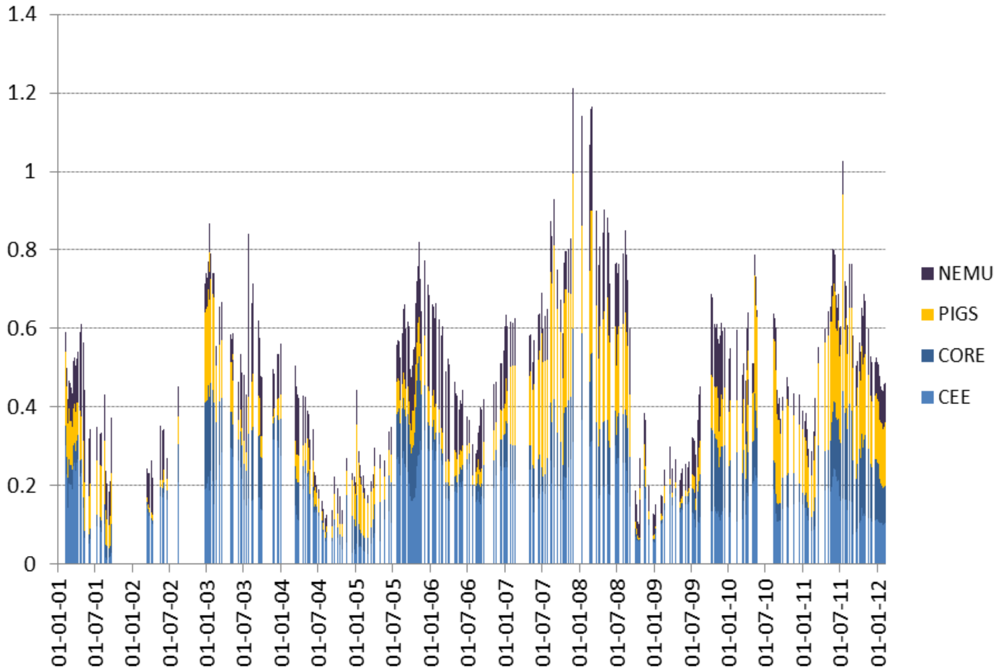
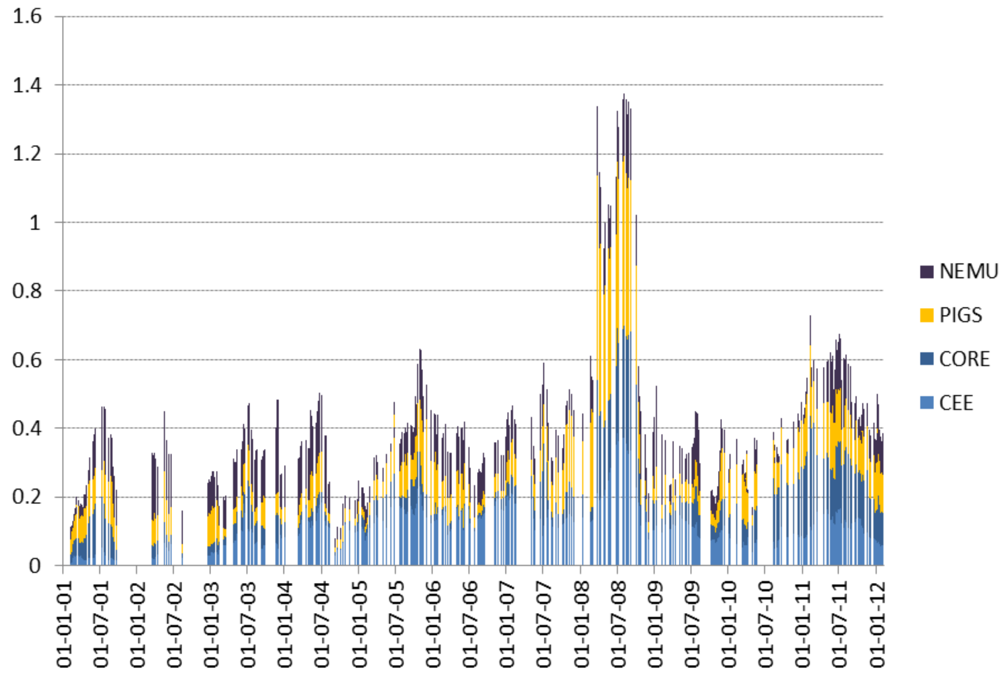


Figure 6c: Decomposition of the Effects of the Hungarian Bond Markets on Other Spreads



