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"How systemic is Spain for Europe?"

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Abstract

We use the forecast-error variance decompositions from a VAR with daily sovereign bonds spreads since 2000 to detail the linkages between EU sovereign bond markets and banks over time. Using new summary statistics on the matrix of bilateral linkages, we show Spain is systemic for Europe. Its fiscal problems expose it to trouble in sovereign bond markets of the other Club Med countries, whereas its internationally grown banking sector transmits domestic economic trouble to the rest of Europe. This spillover has substantially increased since the outbreak of the Fiscal Crisis in the Eurozone in May 2010. We develop a real-time indicator to follow the degree of spillover on a daily basis.[1]

JEL classification: G12, C14, E43, E62, G12, H62, H63.
Keywords: spillover, contagion, sovereign bond spreads, fiscal policy, Eurozone, financial crisis, sovereign ratings.

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[1] The indicators in this paper are available at www.aqr.es

1. Introduction

The Financial Crisis started with losses on subprime loans in some US banks but had global consequences as uncovered debt positions triggered the collapse of major financial institutions both in the US and Europe. This banking crisis called for policy intervention, not just by central banks, but also out of the deep pockets of the tax payer. Massive public sector aid has now fired back to the financial sector as increased sovereign risk undermines bank balances. Simultaneously, rising credit risk and fiscal consolidation threaten economic recovery. This combined Financial and 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 of the Eurozone is so far the last chapter of this global crisis and is characterized both by the cross-country dimension of fiscal trouble and its potential international spillover.

The reasons for the virulency of the crisis are a mix of growing financial imbalances that also distorted economic balances. The high degree of credit leverage in an ever more global banking sector (Schoenmaker and Wagner, 2010) has played a catalysing role in transmitting economic and financial shocks. Well-intended regulation became obsolete in integrating financial markets. In the Eurozone in particular, a lack of institutions to handle banking crises, together with a faltering economic policy, has meant *ad hoc* policy responses meddling through lengthy diplomatic negotiations. Excess holdings of sovereign debt exposed international banks once fiscal positions worsened considerably in several countries. Governments and central banks are therefore looking to strengthen macro-prudential oversight on the banking system. This control requires new tools to measure system risk. An indicator of systemic risk should measure the potential degree of instability in financial sectors, identify its origin and assess its scope. The aim is to warn of the fragility of the economic system to events that might result in a breakdown of the financial system, and assist governments and central banks in preventing an economic meltdown.

A set of quantitative indicators has been developed to measure systemic interactions in financial systems (ECB, 2011). Most measures use day-to-day information from a specific segment of the financial market to analyse the direct interaction between market players. These measures can then be combined to indicate overall stress in financial markets, or linked to macro-economic indicators to forewarn of more general instability in the economy (ECB, 2011). In this paper, we develop a concise measure of overall systemic risk that is based on the forecast error variance decomposition of a VAR model including different asset prices (Diebold and Yilmaz, 2009, 2011). Shocks to an asset price contribute to explaining the variance in the other asset prices some periods ahead. This percentage contribution measures the bilateral link between markets. A market is systemic if it both sends and receives shocks from all other markets. The metric of systemic risk measures how connected a market is to many other markets. The metric is time-varying to track systemic risk in real time.[2]

We apply the metric to EU sovereign bond markets and EU banks over the period May 2000 to January 2012. We first track the magnitude and direction of spillover between bond markets and bank markets separately, and then look at the interaction between both. Our results show that since the start of the Financial Crisis, countries like Spain or Italy have become systematically important. Their bond markets suffered the effects of the economic crisis from a loss of competitiveness, just like the other Club Med countries. The Spanish and Italian bond markets were therefore especially affected by the Greek Crisis. But since they are well integrated into the Eurozone, they have transmitted these effects to the Eurozone core. One reason is that Spanish or Italian banks have expanded abroad. Applying the same metric to a VAR model including the stock prices of the 20 major EU banks, we find that the main Spanish banks – Banco Santander and BBVA – are the most systemic ones. Spain's internationally grown banking sector transmits domestic fiscal trouble to the rest of Europe. This spillover has substantially increased since the outbreak of the Fiscal Crisis in the Eurozone in May 2010. Large EU banks act globally, yet they still have a home bias in investing in domestic public debt (BIS; 2011). These links between the domestic banking sector and the public sector increase the systemic risk of EU banks. Spanish banks are the most systemic in the EU.

The paper is structured as follows. In section 2, we review the VAR model for measuring spillover based on the VAR method of Diebold and Yilmaz (2010), and derive the metric of systemic risk. The main empirical results are discussed in section 3 for sovereign bond markets, and in section 4 for bond and banking markets. The final section summarises the main results, and discusses some policy implications.

[2] The indicators in this paper are available at www.aqr.es

2. Empirical framework

2.1 Measuring sovereign bond spillover

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

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

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

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

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

The method allows us to study the general spillover between different asset markets, and dissect the strength and direction of the spillover between any two markets. Let us define *own variance shares* to be the fractions of the h-step-ahead error variances in forecasting x_i due to shocks to x_i, for i=1, 2,..,n, and *cross variance shares* to be the fractions of the h-step-ahead error variances in forecasting x_i due to shocks to x_j, for i, j = 1, 2,.., n, such that $i \neq j$. Diebold and Yilmaz (2009) suggest using these cross variance shares to measure the spillover from one series x_i to another x_j. In particular, we can compute the percentage contribution of a change in daily quoted asset prices on the variation in asset prices of each particular market included in the VAR model. The matrix Λ of all λ_{ij} contains all bilateral linkages to and from two different markets.[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.

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

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

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

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

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

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

Measure (5) is the sum of each column of the matrix Λ, not including the own contribution of each market.[4] 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 on net. It is also possible to

[3] It is like the weight matrix measuring distance spatial econometrics.
[4] Alternatively, one may include the own effect of the shock.

calculate then *the net pairwise spillover* that shows how much each market *i* contributes to another market *j* in net terms. For this, we need to obtain:

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

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

A second group of statistics measures the degree of connectedness of the different markets. Our measures are based on the homogeneity of the distribution of the bilateral linkages λ_{ij} (either in columns or across rows). A market with similar linkages λ_{ij} across all markets is more connected to the entire set of markets than a market that has just a few important neighbouring markets. Elements λ_{ij} that are smaller than the (row or column) average would indicate the markets to which a market has weaker links. A market with a smaller standard deviation or a small degree of skewness S_i or little kurtosis (in the row or column) is a market that has relatively more links to other markets and is more integrated. We can also combine the measure of skewness along row and column dimensions, and $S_i.S_j$ indicates the skewness both on the emission and receipt of shocks. A market is well connected both in sending shocks to other markets and receiving shocks from other markets if $S_i.S_j$ is low. We call a market systemic if it is strongly connected to all other markets.

All statistics measure interdependence between financial markets. The approach of Diebold and Yilmaz (2009, 2011) improves over partial equilibrium approaches as it measures transmission from one market to another. I.e. it provides an index number between 0 and 100 that reflects the contribution of a shock originating in one market and flowing to another. The index is therefore not a simple measure of co-movement of markets that reflects a similar response to a common shock, but measures the importance of an idiosyncratic shock in a market onto other markets, which is in line with Forbes and Rigobon (2002).[5] The literature on international spillover has bypassed the fact that asset markets are not equally integrated internationally (Kaminsky and Reinhart, 2000). In contrast to

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

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2.2 Measuring systemic risk

We measure all bilateral linkages between markets, and hence get an indication on their connectedness. Some markets interact more with some markets, and less with others, and the reasons for this different degree of interaction can be multiple. The spillover can either reflect the co-movement of fundamentals or be due to contagion. This makes the approach adequate to measure systemic risk, and identify the most systemic markets (and track their evolution on a daily basis).

Systemic events – as opposed to idiosyncratic ones – spread from one market to another such that the overall stability of the system is impaired. First, markets ought to withstand the collapse of a single market player or more market players. Second, the market as a whole should be diversified so that common events do not cause problems for all market players simultaneously. In both cases, a market that is not resilient to the contagion of idiosyncratic events experiences systemic risk, and some agents can be identified as systemic (ECB, 2011). While contagion from one market player to another occurs in a sequential fashion, common systemic events have no clear timing, since all markets are contemporaneously exposed to a similar event. The idiosyncratic or common shocks that hit the system may be exogenous, as for example with an economic downturn, or be endogenous if it occurs for example in a financial crisis following a bank default, or the burst of a bubble in credit and asset markets.[6]

Several approaches exist to measure systemic risk. For obvious reasons, most of the papers focus on financial markets, and in particular on the systemic risk contribution of individual financial intermediaries. Early contributions developed early warning systems using a univariate or multivariate logit/probit models (Berg *et al.*, 2005). These models are useful for signalling risks but do not capture idiosyncratic or systematic factors, nor do they evaluate the importance of exogenous or endogenous shocks to financial systems.

[6] For a complete survey on systemic risk, see Berger *et al.* (2009).

All of the more recent proposals – grown out of the need to understand the Financial Crisis – attempt to measure systemic interactions in financial systems. Our approach is closest to studies that look at the contagion between individual financial institutions (the so-called 'horizontal view' on systemic risk).[7] Acharya and Pedersen (2010) develop a model of systemic risk and look at the effect of financial shocks on the probability that a bank gets undercapitalised. This expected shortfall depends on the bank's leverage, equity volatility, correlation of the bank's equity with a market index, and tail dependence on extreme events. Brownlees and Engle (2010) extend the empirical application of this method to compute marginal expected shortfalls for individual banks, and aggregate shortfalls for the financial system as a whole.[8] A similar method is applied by White *et al.* (2011). They include in a VAR model the Value at Risk measures of bank stock prices and the banking market to test the sensitivity of a bank's value at risk (VaR) to shocks to the entire banking sector. They apply quantile regressions to test contagion under extreme events, and look at the impulse responses to these shocks for a group of banks.

Our VAR methodology is close to theirs as we use daily market data to estimate the systemic risk position of each market player. Following Brownlees and Engle (2010), we take into account the effect of each market's problems on total market conditions, and the feedback of market distress on the position of the agent. Hence, systemic players are those that do not only suffer most individually during the crisis, but also contribute most to overall market losses. Since both market conditions and the position of each individual issuer are endogenous variables, the VAR model estimates this interaction between systemic issuers and the market.[9] Hence, we do not only look at sequential events but measure simultaneous impacts across markets. This overall assessment takes into account the endogeneity of interactions, as in Segoviano and Goodhart (2009). They develop measures of joint distress probability of the banking system in the wake of a crisis, from a panel of individual default probabilities. As in this panel approach, the dimensions of the model grow large for a small number of markets, and the bilateral matrix measures pair-wise contagion. Since we use daily data, estimation of the VAR does not pose particular problems. The complexity of all bilateral linkages can be captured in summary statistics, while time-varying estimation allows tracking these numbers over time while we can still identify the individual sources of vulnerability.

A few other measures of direct interaction between market players exist. A first group is based on the external exposure of financial institutions. These measures look at counterparty risk from bilateral flow

[7] For a full overview of empirical measures of systemic risk, see ECB (2011).
[8] These measures expected capital shortfall of a bank are the basis of a variety of weekly risk measures for big financial firms, under various market scenarios, that are published online by the Stern NYU Volatility Laboratory.
[9] Adrian and Brunnermeier (2008) develop a similar bivariate measure based on the Value at Risk of a bank and the total market.

of funds between institutions, such as interbank exposures (Degryse and Nguyen, 2007; Castren and Kavonius, 2009). This results in a matrix of bilateral balance sheet exposures, which is similar to our matrix of bilateral contagion.[10] A second group considers that market outcomes are the result of interactions between agents, so some papers measure the systemic position of some banks using concepts of cooperative game theory, like the core and shapley value (Tarashev *et al.*, 2010).

A second approach to measure systemic risk incorporates macro-financial data to measure the impact of common systemic events on the financial sector. Early studies that look at systemic crises in the banking sector have used event studies but these have come to mixed conclusions, mostly as direct contagion is hard to distinguish from aggregate shocks.[11] Schwaab *et al.* (2011), for example, compute coincident and early warning indicators of individual and simultaneous failure of financial institutions and measure how macro-economic events affect this credit risk. Alessi and Detken (2011) include forward looking measures of credit market activity to detect emerging instabilities.