3.4. Alternative Specifications of the FAVAR Model

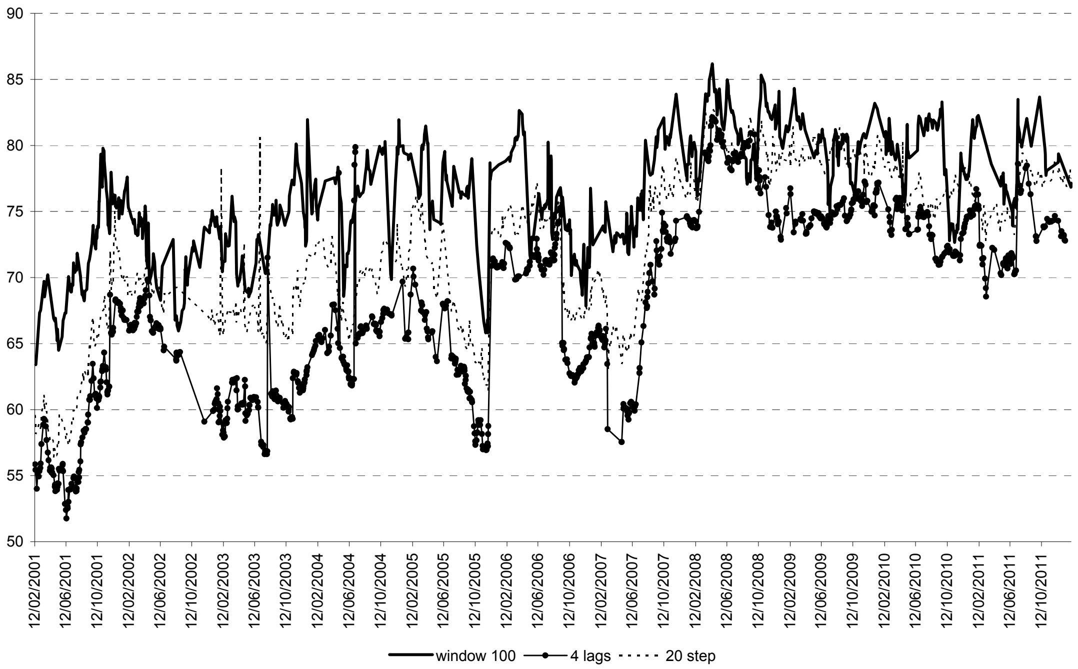
So far, we have controlled the VAR for common market behaviour by including a factor. The importance of this common factor can be seen from calculating matrix Λ for a simple VAR without a common factor (see Table A.1 in the Appendix). The total spillover falls, since the feedback from the common factor to each market is now incorporated into the evolution of the domestic spread. This feedback is obviously stronger for the eurozone countries. The own variable shares (i.e. the diagonal elements of Λ) are therefore larger, as is the spillover from the domestic to other markets. Therefore, omitting this common EMU factor might cause upward bias in the own variance share, as the feedbacks of common events are not taken into account.

The results of Table 2 also show evidence of additional direct spillover from shocks to sovereign markets in addition to the effects of the common factor. An implicit way to take the common factor into account is to de-factorise the spread series for each country and keep just the idiosyncratic part of the spread of each market. The spillover should just reflect the transmission across bond markets of idiosyncratic shocks, now that the common factor is taken out of the model. For those markets sharing common developments, the own variance share indeed increases, and the spillover to other markets is limited (see Table A.2 in the Appendix). In contrast, the model mostly owes to country-specific shocks the deviation from a common factor in markets that do not have much in common with the others. The consequence is that the spillover from these markets to the others is much stronger now. Two contrasting cases are GIIPS and the core eurozone countries. Since the former have been driving rising spreads in the eurozone, the common factor absorbs most of the spillover. Any other country-specific deviation has affected the spread only domestically (for more than 50% in Greece, Ireland or Portugal). By contrast, the spread in the core EMU has not followed the rise of the GIIPS countries to the same extent, but it is still correlated with the spreads in other EU countries (Figure 1). The spillover between the core EMU bond market and the other bond markets is therefore much higher (as is the total spillover in this model). For the same reason, the importance of the opt-out countries (Denmark, Sweden and the UK) on the spillover transmission increases substantially.

3.5. Robustness Checks

In addition, we run a number of other robustness checks, which confirm that the previous results are robust to (i) changes in the number of lags included in the VAR, (ii) the number of steps ahead when making the forecast, and (iii) the sample window. VAR models with 4 lags (instead of 2), a 20-days-ahead (instead of 10-days-ahead) forecast and a 400-day (instead of 200-day) rolling window all depict similar evolution of the spillover over time (Figure 7).

Figure 7: Robustness Checks on the VAR Model



4. Impact of Sovereign Rating News

The long-term rise in the spillover index shows the strong linkages between bond markets, yet the high-frequency movements also suggest that this spillover is affected by macroeconomic news. Such news on economic or political variables can change the outlook for public finances and consequently trigger the sudden sale of government bonds in different markets. The literature has focused on different types of news and studied the reaction of sovereign risk premia to events such as announcements of unconventional monetary policy measures (Kilponen et al., 2012), plans on government rescue packages for banks (Attinasi et al., 2010) and political news (European statements) on Greece (Mink and De Haan, 2011). One particular kind of event that has sparked quite some controversy in public opinion is rating news. The three main credit rating agencies (S&P, Moody's and Fitch) have been accused of destabilising sovereign bond markets with unjustified and untimely rating decisions. Announcements of downgrades of credit ratings or revisions of the rating outlooks of particular sovereign issuers seem to have provoked turbulence on asset markets and higher financing costs (e.g. De Grauwe, 2010; Trichet, 2010).

Research on the role of sovereign rating actions 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 (Afonso et al., 2011; Kräussl, 2005; Ismailescu and Kazemi, 2010). Different types of rating news, such as upgrades versus downgrades, outlook revisions or a combination of the two, usually have different effects on the yield spread.