A third approach goes even further in measuring overall risk by aggregating coincident indicators of systemic stress in various parts of the financial system that aggregates stress measures from the money market to bond markets, and can therefore detect market-to-market contagion (Hollo *et al.*, 2010). This CISS can therefore locate the build-up of systemic stress in some market segments. By contrast, our approach does not consider the effects of current or future macro-economic or financial conditions. Overall macro-economic conditions are only in the background, yet we can evaluate their impact from the variation over time in systemic risk. Nonetheless, we consider a set of individual market players in the VAR. In section 3 we look at bond markets, in section 4, at the banking sector, and we then combine the information of both markets.

2.3 Specification

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

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[10] The matrix is consequently used to measure overall risk exposure and run some counterfactual simulations on the overall resilience of the banking system (Upper and Worms, 2004; Llelyveld and Lledorp, 2006). Similar Monte Carlo experiments have been run on payment data in large-value payment systems.

[11] Therefore, most studies have isolated a few extreme events in bank stock prices. Gropp *et al.* (2009) use a multinomial logit model on these events and find that cross-border contagion risk among EU countries has importantly increased over time.

We choose to include in the basic VAR model two lags of the asset price, and compute the forecast error variance decomposition at a horizon of 10 days (one week and a half) which should be sufficient to capture the horizon at which spillover across markets occurs. We examine spillover between the Spanish bond market and other EU sovereign bond prices using daily data on 10-year sovereign bond yield spreads of 16 EU countries over the corresponding German bond yield over the period May 2000 up to February 2012 (closing price).[12] The selection of the benchmark 'risk-free rate' can slightly distort the results if there is a 'flight to quality' towards the 'safe haven' German bonds. This problem is in our case at least partially mitigated as this flight affects the spreads for all countries in the same way, and we measure spillover by the contribution of a shock to one country's spread to forecast-error of another rather than looking at contemporaneous correlation that can arguably increase with common change in 'risk-free rate' occur. Macroeconomic events and imbalances may distort prices and give a false impression of market stability. Our measure does not run into this problem since we are interested in the bilateral links over time, regardless of the overall evaluation of the market.

Figure 1a shows the spreads for Spain and the other PIIG countries (Portugal, Ireland, Italy, and Greece). After a long period of calm on bond markets, spreads have boomed since the start of the Financial and Fiscal Crisis, to reach unprecedented heights in Greece or Portugal, while spreads for Ireland, Italy or Spain have remained close to 500 basis points since late 2011. We also show a close up image over the period 2008-12 in Figure 1b-c for both the core EMU (Austria, Belgium, France, Finland, Netherlands), and non-EMU countries (Denmark, the UK and Sweden). Figure 1b shows rising spreads during the Financial Crisis, but the explosion of spreads takes place once fiscal problems in Greece come to the fore. All PIIGS experience a gradual rise in spreads, with the strongest reaction in Ireland and Portugal. Only Ireland manages to set itself apart since June 2011 as the spread falls back to 500 basis points. On the contrary, the Italian and Spanish bonds experience a drop in prices in the same period, and are close to a 500 basis points spread since. In core EU countries spreads have been moderate but have nonetheless risen a lot since the start of the Financial and then again the Fiscal Crisis. They experience a similar effect as Italy or Spain since June 2011: Austrian, Belgian and French bonds trade at around 300 basis points at the height of the autumn 2011 crisis. In contrast, Denmark, Sweden or the UK do not experience such an increase and their sovereign bonds pay just a marginal spread over German bonds. They even trade at higher prices than German bonds in late 2011.

[12] For most of the CEE, the bond yield quotations are available only for a few last years. Therefore, they could not be included to the sample.

3. Sovereign bond spillover from/to Spain

3.1 Spillover and linkages across markets

Figure 1 suggests there are important interlinkages between sovereign bond markets, but that these linkages are not equally strong between all markets, and also vary over time. We first look at the spillover between all 16 EU sovereign bond markets using the GVAR model including all bond prices.[13] Table 1 reports the contribution of a shock to bond spreads on other markets and some summary statistics. The bottom rows of the table sum the effect of shocks to a market on all others (either including the own effect or not). The right hand column sums the effect a market receives from all other markets. We also report the connectedness statistics on the bottom (*right*) of each column (*row*).

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

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

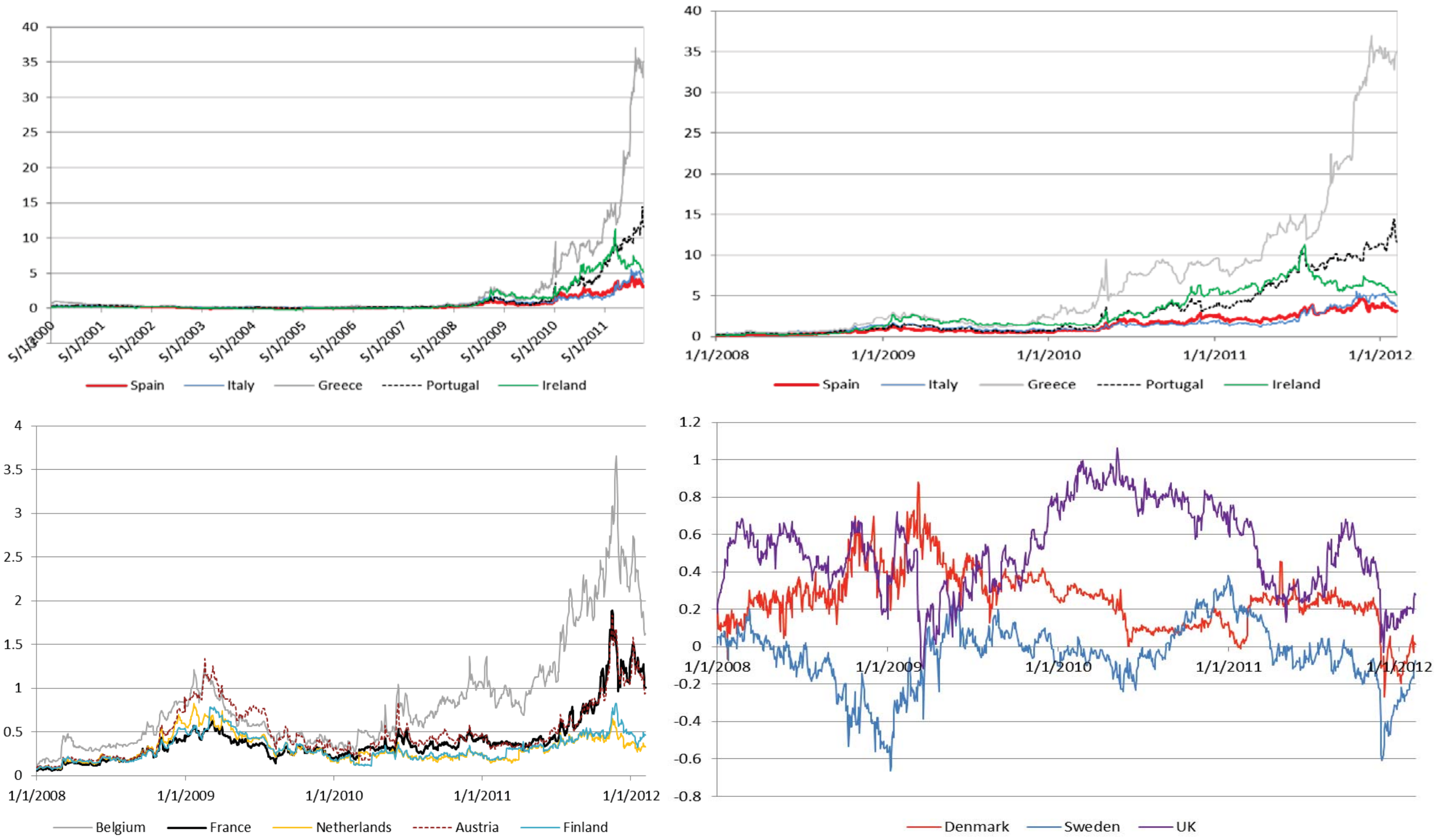


Table 1 summarises this directional spillover for the full sample May 2000- October 2011. It captures the linkages on financial markets and shows the structure and intensity of the degree of spillover between different sovereign bond markets. The total spillover amounts to 55%, meaning that more than half of the variation in sovereign bond spreads can be explained by shocks to bond spreads in other countries. Only 44% of all movements are caused by purely domestic factor, i.e. idiosyncratic dynamics of the spread in the past. This result confirms the importance of controlling for a 'global factor' that reflects changes in other markets. The size of the global effect is in line with what other studies find: a major part of the bond spreads are not determined by domestic factors but by international bond markets.[14] But in contrast to those studies, our result is not derived from a partial equilibrium assumption, in which global conditions cause domestic changes, but if fully accounts for the feedback of domestic markets to international markets.

We can actually see the large variety of spillover effects between bond markets from the bilateral entries in Table 1. The country-specific effect of spillover is not alike for each country. The colour-scale goes from red for the lowest degree of connection to green for the highest degree of connection. An overlook view shows the highest degree of connection for domestic markets. For non-EMU members (Denmark, Sweden and the UK) the domestic factor accounts for nearly 95% of the changes in the bond spread, and for the CEE (the Czech Republic, Hungary, Poland) it is around two-thirds, but the idiosyncratic change amounts to just one fourth for the EMU countries. The intermediate colours dominate between EMU bond markets. They are strongly integrated and shocks to spreads mostly affect other markets, rather than being idiosyncratic.

The colour-scale also reveals that the bilateral linkages are quite distinct for non-EMU countries. Linkages are weak both among them and with the other EU countries. Less than 15% of the shocks to bond spreads to these countries spills over to other markets. The most extreme case is the UK whose sovereign borrowing cost does not seem to have any effect on the other EU countries at all. The same applies to the spillover the non-EMU countries receive as they are relatively insulated from bond markets in the Eurozone. Nonetheless, Denmark or Sweden are substantially more linked to the EMU probably because of strong trade linkage to the core eurozone countries (as well as their participation in ERM2). A similar explanation holds for the CEE who have few effects on other markets, although their bilateral linkages are strong. About one third of all the spillover to other markets only occurs between the Czech Republic, Hungary and Poland themselves. Despite its

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

economic proximity and the importance of its banking sector, Austrian bond prices do not affect by much the CEE spillover nor are they influenced very much by the CEE bond markets.

The spillover between EMU countries differs for the two main groups: a core of EMU countries (Austria, Belgium, France, Finland and the Netherlands) and the group of PIIGS (Portugal, Ireland,

Italy, Greece and Spain). For the former group, the domestic effect is still the strongest, but the spillover to other core EMU members and the PIIGS is as important. For the latter group of PIIGS, there are very significant bilateral linkages between individual PIIGS countries, which often explains up to 20% of the total variation in the spread. The Spanish spread, for example, affects Italy by 20%, Greece, Portugal and Ireland by 11% each. However, the PIIGS also have a substantial impact on the core EMU countries: Spanish spreads affect Belgian ones by no less than 16%.

The Spanish bond market in particular seems to be a systemic link on European bond markets. The net index is the highest of all markets: the net spillover to other markets is about 1.6 times as large as the effect of a shock on its own market. A similarly large net effect on EU bond markets comes from Belgium (index 1.43), Italy (index 1.33) or France (index 1.11). Together with Belgium, the effect of shocks to the Spanish sovereign bond market are most equally spread over other EU markets. The skewness measure is the lowest for Belgium and Spain.

The same cannot be said for the shocks Spain receives from other markets. Core EMU countries like Austria, Belgium or Finland receive shocks from nearly all other EU markets in equal measure. Spain and Italy have a slightly more skewed distribution of the shocks they receive from others among the PIIGS countries. It is actually their mutual exposure that skews the distribution, but otherwise both markets receive the effects of shocks to other EU markets in equal measure. The combined skewness measure classifies Belgium as the most systemic bond market in Europe (followed by Finland and Italy).[15] If we account for the mutual exposure of Spain and Italy, then both countries are crucial in sending and receiving shocks to and from all EU bond markets.

[15] Belgium economically rather belongs to the core EMU countries, and despite a high public debt it pays a subdued credit risk. This makes Belgium actually the country with the most open bond market in Europe: it is both the biggest receiver of shocks abroad as well as the country that affects (in relative terms) most the other EU countries.

3.2 Time variation

The analysis based on full sample estimates might not fully uncover the change over time in all these bilateral linkages. The Financial Crisis is commonly believed to have significantly increased co-movements across asset markets, and the Fiscal Crisis starting in 2010 the co-movements across sovereign bond markets. Figure 1 shows how the spreads of all EU countries have closely moved together since early 2002, and how the PIIGS have seen a divergent move away from the German 10 year bond rate since 2010. To examine this time-variation in spillover, we follow Diebold and Yilmaz (2009) run the VAR model over a 200-day rolling window and reproduce all linkages for each pair of markets.

Figure 2 summarises the evolution of total spillover. Spillover has been substantial most of the time as the index never falls below 50%. We can compare our estimate that varies between 40 and 80% with Diebold and Yilmaz (2009) who estimate such spillover for global stock markets (1995-2007) between 40 and 55%.[16] The 2001-06 period shows a high level of spillover as most movements in bond rates were driven by the same factors. We can observe some specific spikes in spillover, for example, after September 11th, the application of the Excessive Deficit Procedures to some EU countries or the revision of the Stability and Growth Pact in March 2005. The total spillover oscillates between 55 and 70% till the end of 2005 when it significantly declines to 50% in early 2007.

The start of the Financial Crisis in mid-late 2007 raised again the co-movement of sovereign bond spreads. The spillover index shoots up to 70% and it has remained at this high level with peaks of 75% until January 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. We can discern the consequence of some major events on the co-movement of bond spreads, like:

A. the collapse of Lehman Brothers (September 2008);

B. the bankruptcy of Dubai World (November 2009);

C. the fiscal trouble of Greece (May 2010);

D. the set-up of the European Stability Mechanism (ESM)(February 2011);

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

E. the spread of the Fiscal Crisis to Spain and Italy (June 2011), and the measures adopted in August and September 2011 by the ECB.

A Bai-Lumsdaine-Stock (1998) test on the VAR model for the central 70% part of the sample (between February 6th, 2002 and May 4th, 2010) shows that a significant break occurs between April 22nd and April 30th 2010 for the homoskedastic version, which corresponds to the first crisis meeting of the Eurogroup on the Greek fiscal situation.[17]

We repeat the computations of all bilateral linkages on a subsample starting in January 2008. In order to better perceive the fluctuations since the Financial Crisis, Figure 3 shows a close up image of Figure 2 since the start of the Fiscal crisis in April 2010. The time-varying plot of the total spillover hides a lot of the changes in bilateral linkages across markets during this crisis. Table 2 collects the same statistics for this subsample. As expected, the total spillover has increased on average to 66%, and as the relations between all sovereign bond markets have become stronger, they have also maintained the same order of interaction. Eurozone bond markets are much more interconnected than non-EMU markets. The core EMU and PIIGS are mainly linked to each other, and a few countries connect both groups. The Spanish bond market has become the main contributor to other markets, closely followed by Italy and France. Belgium and Hungary too send relatively more shocks abroad than they originate domestically. Belgium and Spain still are the countries with the most homogenous effect on all other markets. In contrast to the full sample estimates, Spain now receives also the effect of many more bond markets. Since Spain both receives and sends out shocks to many more EU bond markets, it becomes the most systemic bond market in the EU.

[17]) The heteroskedastic version of the test indicates a break between July and September 2009, and marks the start of the gradual increase in spillover after the first peak in 2008.

Table 1. Total spillover, May 2000- February 2012

	CZR	HUN	POL	AUT	BEL	FRA	FIN	NLD	ESP	GRC	IRE	ITA	PRT	DNK	SWE	GBR	from Others	S_j	kurtosis	S_i S_j
CZR	53.82	7.91	8.06	3.01	3.37	0.79	1.97	1.24	4.58	0.86	2.11	5.02	0.97	5.15	1.11	0.02	46.18	3.76	14.60	14.43
HUN	7.13	53.95	8.86	2.87	3.74	0.84	0.83	1.03	4.39	1.65	3.15	4.86	1.46	5.01	0.17	0.06	46.05	3.75	14.56	14.22
POL	7.41	7.27	61.41	1.35	2.10	0.33	0.92	0.41	3.14	1.21	2.12	3.62	1.25	6.43	1.00	0.03	38.59	3.82	14.98	14.58
AUT	2.07	3.56	1.92	24.78	13.34	4.84	11.05	8.31	9.72	2.09	4.10	11.44	1.80	0.79	0.12	0.05	75.22	1.60	2.97	3.45
BEL	1.91	2.35	1.69	8.28	24.44	3.20	9.24	5.65	16.15	1.86	6.04	16.01	2.62	0.39	0.13	0.03	75.56	1.50	1.71	1.08
FRA	1.85	1.33	1.24	10.08	9.99	29.94	10.19	13.21	6.24	1.37	3.89	6.63	1.67	1.42	0.47	0.48	70.06	2.23	6.02	7.44
FIN	1.89	2.18	1.66	11.23	14.10	4.75	21.60	8.18	10.38	2.54	3.70	14.03	1.64	1.54	0.36	0.22	78.40	1.16	0.61	1.80
NLD	2.01	2.57	1.12	9.06	9.37	9.87	9.45	29.22	7.50	1.65	4.70	7.00	2.68	2.33	0.61	0.85	70.78	2.51	7.83	6.78
ESP	1.61	1.66	1.26	6.04	12.23	1.89	7.16	4.47	30.76	3.00	8.22	16.97	3.99	0.35	0.18	0.21	69.24	2.21	5.39	3.05
GRC	1.55	1.16	0.96	2.96	9.27	1.84	5.26	2.46	10.71	38.00	10.10	8.82	6.43	0.14	0.07	0.28	62.00	2.95	10.05	11.05
IRE	1.33	1.41	0.96	3.74	8.60	2.18	4.17	3.13	11.28	5.81	40.41	5.85	11.01	0.06	0.01	0.04	59.59	3.12	10.91	9.02
ITA	2.14	2.04	1.68	4.65	13.93	1.72	4.88	3.57	20.52	3.30	7.27	29.48	4.11	0.51	0.13	0.07	70.52	2.04	3.76	2.97
PRT	1.05	1.38	0.81	2.54	8.97	0.40	1.52	1.18	11.26	6.66	17.59	7.49	39.00	0.06	0.03	0.02	61.00	2.60	7.60	9.11
DNK	4.45	6.21	4.43	1.78	0.94	2.89	2.70	3.56	0.26	0.46	0.55	0.73	0.38	64.58	5.89	0.19	35.42	3.89	15.34	15.01
SWE	1.56	0.91	1.13	0.16	0.21	0.65	0.34	1.09	0.61	0.12	0.18	0.32	0.19	5.80	85.84	0.88	14.16	3.97	15.84	15.77
GBR	0.33	0.17	0.15	0.29	0.29	0.75	0.48	1.77	1.67	0.50	1.05	0.81	0.93	0.21	1.63	88.96	11.04	4.00	15.98	15.98
Contribution to others	38.29	42.11	35.94	68.05	110.45	36.95	70.16	59.28	118.43	33.10	74.75	109.60	41.15	30.19	11.91	3.42	883.78			
Contribution including own	92.12	96.06	97.35	92.82	134.89	66.89	91.76	88.50	149.19	71.10	115.17	139.09	80.15	94.77	97.75	92.39	55.2%			
From others	46.18	46.05	38.59	75.22	75.56	70.06	78.40	70.78	69.24	62.00	59.59	70.52	61.00	35.42	14.16	11.04				
Net spillover	7.88	3.94	2.65	7.18	-34.89	33.11	8.24	11.50	-49.19	28.90	-15.17	-39.09	19.85	5.23	2.25	7.61				
net index	0.15	0.07	0.04	0.29	**1.43**	**1.11**	0.38	0.39	**1.60**	0.76	0.38	**1.33**	0.51	0.08	0.03	0.09				
S_i	3.84	3.79	3.81	2.15	**0.72**	3.34	1.55	2.70	1.38	3.74	2.89	1.46	3.50	3.86	3.97	4.00				
kurtosis	15.06	14.78	14.89	5.75	**0.86**	11.94	3.03	8.23	**2.36**	14.49	9.29	**2.68**	12.92	15.21	15.82	15.99				

Source: data Bloomberg, own calculation.

Figure 2. Total spillover, 200-day window, 10 steps ahead forecast.

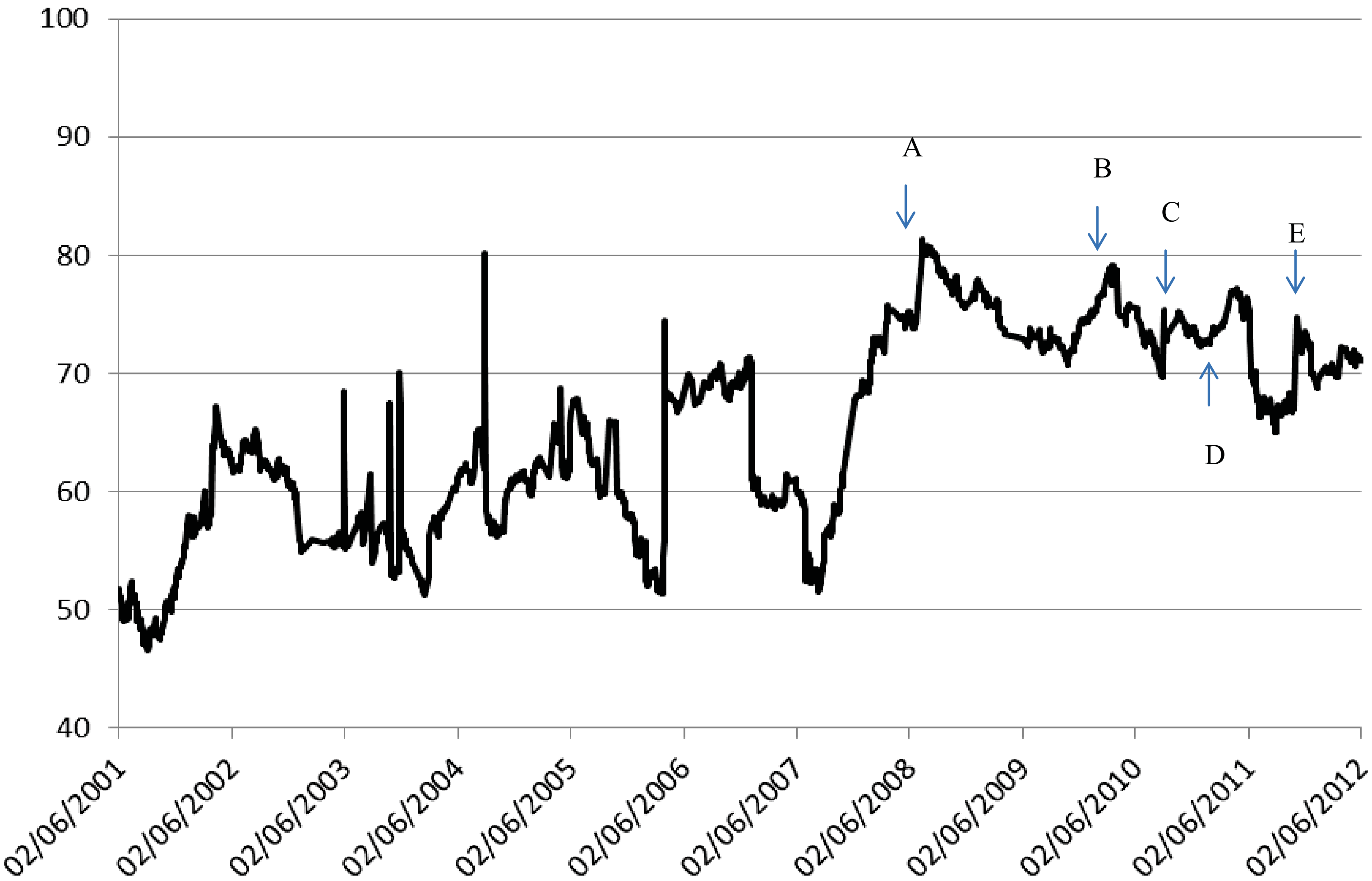
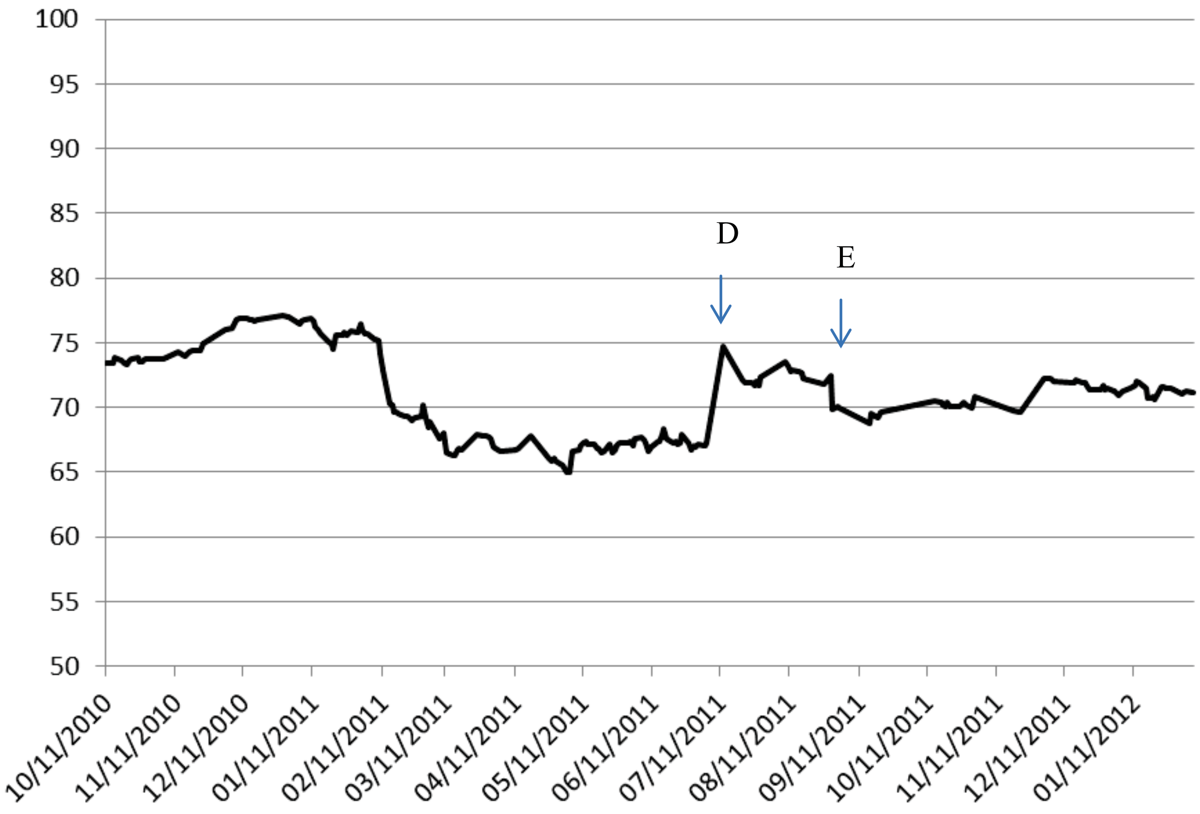