Moreover, rating news seems to have triggered reactions in the bond markets of other sovereigns too. This is a consequence of financial integration: banking regulation, collateral rules, credit default swap contracts or investment mandates force domestic and foreign investors to relocate their savings towards higher rated bonds in response to downward rating revisions or adjustments (Sy, 2009). The pre-crisis consensus finding was that due to this portfolio shift a rating downgrade would raise the spread for the rated country but reduce it for other countries (Gande and Parsley, 2005).[18] However, this substitution effect in the bond portfolio has not been functioning since the start of the financial crisis. Afonso et al. (2011) analyse sovereign bond spreads and CDS quotes of EU countries and find a significantly positive response after a rating downgrade. This downgrade does have effects on other markets if it concerns EMU countries with a low rating

[18] Although most of this effect could have been anticipated in the bond market already (González-Rozada and Levy Yeyati, 2008; Ismailescu and Kazemi, 2010).

(GIIPS). Arezki et al. (2011) use a VAR model with rating dummies and confirm this result, but they additionally show that the effects depend on which country suffers the downgrade, which rating agency gives its verdict or the level of the rating (the lower the rating, the stronger the response).

4.1 Measuring the Impact and Spillover of Sovereign Rating News

Analysing the dynamic relationship between spreads and rating news is rather complex since there are several methodological problems. First, markets anticipate rating news. Hence spreads move before a credit agency makes its decision public. Often, announcements of a revision to the outlook of a rating are made months before the final rating decision. Second, isolating the effect of rating news is not easy since much other macroeconomic news occurs that changes the outlook of public finances. This contaminates the sample. Most papers that look at corporate bonds isolate the rating decision in a time span during which no other decisions were made or no other general news regarding the firm occurred (Mitra and Mitra, 2011). The evidence on the impact of rating announcements on sovereign risk premia is even further complicated if we consider the triggering effect of a rating decision on other sovereigns. A particular additional problem is that agencies often take rating action on several sovereign issuers on the same day and the rating action might even overlap with the decisions of the other two agencies. Third, the horizon of the impact of rating news is rather uncertain.

To deal with these points, we extend the VAR model for analysing bond market spillover and include a dummy for rating adjustments. Not only does the model allow us to examine the impact effect of ratings, but also we can examine if spillover on sovereign markets is special if it is related to actions by the main rating agencies or just reflects financial integration and reacts in a similar way to any kind of news. Our approach therefore aims to separate the ‘usual’ spillover on bond markets from the impact of rating news on bond spreads.[19]

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

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

[19] Unlike Arezki et al. (2011), we include all 16 sovereign bond markets in a single VAR. They are interested in the effects of ratings on several markets too, but do not explicitly model the channel by which this occurs. They, by contrast, look at spillover between different asset markets on a country-by-country basis.

These dummies correspond to the dates for the rating changes and we use a *step dummy* where each rating category is assigned a numerical value (going from a maximum of AAA to a minimum of D).[20] As in Arezki et al. (2011), this index is summed for all 16 countries in the sample. 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 the *rating actions of each rating agency* (S&P, Moody's, Fitch), and (iv) the differential effect of *rating actions related to single sovereigns*. The various types of rating actions probably have differential effects and it is not obvious which event represents proper rating news and possibly triggers (or is triggered by) sovereign yield spread dynamics.

The sovereign ratings are the long-term local currency debt rating 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 of rating actions. Figure 8 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 across countries. Following Romer and Romer (2010), we can also choose to include an impulse dummy on the day of the rating/outlook change. Panel b) draws this dummy on the date when the rating action (by each rating agency) was taken. Panel c) further distinguishes 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 than rating changes it records changes in rating outlooks, which might arguably indicate rating action ex ante and as such might represent real news.

4.2 Rating News and Spillover

We now replicate the same FAVAR 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 8). Table 3a 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 8) are rather similar (Table 3b). 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

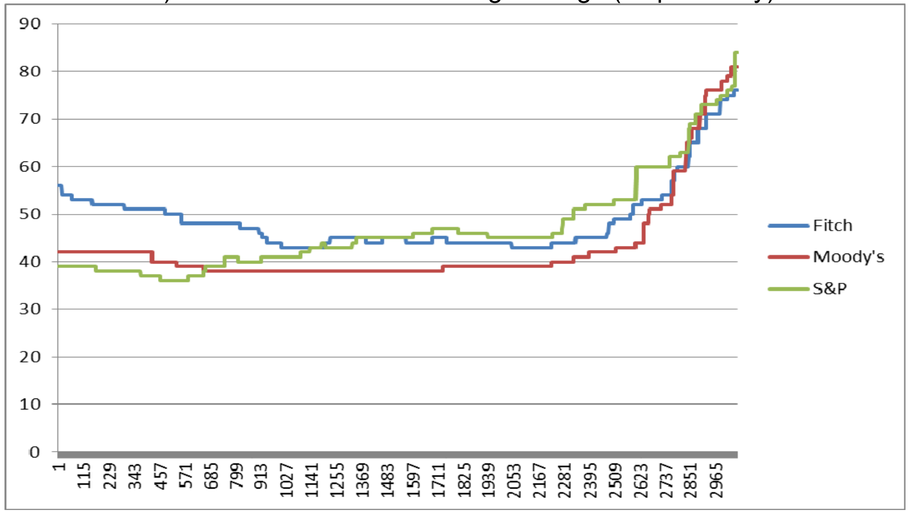
[20] Arezki et al. (2011) include all rating changes in Europe, but find that the EU rating events are the most important ones.

across markets. However, Tables 3a and 3b provide some finer details on the dynamic relationship between sovereign rating news and sovereign bond yield spreads.