Table 2. Total spillover, January 2007- February 2012

	CZR	HUN	POL	AUT	BEL	FRA	FIN	NLD	ESP	GRC	IRE	ITA	PRT	DNK	SWE	GBR	From Others	S_j	kurtosis	$S_i S_j$
CZR	30.85	5.50	10.13	7.10	5.61	0.74	4.92	3.62	11.28	1.14	3.14	13.52	1.30	0.40	0.69	0.06	69.15	2.34	6.62	8.28
HUN	7.48	24.42	12.00	2.50	5.66	1.59	2.36	2.58	13.13	3.52	5.48	13.66	3.88	0.06	1.35	0.34	75.58	1.65	2.79	5.69
POL	7.56	6.39	27.18	2.65	6.13	1.13	2.55	1.33	15.06	3.04	6.19	13.36	4.68	0.04	2.49	0.23	72.82	2.02	4.54	5.04
AUT	4.23	4.49	4.84	18.41	12.16	3.82	12.47	8.02	10.42	2.96	3.07	11.80	1.96	0.22	0.79	0.34	81.59	0.86	-0.05	0.94
BEL	3.58	3.86	6.33	8.39	18.37	3.30	9.33	7.33	14.25	2.21	4.50	15.59	2.15	0.09	0.65	0.07	81.63	0.97	0.01	-0.10
FRA	4.08	1.92	4.48	13.62	10.46	16.57	10.28	12.89	7.67	2.37	2.55	8.59	1.80	1.32	1.17	0.24	83.43	0.64	-0.93	1.93
FIN	2.68	3.20	5.26	11.82	13.24	2.57	18.03	8.08	10.66	3.16	2.48	15.10	1.45	0.70	1.41	0.16	81.97	0.85	-0.66	1.09
NLD	3.50	3.75	3.75	10.73	9.94	6.77	9.43	22.58	8.83	2.16	3.40	8.79	3.84	1.31	0.55	0.66	77.42	1.75	4.15	3.79
ESP	3.61	3.62	7.47	7.25	10.24	1.65	7.19	5.44	22.15	3.22	7.24	15.68	3.94	0.10	1.01	0.20	77.85	1.58	2.76	-0.12
GRC	2.84	1.79	5.52	3.50	10.42	2.16	5.44	3.39	10.92	32.38	5.48	10.64	4.72	0.06	0.49	0.27	67.62	2.74	8.89	10.66
IRE	2.60	1.64	5.84	4.05	8.25	1.30	3.69	1.95	11.11	3.92	36.18	7.29	11.33	0.18	0.10	0.56	63.82	2.95	9.97	9.24
ITA	3.70	3.77	6.29	4.93	11.94	2.03	4.97	4.40	18.14	3.60	6.61	24.73	3.87	0.14	0.61	0.27	75.27	1.89	3.37	0.24
PRT	1.12	3.00	4.80	3.79	9.79	0.25	1.83	0.83	12.22	3.79	13.66	9.39	34.71	0.06	0.37	0.38	65.29	2.49	7.30	8.60
DNK	2.01	0.09	0.37	2.16	0.24	2.02	3.53	3.24	1.11	1.45	0.36	0.50	1.13	77.69	1.78	2.33	22.31	3.98	15.88	15.89
SWE	1.98	1.32	0.43	4.11	1.97	3.94	2.21	5.36	1.40	0.75	0.35	1.01	0.81	2.16	70.43	1.78	29.57	3.95	15.74	15.71
GBR	0.35	3.42	1.02	0.43	0.60	1.12	2.25	1.61	2.52	1.64	1.13	1.87	2.22	1.14	4.88	73.83	26.17	3.97	15.84	15.86
Contribution to others	51.31	47.76	78.52	87.04	116.7	34.39	82.47	70.06	148.7	38.91	65.63	146.8	49.08	7.98	18.34	7.86	1051			0.00
Contribution including own	82.16	72.18	105.7	105.5	135.1	50.96	100.5	92.65	170.9	71.29	101.8	171.5	83.79	85.67	88.77	81.69	65.7%			
From others	69.15	75.58	72.82	81.59	81.63	83.43	81.97	77.42	77.85	67.62	63.82	75.27	65.29	22.31	29.57	26.17				
net spillover	17.84	27.82	-5.71	-5.45	-35.0	49.04	-0.50	7.35	-70.9	28.71	-1.81	-71.5	16.21	14.33	11.23	18.31				
net index	0.58	1.14	0.21	0.30	1.91	2.96	0.03	0.33	3.20	0.89	0.05	2.89	0.47	0.18	0.16	0.25				
S_i	3.53	3.45	2.49	1.09	-0.10	3.03	1.28	2.17	-0.07	3.88	3.14	0.12	3.45	3.99	3.97	3.99				
kurtosis	13.28	12.97	7.89	0.71	0.01	10.19	1.43	5.52	0.23	15.35	10.87	0.60	12.58	15.96	15.83	15.95				

Figure 3. Total spillover plot, 2008-2011

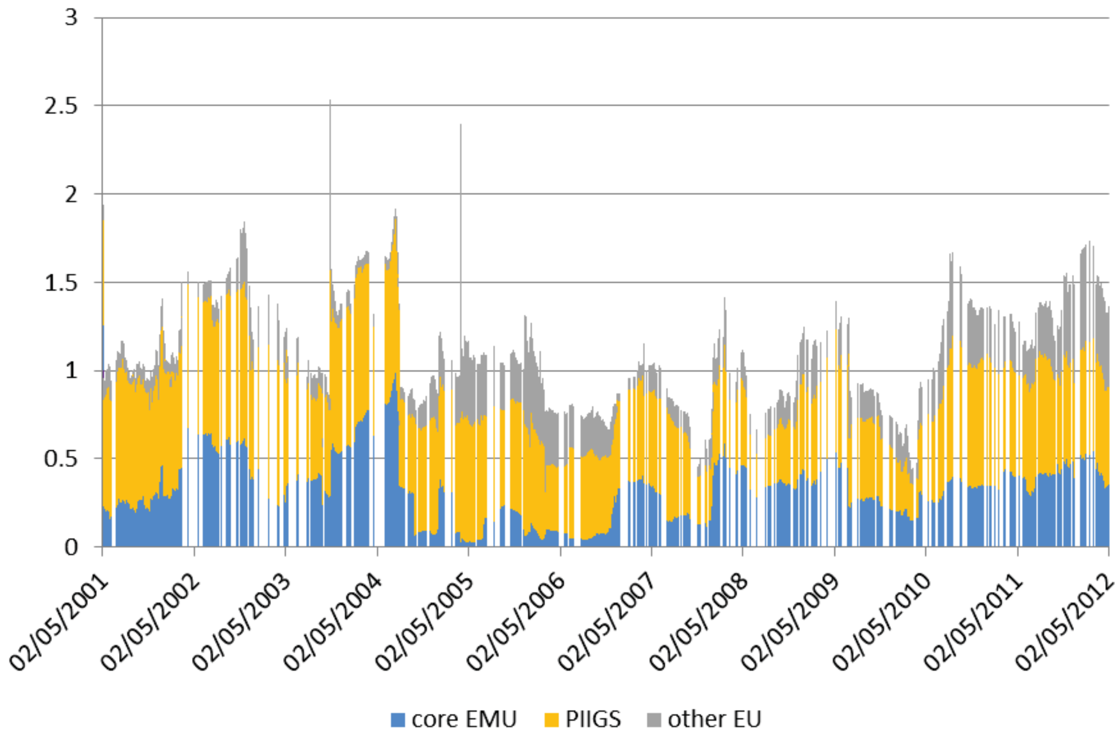


We can detail even more the spillover of Spanish fiscal problems to European bond markets. Figure 4a shows the total directional spillover of the Spanish bond spread on other EU markets (excluding the own contribution of Spain). The overall spillover shows that the effect was subdued up till the start of the Fiscal Crisis. Spillover from Spanish spreads has shot up and stayed high, but then rose again until the agreement on the European rescue fund in July 2011, when it seems that domestic factors become rather more important again for the size of spreads and consequently for the importance of the spillover. Other studies argue that in 2010, investors started to put a higher weight on the domestic fiscal position and discerned the problems of Greece from other EU sovereigns (Manasse, 2010). This explains the slight fall in spillover over early 2011. But we can observe consequently a tremendous increase in spillover – both to the PIIS and core EMU – in June/July 2011. This likely reflects the contagion effect of Greek and Portuguese fiscal trouble to Italy and Spain. The rescue package of July 2011 does not seem to have separated those fiscal trouble from other bond markets permanently. The spread to other countries has continued to increase over the autumn 2011. If the

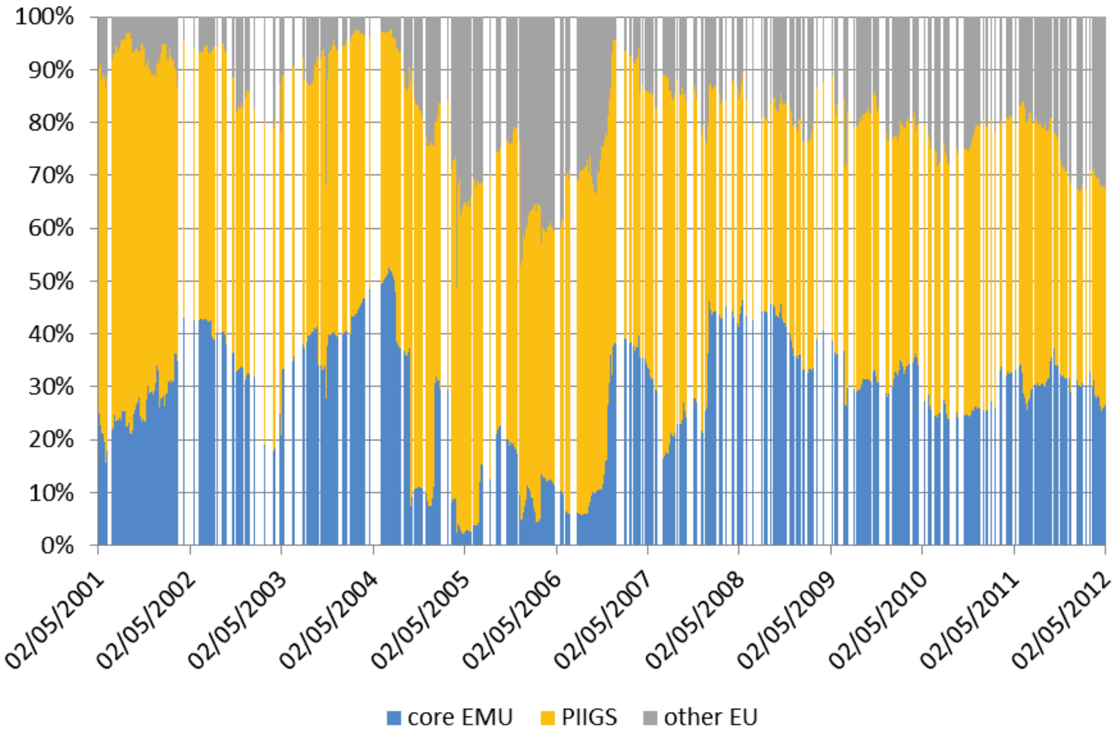
Fiscal Crisis turned European, it is in part because the Spanish bond market started to emit more shocks to other countries. Only with the December 2011 agreement on the Fiscal Compact and the intervention of the ECB on secondary debt markets, has the spillover receded somewhat. De Grauwe and Ji (2012) argue that the surge in spreads over 2011 is disconnected from the rise in public debt ratios and is sign of mispricing of sovereign risk. This makes spillover the main driver of sovereign bond spreads across the monetary union.