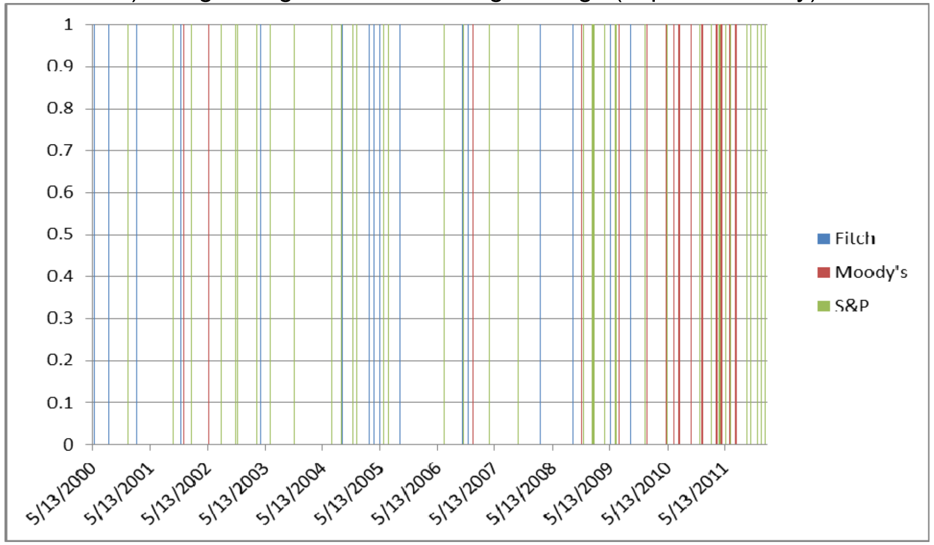
First, it seems that the spillover runs both from bond yield spreads towards rating actions and vice versa. The bottom row of Table 3a shows a spillover of 7.42 transmitted by the step-dummy rating variable to the bond markets, whereas the spillover absorbed from the bond markets is just 4.76. A similar finding is visible in Table 3b, with the difference that the spillover transmitted and absorbed by the impulse-dummy rating variable is almost identical. A further look at Table 3 shows some interesting findings: the countries most affected by overall rating actions are Portugal and Ireland.

Figure 8: Sovereign Credit Ratings

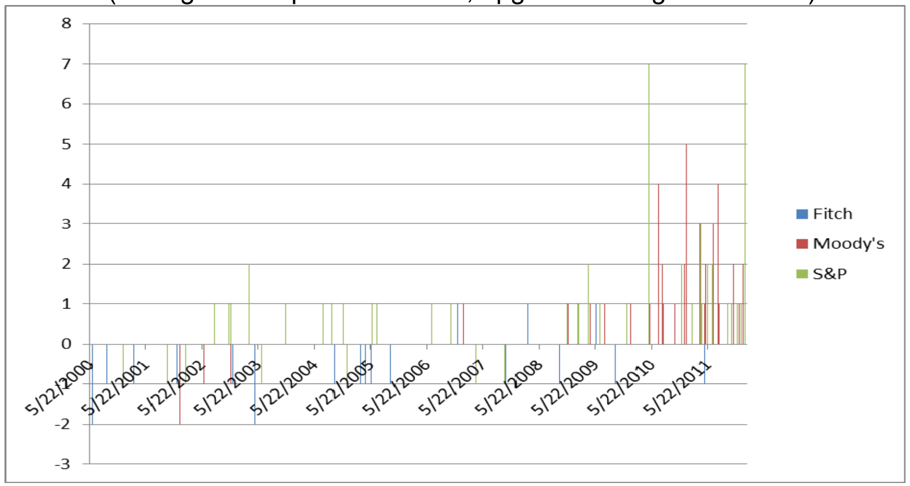
a) overall level of EU sovereign ratings (step dummy)



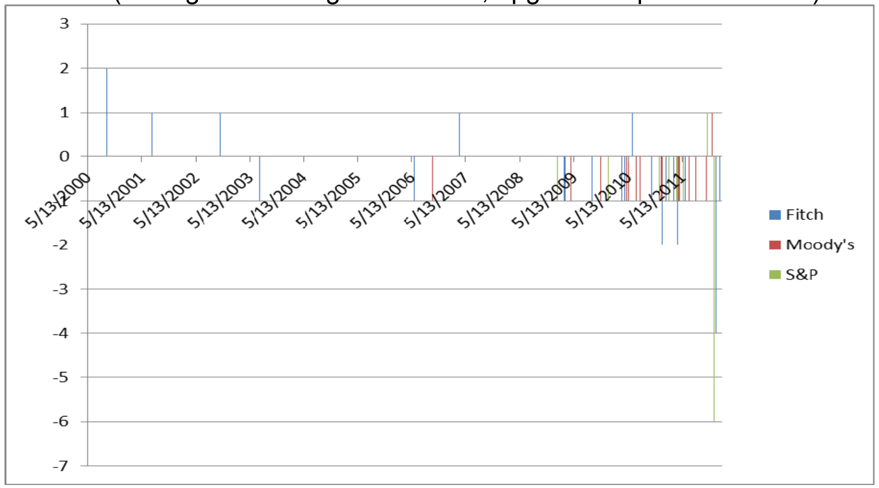
b) rating changes of EU sovereign ratings (impulse dummy)



c) rating changes of EU sovereign ratings by direction
(downgrades – positive values; upgrades – negative values)



d) rating outlook changes of EU sovereign ratings by direction
(downgrades – negative values; upgrades – positive values)



On the contrary, it is not just changes in spreads in the GIIPS that trigger a rating change. Other countries affecting the rating change include France and Belgium. The finding for Belgium seems to corroborate the result in Table 1 that this country has 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 the core EMU and GIIPS, and of course mostly so in the countries whose ratings have been regularly adjusted since the start of the debt crisis.

As noted above, with respect to the decisions of credit rating agencies it is not obvious which events 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 than an overall rating level or changes by the three rating agencies along different dimensions: (i) distinguishing between rating downgrades and upgrades (Table 4), (ii) testing the effect of rating outlook changes rather than rating changes themselves (Table 5), (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 the rating impulse dummy variable as in Table 3b.

Table 3a: 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 4a and 4b report the results when we use the impulse dummy for rating actions as in Table 3b 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, rating downgrades both receive and transmit more spillover to sovereign bond markets. The impact to and from individual sovereign bond markets is somewhat weaker than in the previous case and it seems that rating downgrades follow the developments in sovereign bond markets (the spillover absorbed is 4.88) rather than vice versa (the spillover transmitted is 2.58). The latter holds when we consider rating upgrades (Figure 3b), but the overall interrelation with bond markets is weaker. This evidence is partially at odds with the conclusions of previous event studies arguing that rating downgrades have a very significant spillover effect on sovereign bond markets. Although we find that negative rating news is related to more spillover than positive news, it seems that the rating decisions are followed by developments on bond markets rather than vice versa. However, this result can also have a negative connotation for rating agencies, suggesting that the role of sovereign credit ratings as forward-looking information is fairly limited. The fact that rating actions provide little additional or forward-looking information is apparent from Figure 9, where very few rating decisions are taken over almost a decade and are heavily concentrated in the recent period.

Table 5 reports 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 seems to suggest more intense spillover across markets (as compared to Table 3b). But it also seems that rating agencies react more strongly to sovereign bond markets when deciding on changing the rating outlook than on changing the rating itself (8.25 vs. 4.39). On the contrary, the response of bond markets to changes in a rating outlook is weaker (2.42 vs. 4.86). This may come as something of a surprise given that outlook changes signal future rating changes and as such can be deemed to represent news more than an actual change of rating. However, it seems that bond markets might not be convinced until the change is actually carried out.

Table 6 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 the upper left panel of Figure 9. Still, there are some interesting differences. In the pre-crisis period, we can see that while the overall rating level of EU sovereigns was improving (a decreasing overall value of the step dummy) according to Fitch and was worsening according to 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 6 reports the rating spillover when the 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 3b (and consistently with the step-dummy approach in Table 3a) it seems that there is more effect of spreads on rating decisions than vice versa. In Table 6 we can see that this is mainly due to the result for S&P, where the spillover absorbed substantially exceeds the spillover transmitted. Second, while there is some kind of interplay between the rating decisions of S&P and Fitch, Moody's is rather detached from the rating decisions of the other two agencies. This may also be related to the fact that the frequency of rating changes by Moody's is lower than in the other two cases (see Figure 9). Third, it seems that that Portugal and Ireland are the two countries whose bond yield spreads absorb the most spillover from rating decisions. By contrast, the spillover from spreads towards rating decisions is driven mainly by the spread dynamics of core EMU countries such as Austria, Belgium and France.

Finally, to evaluate the potential international spillover of rating actions it seems useful to separate the rating actions on individual sovereigns given that the severity of rating actions is concentrated in a few sovereigns. For instance, Greece was subject to 13 rating actions (including 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 (Table 7), the impact of a country's rating change – in particular a downgrade – affects the sovereign spreads of other countries more than its own. For instance, a Greek downgrade affects the spreads of Portugal and Ireland, while the impact on the Greek spread is very limited. Similarly, the Portuguese and Irish sovereign spreads imply major spillover towards the Greek rating variable rather than the dynamics of Greek sovereign spreads themselves.

4.3 Impact of Rating News

The results of the analysis reported in Table 7 suggest international spillover of rating decisions on Greece, Portugal and Ireland, which were the sovereign ratings subject to more severe changes in our sample. To learn more about the dynamic response of these rating actions on domestic and foreign sovereign bond spreads we use impulse-response functions (IRFs). Again, we aim at generalised IRFs so that the results are invariant to the ordering of the variables. Figures 9a–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 8a shows that a rating change, i.e. a downgrade, of Greek sovereign bonds significantly increases the spread for all GIIPS countries, while the spread of almost all other countries decreases. Similar findings can be observed in Figures 9b and 9c for Portugal and Ireland. Interestingly, it seems that CE countries are perceived rather as safe havens, like the core EMU countries. We can also see that most of the impact materialises rather quickly, i.e. within around 5 days. After 10 days, the spread rises by 4 to 20 basis points. However, it should be noted that most of the rating actions related to these three sovereign issuers were downgrades.