Figure 4. Decomposition of the effect of Spanish bond spreads.

(a) total effect on other markets, divided by subgroup



(b) total effect on other markets, scaled to 100%



(c) total effect from other markets

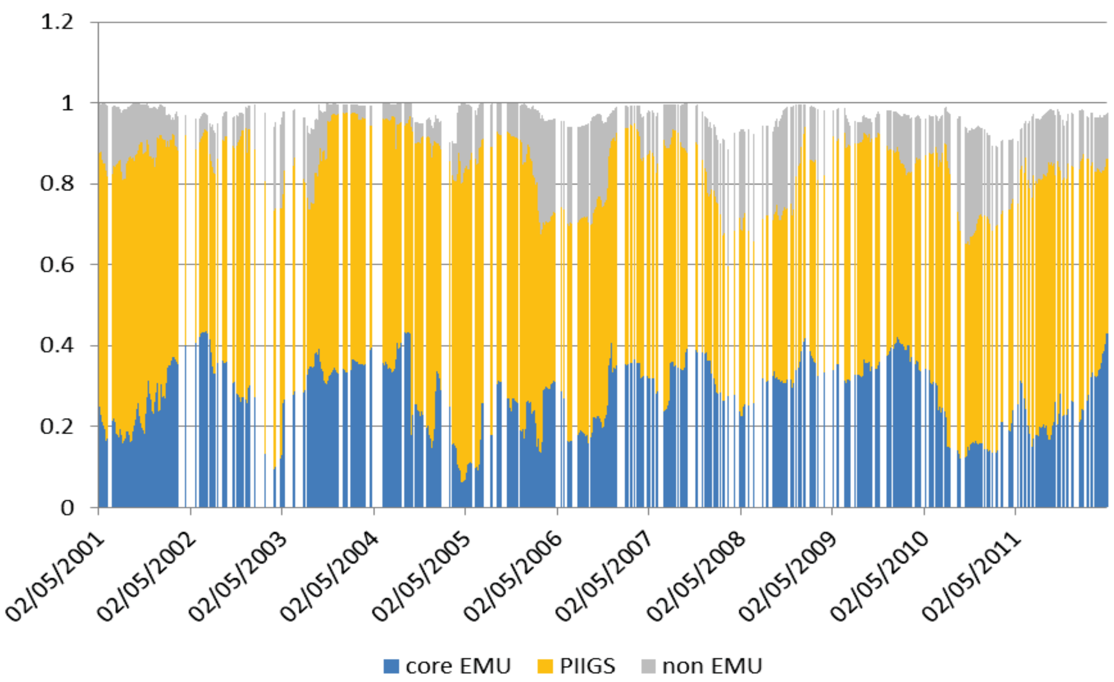
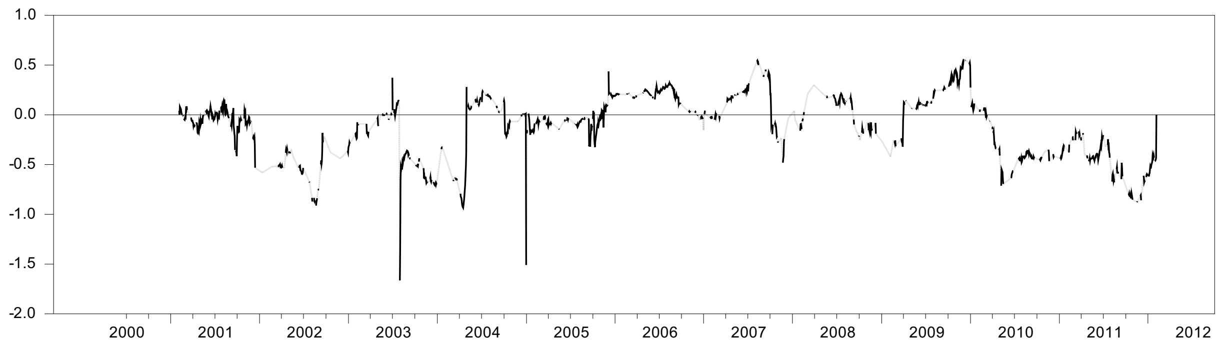


Figure 5. Net spillover from Spain to EU sovereign bond markets.



We can also see the countries on which Spanish spreads has the strongest impact. In order not to clutter the graph, we have grouped countries as in Figure 1 into core EMU, PIIGS (but excluding Spain), and the non-EMU countries. Figure 4a shows the percentage contribution relative to the total contribution, while Figure 4b scales the effect to 100% so as to see the percentage division across countries. A first observation is that the contribution of changes in sovereign spreads in Spain on other markets is fluctuating significantly over time, and it is quite different across groups. The spillover mostly affects core EMU and PIIGs early in the sample, more or less in equal measure. The spillover to non-eurozone countries becomes much stronger till the start of the Financial Crisis. Since early 2008, the spillover remains stable and is equally divided between the core EMU and other PIIGS. The non-EMU countries are much less affected. The 2011 crisis has not changed much this division, perhaps with a marginally stronger spillover effect on the non-eurozone countries.[18]

In a similar fashion we can calculate the time-varying effect of shocks in all other markets' spreads on the spreads of the Spanish bond market (Figure 4c). The overall effect is rather stable, and there are stronger links from the core EMU and other PIIGS to Spain. This implies strong bilateral linkages, but the linkages from other markets are spread in an even and stable way over time. The PIIGS seem to exert a slightly stronger effect since the start of the Fiscal Crisis, but during the autumn of 2011 the effect of core EMU becomes stronger again. This again corroborates the argument that the debt crisis has turned European.

[18] This does not exclude changes in the composition within each group, for example due to changes in the solutions for the Greek fiscal trouble.

Since Spain has stronger effects on other markets than it receives from other bond markets this implies a positive net spillover of the Spanish bond market (Figure 5). Spanish fiscal trouble contribute to spread movements in other PIIGS and the core EMU countries, and this has been particularly the case since the start of the Fiscal Crisis. Figure 5 suggests that the increasing effect of Spain on other bond markets has been halted by a combination of the December EU agreement on the Fiscal Compact and ECB interventions.

4. Spain at the junction of bond pressure and bank markets

The Financial Crisis started with losses on subprime loans in US banks but then affected the banking sector more widely, triggered the collapse of major financial institutions both in the US and Europe and called for policy intervention, not only by central banks but also out of the deep pockets of the tax payer. Massive public sector aid has now fired back to the financial sector as increased sovereign risk undermines bank balances. Both rising credit risk and fiscal consolidation threaten economic recovery and deteriorate fiscal balances. This Financial and Fiscal crisis is characterised by the speed of transmission and the strength of the feedback linkages across borders between sovereign bond markets and the banking sector.

Spain has seen a rapid rise in public debt but the debt ratio is still below the EU average. One of the reasons is that Spain did not aid its banking sector to the same extent as other OECD countries. The fiscal problems are mainly due to a strong fall in tax revenues after the housing bubble burst in an economy that had become biased to fast growth in labour-intensive but unproductive activities like construction, tourism and public administration. The problems of the Spanish banking sector are mostly concentrated in its ailing savings banks, which suffer the decline in real activity and the fall in housing prices. These hidden losses are still threatening the healthier parts of the Spanish banking sector and possibly also the fiscal position of Spain. In this section, we examine how the combination of exposure on the fiscal and banking side spills over to other EU banks and sovereigns.

4.1 Linkages in the EU banking sector

We first need to look at the connection of Spanish banks to the European banking market, and measure the systemic position of different large EU banks. We have a sample of the 20 largest banks in the EU (measured by average total assets over the period 2000-2011). The two major Spanish banks in our sample are Banco Santander and BBVA. We use the return on their stock listing but the GVAR is otherwise identical to that of the model for the EU sovereigns. We first look at the bilateral links between the major EU banks, as in Diebold and Yilmaz (2011). The most systemic bank is the one that is most likely to suffer and transmit the effect of general market weakness in the banking sector, since it is the bank that is most connected to other banks.
Our study relates in various ways to the literature. First, Yilmaz (2011) applies the same GVAR model on the volatility of 14 EU banks' stock prices to examine their bilateral linkages. Our study is similar but examines return linkages. Second, most measures of systemic risk we discussed in Section 2 have been applied to individual financial institutions. Our decomposition of the GVAR results and the systemic risk measures have a similar interpretation as those developed by Brownlees and Engle (2010).

We do not resume all bilateral linkages in Table # but just those from Banco Santander and BBVA. The reason is that in contrast to the linkages between sovereigns, all banks are linked with all other banks in more or less the same way. For all banks, the shock to its own return has the largest impact, but the linkages to other banks are dominant: on average, about 87% of the bank's return comes from the shocks to other bank's return. Since most banks send and receive a lot of shocks to all banks, the distribution of the bilateral effects is rather uniform. Within the set of 20 banks, the net index shows that BBVA is the most exposed bank in the EU, and is closely followed by Deutsche Bank (1.67) and then by Banco Santander (1.09). The top 5 of strongly exposed banks is complete with Lloyds and Commerzbank. However, while Deutsche Bank is exposed to all other EU banks, the Spanish banks are mostly exposed to each other. Their strongest bilateral link is between themselves.

This result corresponds with other measures that have been suggested to measure the strength of links between banks.[19] Schoenmaker and Oosterloo (2004) propose a set of metrics on the cross-border penetration of banking assets. They look at the share of assets held by domestic and EU credit institutions as a percentage of total assets of credit institutions in an EU country. They show that EU bank markets are still mostly dominated by domestic banks, but there are a few international banks that are also global players. Table 4 shows the ranking of the 30 main EU banks in 2002 by total

[19] See Moshirian (2006) for an overview of the literature on international banking.

assets and the total activity abroad and in EU countries. The most international banking groups – those with most assets abroad – are HSBC Holdings, Deutsche Bank, BNP Paribas, HypoVereinsbank, ABN Amro, Santander Central Hispano, ING Group, BBVA, Fortis Group, Nordea Group and Westdeutsche Landesbank. Some of these international banks are not global players but EU banks, as they keep most activities in the EU. This is not the case for the Spanish banks. They hold relatively more assets in non-EU countries.[20]

Table 3. Bilateral links, Banco Santander and BBVA to EU banks, 2000-2012.