Overall, our findings are in line with previous empirical research using the event studies approach (e.g. Afonso et al., 2011; Kräussl, 2005; Ismailescu and Kazemi, 2010). In particular, we find bi-directional causality between ratings and spreads, a higher impact of negative rating actions and spillover of rating news to other sovereign markets. We also confirm that due to this portfolio a negative rating action can raise the spread for some countries perceived by investors as being similar (GIIPS), but can reduce it for other countries (Gande and Parsley, 2005; Arezki et al., 2011).

A related literature uses discrete response models to analyse the determinants of sovereign debt rating actions themselves, i.e. which factors rating agencies look at when assigning a certain rating level. Afonso et al. (2009) explain the level of ratings by debt levels and output growth, for example. Other papers find that the outlook status, past rating events and the duration of the existing rating matter (Hill et al., 2010). Empirical studies which, like us, find a bi-directional causality between changes in ratings and spreads (Afonso et al., 2011; Ismailescu and Kazemi, 2010) imply that ratings rather reflect information from sovereign bond markets. In other words, ratings do reveal new information to market participants, but confirm existing priors. The habit of following the market consensus turns out to be very problematic, especially when sovereign bonds are mispriced (de Grauwe and Ji, 2012). This seems to fit well with the recent European experience, as prior to the global financial crisis both bond spreads and ratings were subdued and both rose in step after its onset (compare Figures 1 and 8a).

Table 4a: 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 down	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 down	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 4b: 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 up	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 up	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 5: 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 6: 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	RATING Fitch	RATING Moody's	RATING 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
RATING 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
RATING Moody's	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
RATING 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 7: 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 9a: VAR Model: Sovereign Spread Response to Change in Rating (Change in Rating of Greece)

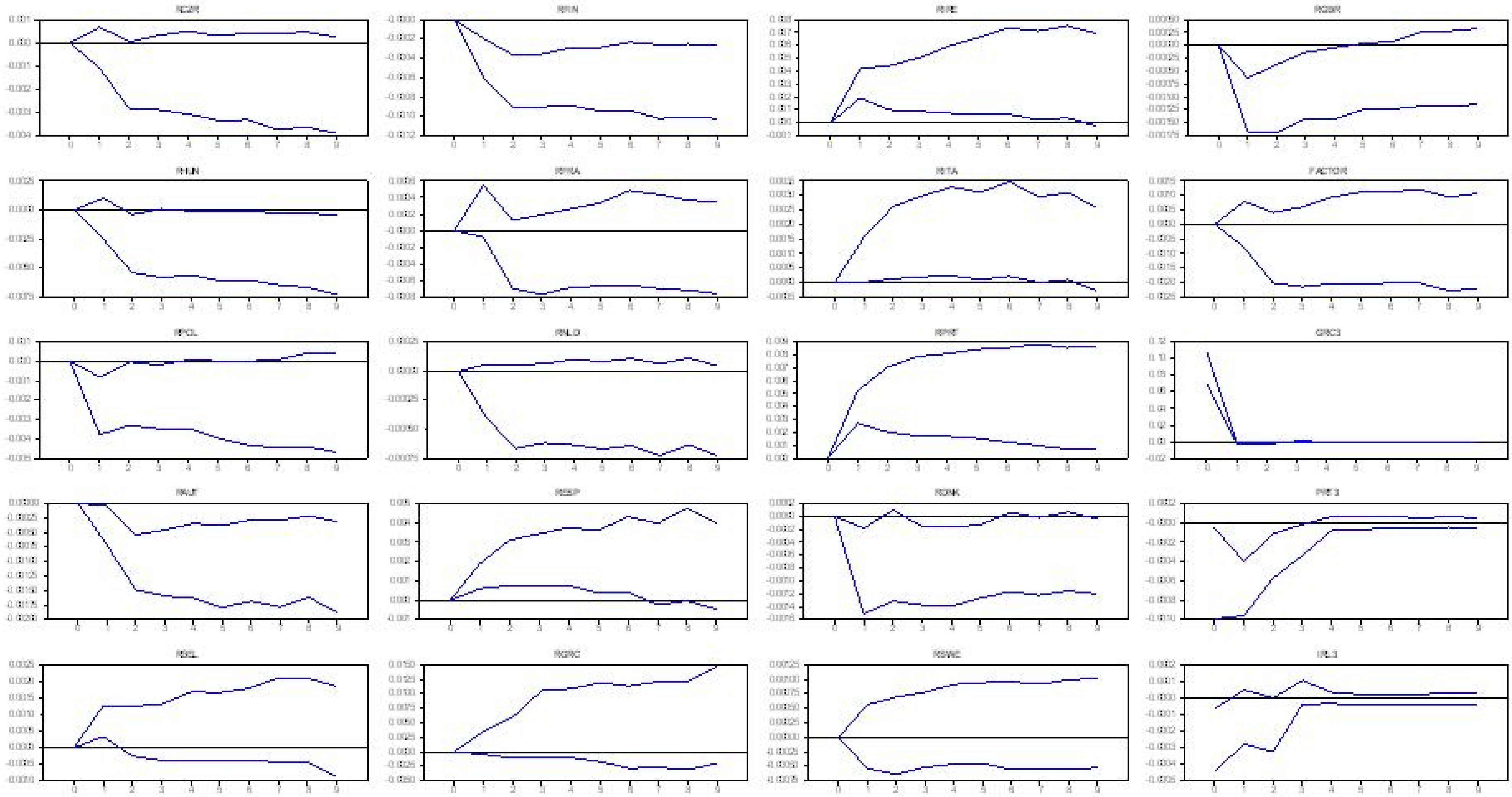


Figure 9b: VAR Model: Sovereign Spread Response to Change in Rating (Change in Rating of Portugal)