	Santander	BBVA	S_j	kurtosis	$S_i S_j$
BNP Paribas	5.82	6.11	1.67	4.39	0.14
Deutsche Bank	5.86	5.94	2.42	8.01	1.51
HSBC	5.12	5.53	3.41	13.62	4.29
Barclays	4.35	4.88	3.50	14.24	7.39
RBS	3.45	3.93	3.28	12.05	9.71
Crédit Agricole	5.28	5.80	2.26	7.33	6.85
Santander	11.04	9.27	1.90	4.18	3.48
Lloyds	4.03	4.46	2.81	8.59	8.94
Société Générale	5.53	6.03	1.50	3.83	3.72
Unicredit	5.60	6.17	2.46	8.50	6.46
Commerzbank	5.09	5.62	3.49	13.94	13.35
Intesa San Paolo	6.78	7.00	2.07	6.18	5.07
Nordea	5.71	6.31	2.39	7.36	7.66
Dexia	4.16	4.60	3.75	15.62	14.20
BBVA	8.73	10.76	1.85	4.35	3.08
Natixis	4.59	5.18	3.96	16.96	14.97
STA	5.92	5.76	3.62	14.82	13.68
KBC	4.87	5.27	3.94	16.67	14.70
SEB	5.21	5.77	3.07	11.32	9.52
Monte dei Paschi	5.66	6.03	2.90	10.88	9.82
Contribution to others	101.74	109.68	total spillover		86.9%
Contribution including own	112.78	120.44			
from others	88.96	89.24			
net spillover	-12.78	-20.44			
net index	1.16	1.90			
S_i	1.83	1.67			
kurtosis	3.98	3.12			

[20] Schoenmaker and van Laecke (2007) update these numbers and compute a Transnationality Index (TNI) developed by Sullivan (1994), which weights the assets and revenues side, as well as employment, in branches at home and abroad as a percentage of total bank activity. The conclusions for EU banks are similar as in Schoenmaker and Oosterloo (2004).

Other evidence on the degree of connectedness of Spanish banks comes from Schoenmaker and Wagner (2010) who compute measures of integration of banks country by country. They find that the German, Dutch and British banking market are the most integrated in Europe as they score highest both on measures of inflows and outflows. The French and Spanish bank have known a strong expansion abroad but since there are few foreign banks from other EU countries at home, their banking market is overall not well integrated. An additional complication for Spain is that the international presence of its banks is a bit skewed due to the importance of Banco Santander in the UK. Other EU countries are not as well integrated, and just a few banks dominate the market in Scandinavia or in the CEEC.

Our measure updates the evidence in Schoenmaker and Wagner (2010) to January 2012 and shows that the major EU banks are indeed exposed to each other, and that Spanish banks in particular – are the most systemic ones. This exposure mostly comes from the expansion abroad of Spanish banks. This is confirmed by a comparison of the degree of connectedness to all other banks between the shocks banks emit and the ones they receive. BNP Paribas, Deutsche Bank and HSBC form the EU top-3 of banks that most contribute to developments in the banking market. Banco Santander and BBVA are 4th and 5th respectively on this measure. However, when considering the skewness of shocks banks receive, then the top-5 is nearly entirely formed by French and Spanish banks. The bank most subject to shocks is Société Générale, followed by BNP Paribas and the Spanish banks. The top-5 is completed by an Italian bank, Intesa SanPaolo. Hence, the outward integration of French and Spanish banks has made them contribute to market sentiments in Europe, but has also made them more vulnerable to these developments. As a result, Banco Santander and BBVA are in the top systemic banks in Europe.[21]

Overall, the EU banking system does not seem to have suffered particularly from increased systemic risk since 2007. We can see this from the variation in spillover over time. The total spillover between bank returns is high and quite stable over time. We plot in Figure 6 the spillover index since summer 2002. The index fluctuates between 70 and 90%. In comparison to sovereign bond markets, which have an average spillover of about 55%, the EU banking market is well integrated. Well before the start of the Financial Crisis the spillover index started to rise already, and it has stayed very high throughout. Hence, bilateral exposure between the main European banks predates the crisis.

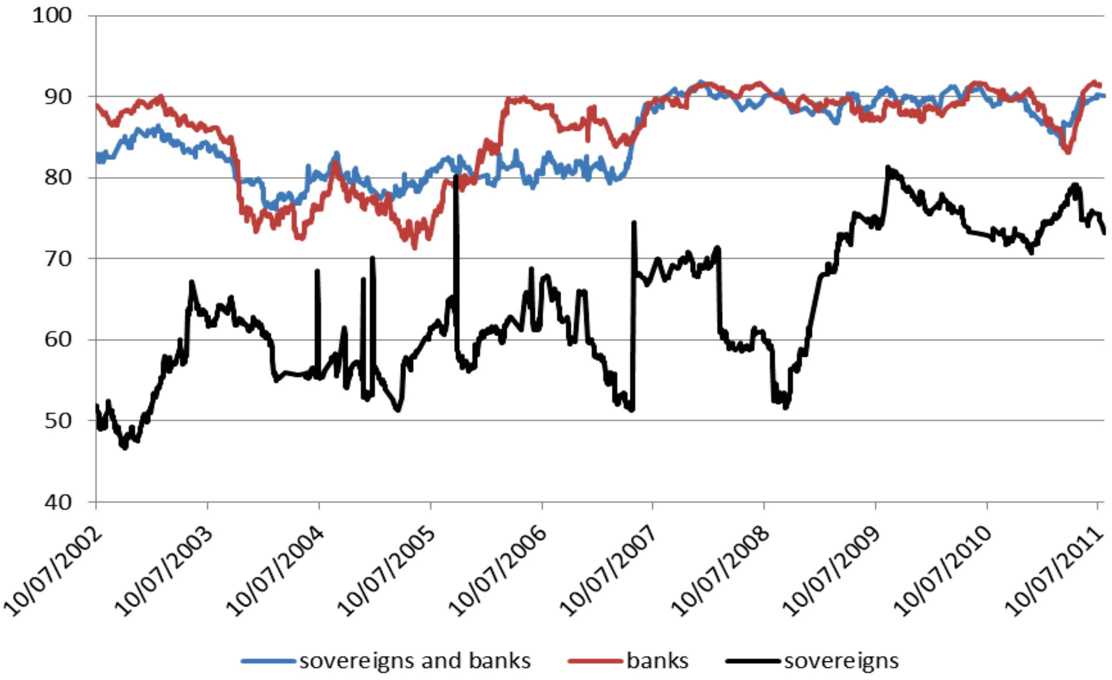
[21] An update of these numbers is available in a recent CEPR Report by Allen *et al.* (2011). This report shows that the ratio of foreign to total assets for major banks in Europe is highest for Deutsche Bank, Banco Santander, UniCredit, BNP Paribas and Société Générale.

The crisis does nonetheless play a role, and the fiscal positions of EU countries seem to have a particular effect on EU banks. We can see this from the main change in the index that occurs after the set-up of the European Stability Mechanism in February 2011. The spillover between banks suddenly falls while at the same time the spillover between EU sovereigns started to increase. Hence, the effect of the Mechanism seems to be to dilute the difference between sovereigns while accentuating them between banks. Fiscal problems became common to Europe, and as the EU banks started to get involved, markets started to recognise their differences.

Table 4. Measures of cross-border activity of the 30 major EU banking groups in 2001 (Schoenmaker and Oosterloo, 2004).

banking Group	% of business at home	% of business in EU
HSBC Holdings	33	8
Crédit Agricole Groupe	81	10
Deutsche Bank	39	30
Royal Bank of Scotland	74	7
BNP Paribas	46	24
HypoVereinsbank	50	29
HBOS	93	4
Barclays	71	7
ABN Amro	33	34
Santander Central Hispano	38	7
ING Group	43	45
Rabobank	76	8
Société Générale	64	13
Lloyds TSB Group	84	8
Banco Bilbao Vizcaya Argentaria	34	10
IntesaBci	67	14
Fortis Group	52	45
Commerzbank	72	21
Abbey National	92	6
Dresdner Bank	64	22
Nordea Group	18	79
UniCredito Italiano	68	7
Dexia	56	40
Westdeutsche Landesbank	49	32
Bayerische Landesbank	65	28
KBC Bank	51	36
Crédit Lyonnais	76	8

Figure 6. Total spillover plot.



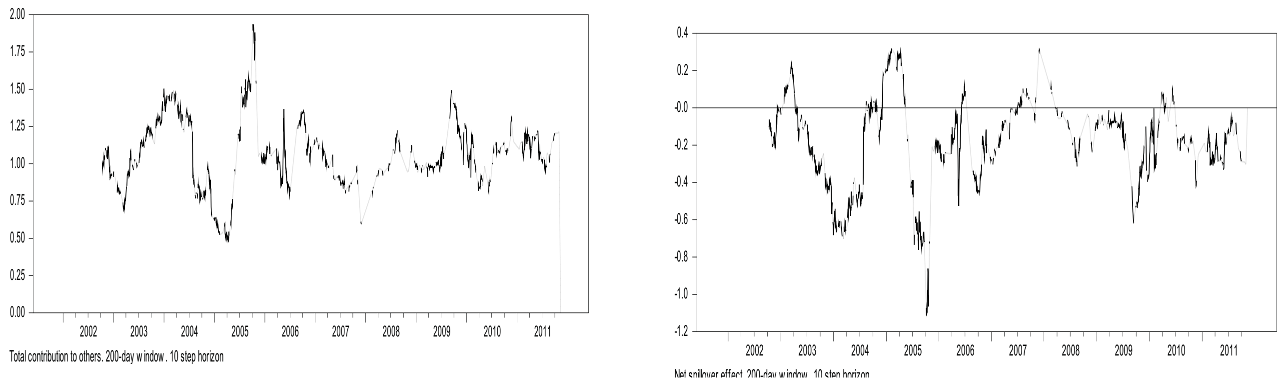
Likewise, the systemic importance of the big Spanish banks is not a by-product of the crisis. They have always been strong contributors to EU banking markets. Figure 7 shows in detail the position of both Banco Santander and BBVA, and it plots the total contribution (left hand side) and net spillover (right hand side). Their total contribution to EU banking markets increases with the start of the Financial Crisis, and they become net contributors to market developments, but this increase is not unusual in comparison to the degree of interlinkages with EU banks that existed before. Both banks have known periods in which their market valuation contributed to the overall valuation of EU banks.

In contrast to the period 2000-2007, since the start of the Financial Crisis, both banks start to show a rather similar pattern. Such a high correlation should not come as a surprise since their mutual linkages are so close. They both start to emit shocks since the start of the Financial Crisis, and this spillover gets especially strong in 2009. Once this effect falls back during the spring of 2010, fiscal trouble in Greece in May 2010 make both bank's spillover increase again to a higher level. Both banks have as a consequence been net contributors to shocks to other EU banks since mid-2008. The various policy interventions over 2010 and 2011, such as the Dieppe Declaration by the French President Sarkozy and the German Chancellor Merkel, the set-up of the European Stability Mechanism (February 2011), the July 2011 agreement seem to have had mixed effects on the spillover coming from the Spanish banks. Only the interventions by the ECB as of December 2011 to provide easy financing means to banks seems to have tamed the net contribution of Spanish banks and the net spillover has fallen to nil for the first time since the start of the Fiscal Crisis in 2010 for both Banco Santander and BBVA.

We can also see the systemic importance of Spanish banks from the decomposition of their total joint contribution into mutual effects and the effect on all other EU banks. Their mutual effect remains rather stable throughout the crises, and has a slight tendency to decline over time (Figure 8a). This decline reflects the increased activity of both banks in international markets. The Financial Crisis and the Fiscal Crisis make both Banco Santander and BBVA emit quite some shocks to the other EU banks, but not between them. Hence, Spanish banks have become systemically more important during these crisis moments. Since the effect of all EU banks to the Spanish banks is quite stable and high over time too (Figure 8b), Spanish banks are net contributors to instability in the European banking sector.

Figure 7. Total contribution and net spillover from Banco Santander and BBVA.

(a) Banco Santander



(b) BBVA

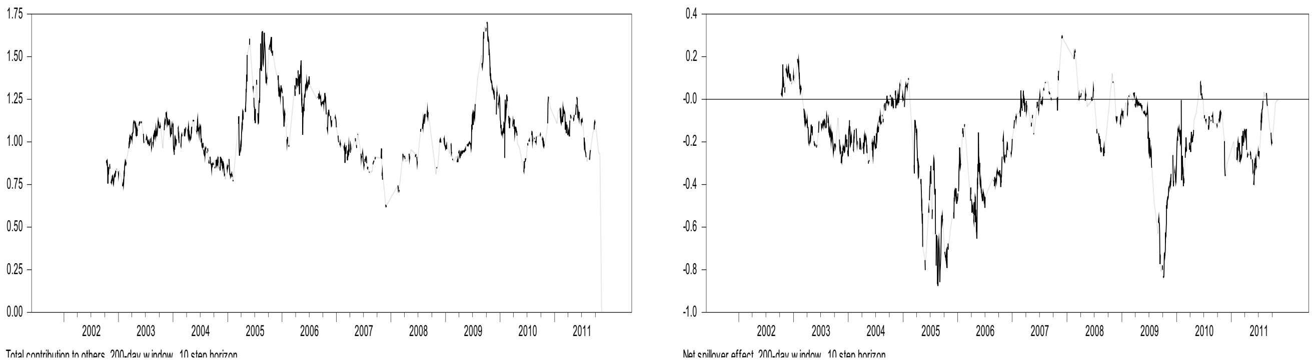
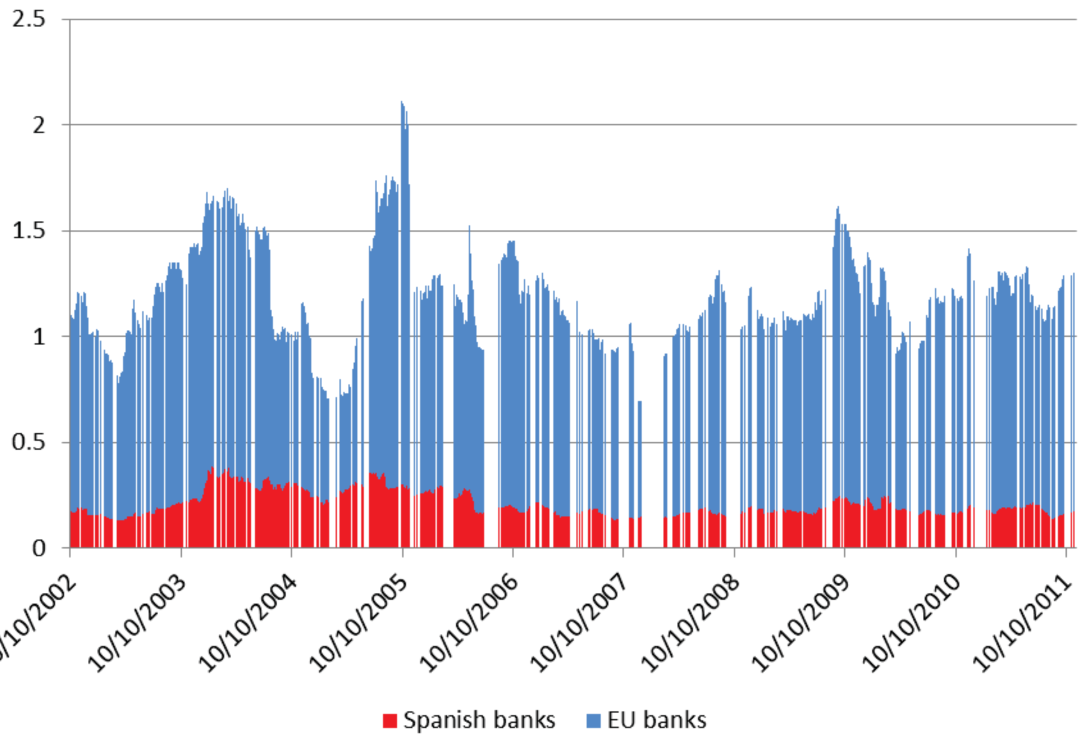
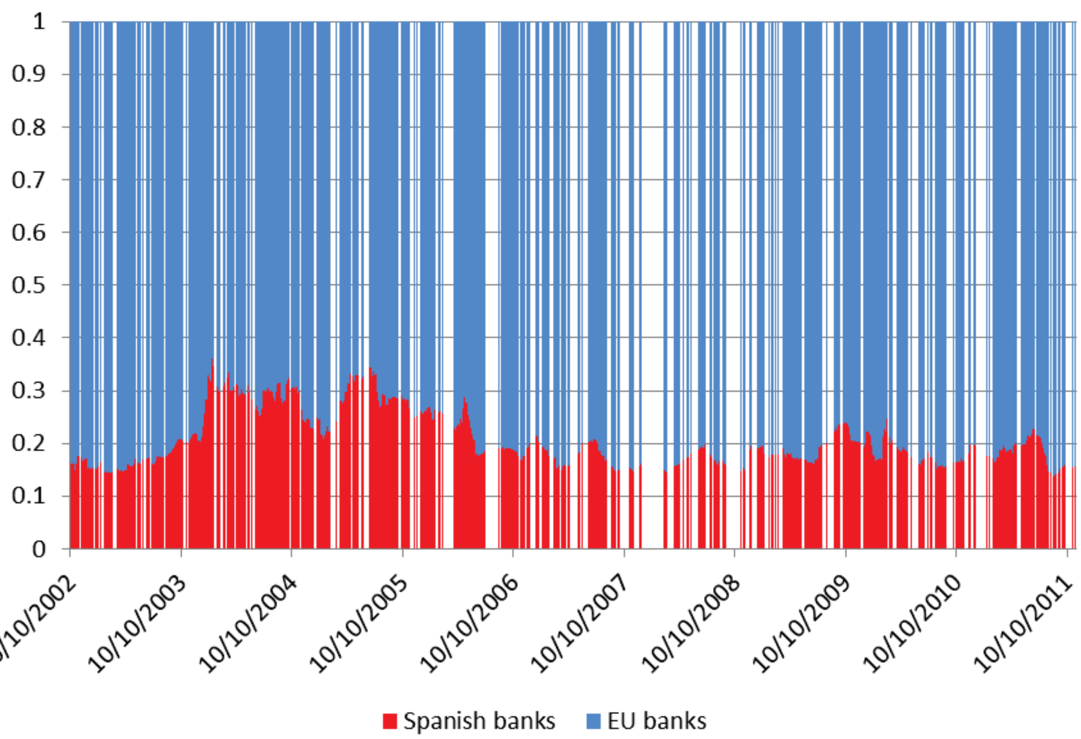


Figure 8. Spillover between Spanish and EU banks.
(a) shocks from Spanish banks to EU banks



(b) shocks from EU banks to Spanish banks



4.2 The banking sector, public finances and spillover

Banking crises have typically been followed by sovereign crises. The indirect effect of a disruption in the financial system is the devastating effect on output (Kaminsky and Reinhart, 1999). The recovery time tends to take a decade or longer, if there is a return to normal growth patterns at all (Cerra and Saxena, 2008). Tax revenues fall to substantially lower levels for a prolonged period. The direct effect of a collapse of the banking sector is the fiscal cost it supposes for governments intent to save the financial system (Honohan and Klingebiel, 2003). Sovereign debt positions and the health of the banking system are therefore directly related (Mody, 2009).

The growth of international banking – in particular in the Eurozone – has become a key channel of international transmission. As a consequence¸ the effects of a purely domestic banking crisis now have consequences not just for the sovereign, but through the interbank market, spread to other banks. The direct impact is for banks with an international presence in the market suffering the combined banking/sovereign crisis. The crisis implies a decrease in the value of collateral held by the banks (liquidity channel) and a decrease in the value of the banks' portfolio (balance sheet channel). The holdings of debt of the sovereign aggravate this problem as higher rates further erode the value of collateral and the portfolio. This feeds back into difficulties in the 'home' banking sector of the international bank, and can also worsen the position of the 'home' sovereign.

This spread of a banking/sovereign from Greece to other Eurozone countries shows how fast relatively small problems can translate into a major banking and sovereign crisis. The especially virulent link between banking and fiscal crises in the Eurozone is due to the absence of a European banking resolution framework in a closely integrated EMU banking market (Merler and Pisani-Ferry, 2012). Even relatively small banks at a European scale are large banks for small Eurozone countries. The latter cannot assume the fiscal cost of the failure of a big European bank. At the same time, European banks have held a large portion of sovereign debt at home. Although the introduction of the euro has made banks diversify their holdings of public debt across a portfolio of Eurozone countries, the major part of public debt is still in the hands of domestic banks. Figure 9 shows that in all but a few small Eurozone countries, up to 40% are owned by domestic banks. Merler and Pisani-Ferry (2012) show how during the crisis, this sale of public debt of the PIIGS countries by non-residents has even reinforced this home bias.[22] Domestic banks have been using in part the provision of liquidity by the ECB to buy domestic public debt. This implies that banks have become even more exposed to domestic sovereign problems.

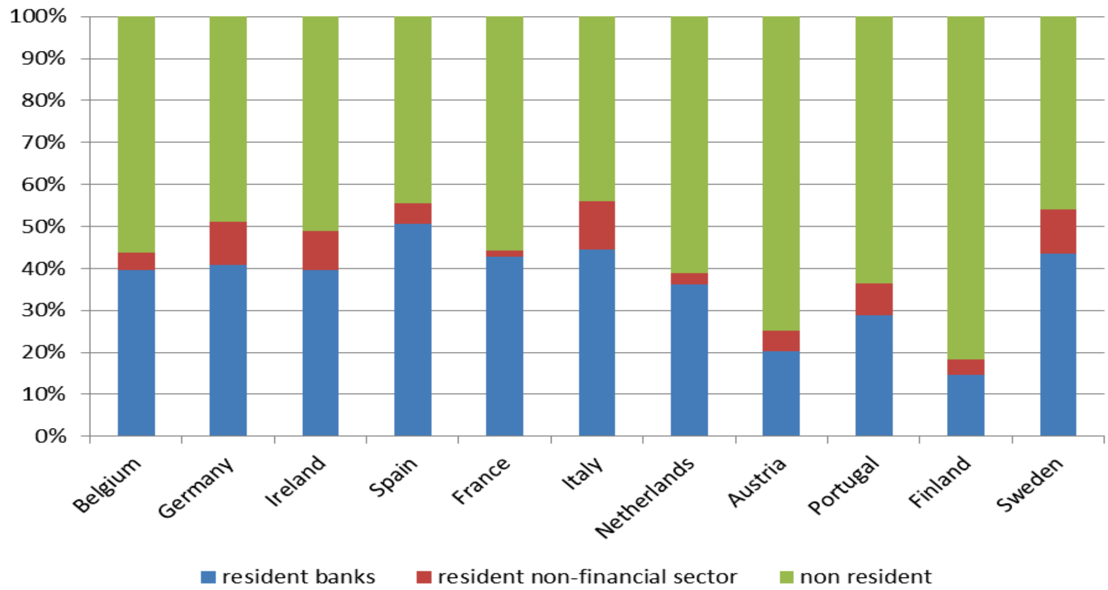
[22] REF% show also that since the start of the crisis, non-residents have disinvested in foreign public debt, except in the debt of safe haven countries like Germany, Switzerland or the US.

Cross-border banking has accentuated the effect of fiscal trouble. Suspicions of troubled debt holdings of foreign banks restricted interbank lending and liquidity on international financial markets dried up quickly. Figure 9 also learns us that about half of all public debt is held internationally. For the Eurozone countries, these international holdings are mostly holdings by other Eurozone banks. Cross-border flows in the EU are dominated by bank flows, and are the result of the bank-based nature of finance in Europe (Allen *et al.*, 2011). This means that EU banks have a diversified portfolio of public debt across the Eurozone. These linkages increase the exposure to banking and sovereign problems in the rest of the Eurozone. The BIS (2011) provides a breakdown of the debt holdings by the cross-border claims of foreign banks on the public sector in other Eurozone countries. Figure 10a summarises the external position of the Spanish banking sector as a whole *vis-à-vis* all other EU countries. The main insight is that Spanish banks have a bias towards a position to the UK, as half of all foreign claims are on financial agents in that country. Portugal is the main other market that Spanish banks have a claim on. The rest of the claims are distributed according to the economic weights of the main Eurozone countries. Figure 10b illustrates the distribution of these foreign positions by sector. Spanish banks have predominantly lent to the private sector, yet there is some more exposure to Austrian, Belgian or French banks, and to the sovereign debt in Belgium, Greece, Italy and Switzerland. This snapshot of statistics seems to corroborate our finding of strong links between Spain and Italy and Belgium, yet the dominance of the UK does not come out that clearly.

We look at the interplay between sovereign bond holdings by large EU banks.[23] We estimate the GVAR model including all 16 sovereigns and 20 EU banks. As a table with all bilateral linkages becomes too large, we report in Table 6 only the effects between the Spanish bond market and EU banks.[24] We reorder the table to report also the main summary statistics on the distribution of linkages. As in section 4.1, the results show that banks are mostly integrated with each other, and their linkages are rather homogenously distributed. As in section 3, 3 groups of EU sovereigns can be distinguished: the PIIGS, core EMU and non-EMU countries. The order of the bilateral effects is identical to the previous findings.

[23] Empirical research that details these linkages are limited to a few studies (Bouveret, 2011).
[24] A full set of results is available upon request.

Figure 9. Holdings of debt by sector, 2010.



Source: Eurostat Government Statistics (2011).