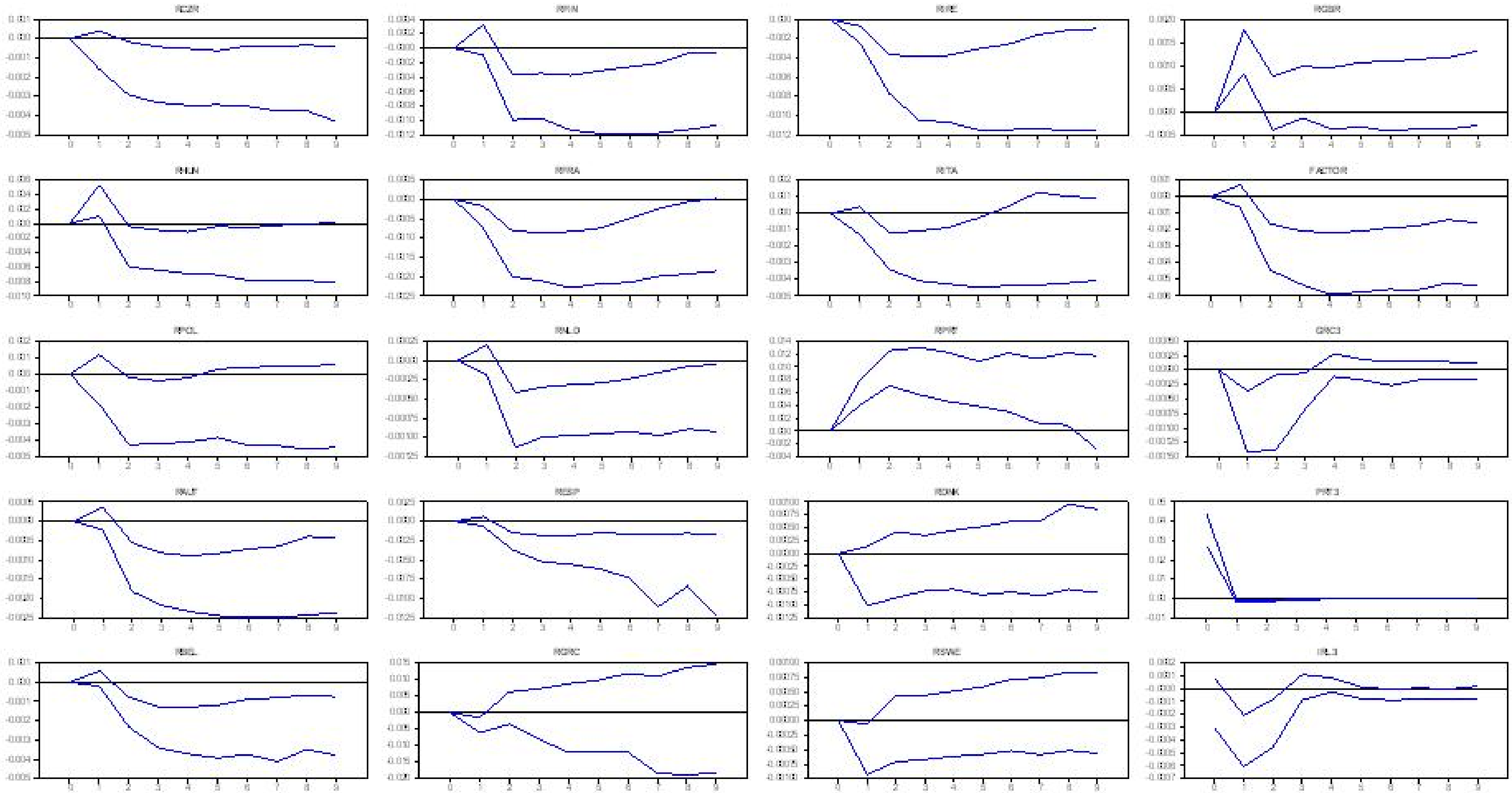
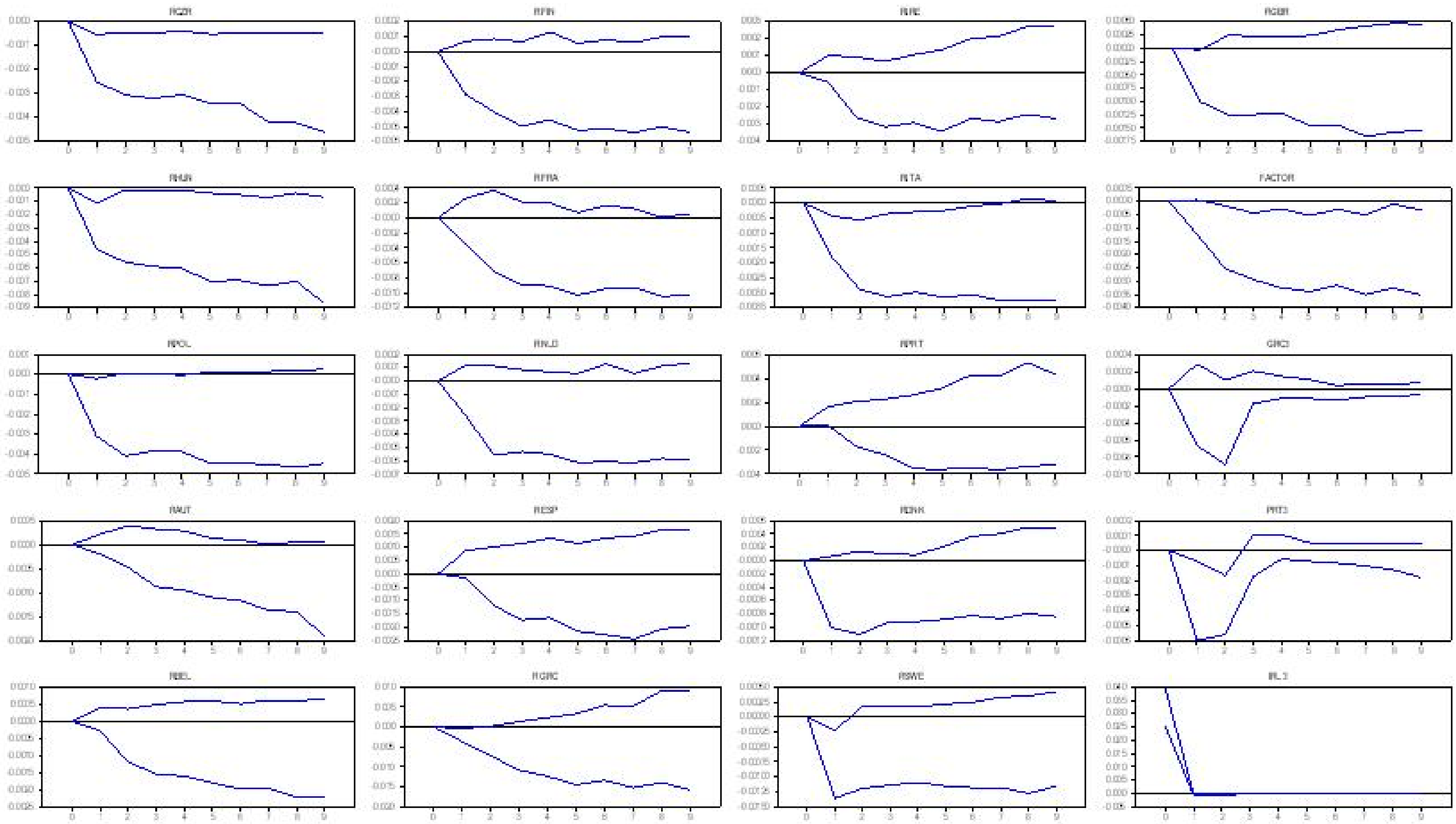


Figure 9c: VAR Model: Sovereign Spread Response to Change in Rating (Change in Rating of Ireland)



5. Conclusion

The speed and depth with which fiscal problems have spread across eurozone countries has come as a surprise to markets. 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 debt crisis in May 2010, coupled with a very rapid rise in bond spreads and the downgrading of all EMU countries but Germany, show 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 the spillover has increased substantially and permanently 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 CE countries affect each other, but Denmark, Sweden and the UK are insulated from the impact of other EU countries.

Our VAR-based evidence on rating announcements is in general consistent with previous studies on EMU countries, but a few findings are substantially different. We find that sovereign rating news contains some new information and has a significant impact on spreads. However, in most cases the spillover running from spreads towards rating decisions is similar or even stronger. This result, which is robust across different alternatives of the rating variable in the VAR, suggests that in general rating actions react to sovereign bond market developments rather than providing much additional information. Still, even though the effect of rating news on sovereign spreads is not in general very strong, its effect can be nonlinear. Consistently, we find that rating actions on most troubled sovereigns (Greece, Ireland and Portugal), i.e. mainly downgrades near or within the speculative grade, spill over internationally. The effect is immediate and generalised but rather heterogeneous. Indeed, while the spreads for some countries widen, those for some others narrow due to reallocation of investments.

There are several possible extensions to the analysis of rating decisions in this paper. First, we might consider including different asset markets (sovereign bonds, corporate bonds, stock markets, the banking sector) in a single VAR. This is important given that markets interact, which in the European context holds especially for 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 on other asset markets as well both domestically and abroad. Adjustments of sovereign ratings affect the financing costs of firms and banks (Kaminsky and Schmukler, 2002). The sovereign bond rate puts a floor under the bond market, as sovereign bonds are 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 (the price channel).

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APPENDIX

Table A.1: Spillover Table, No Factor, Full Sample (May 2000–February 2012)

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	From others
CZE	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 in 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 in spillover absorption	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 in spillover 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-Factorised Spread Series, Full Sample (May 2000–February 2012)

	CZE	POL	HUN	AUT	FIN	NLD	FRA	BEL	ESP	ITA	GRC	PRT	IRE	DNK	SWE	GBR	From others
CZE	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 in 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 in spillover absorption	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 in spillover 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

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