The interlinkages between EU sovereigns and banks do not show particularly strong effects. There is no clearly distinguishable effect of an EU sovereign on its domestic banks. For example, shocks to the Spanish bond market do not affect most strongly Banco Santander or BBVA (in this case, it is the Italian banks Unicredit and Intesa San Paolo). Nonetheless, for most banks, the shock from the domestic sovereign is the most important shock they receive. Table 6 shows that the net index for the Spanish banks is the highest among all EU banks and sovereigns. Hence, controlling for the effect of the sovereign, Spanish banks are the ones that contribute most to the evolution of stock prices of other EU banks. BBVA is the bank with most effects on other banks in the Eurozone, just before Unicredit. Both banks are mostly Eurozone banks, and this is why Banco Santander has slightly smaller effects on other banks. The top-5 banks are complete with Deutsche Bank and BNP Paribas. Among the sovereigns, Italy and Spain have the strongest effect on banks and other sovereigns, and so does Greece, Austria and Hungary. The results for these three countries show the importance of controlling for the banking sector. The absolute effect of these sovereigns on bond markets is relatively small, even if the fiscal problems of Greece or Hungary are large. But it is the holdings of this debt by banks that increase the spillover beyond the domestic bond market. Austria in particular as been quite exposed to the effects of the Financial Crisis on the Central and Eastern European economies, since its banking sector is dominant in these countries.[25]

[25] The Vienna Initiative involved banks in a restructuring of debt in these countries.

Figure 10.a. Exposure of Spanish banks to EU countries, in % of total foreign claims (BIS, 2011).

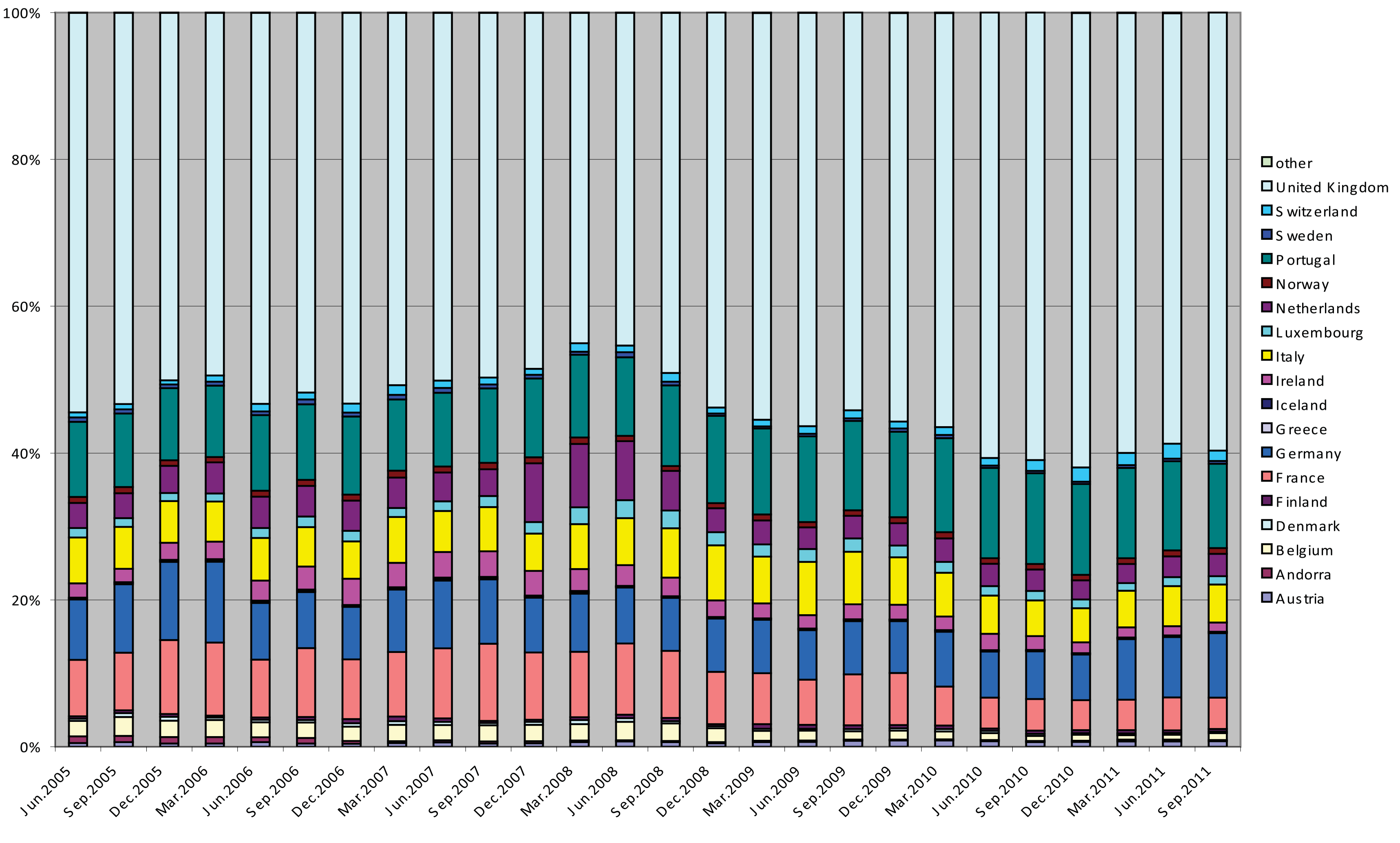


Figure 10.b. Exposure of Spanish banks to EU countries, distribution across sectors (September 2011)(BIS, 2011).

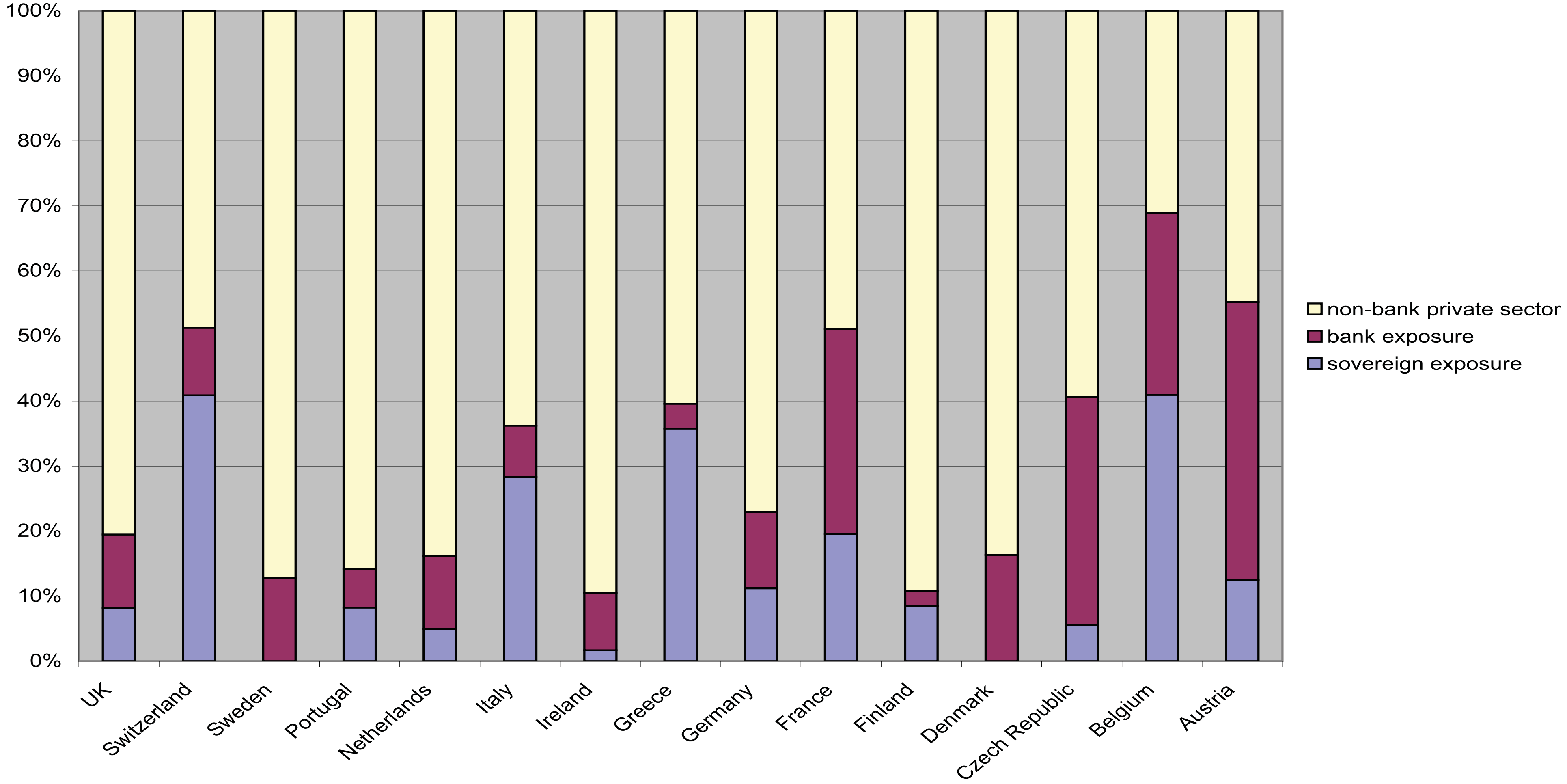


Table 5. Bilateral links, Spain, Banco Santander and BBVA to EU sovereigns and banks, 2000-2012.

	ESP	Santander	BBVA	From Others	S_j	kurtosis	$S_i S_j$
CZR	2.82	2.36	2.50	65.40	5.68	33.30	-5.46
HUN	2.70	3.86	4.51	76.20	5.08	28.66	-3.73
POL	2.87	3.04	3.30	64.51	5.78	34.19	-5.15
AUT	5.80	1.49	2.05	78.28	3.79	17.40	5.48
BEL	11.25	2.11	2.60	85.74	2.49	5.96	0.21
FRA	5.41	1.38	1.63	76.10	3.77	16.84	3.14
FIN	7.24	1.90	2.17	85.90	2.31	5.19	0.10
NLD	4.48	1.85	2.49	78.94	4.18	20.66	2.54
ESP	20.77	1.95	2.50	79.23	3.11	10.84	0.87
GRC	8.55	2.05	2.20	75.99	3.70	16.50	-0.03
IRE	7.99	1.54	1.94	69.17	4.52	22.94	0.44
ITA	14.12	2.34	2.60	81.49	3.20	10.89	0.62
PRT	8.95	1.86	2.20	75.29	3.49	13.96	0.85
DNK	0.25	1.70	0.87	38.99	5.93	35.45	6.32
SWE	1.22	0.23	0.47	19.93	5.98	35.81	3.75
GBR	2.02	0.04	0.04	16.90	5.99	35.91	5.98
BNP Paribas	1.64	5.43	5.63	90.95	0.61	0.06	0.02
Deutsche Bank	0.85	5.75	5.74	89.09	0.93	1.32	0.94
HSBC	0.93	4.90	5.31	87.73	1.43	4.02	2.02
Barclays	1.26	4.12	4.57	89.53	0.91	1.80	1.86
RBS	1.27	3.24	3.66	83.53	2.75	10.90	8.20
Crédit Agricole	1.50	5.00	5.53	90.39	0.68	0.43	2.14
Santander	1.31	10.21	8.48	89.79	1.05	1.39	1.96
Lloyds	1.00	3.87	4.46	85.78	2.03	6.04	6.24
Société Générale	1.45	5.17	5.67	91.67	0.42	-0.59	1.04
Unicredit	2.26	5.01	5.51	90.95	0.73	1.01	1.98
Commerzbank	1.16	4.86	5.30	86.31	2.01	7.20	7.70
Intesa San Paolo	1.92	6.17	6.28	89.41	1.13	2.03	3.00
Nordea	0.96	5.47	5.85	88.07	1.32	2.81	4.20
Dexia	1.82	3.85	4.36	85.31	2.56	10.85	9.86
BBVA	1.57	7.89	9.53	90.47	0.90	0.89	1.47
Natixis	1.24	4.26	4.73	86.13	2.38	9.66	9.00
STA	0.76	5.64	5.37	83.72	2.57	10.56	9.83
KBC	1.80	4.37	4.62	88.73	1.51	5.04	5.49
SEB	0.90	5.07	5.45	88.00	1.30	3.24	4.01
Monte dei Paschi	1.80	5.06	5.32	87.25	1.91	6.56	6.71
contribution to others	113.05	124.83	135.94		total spillover		78.6%
contribution including own	133.82	135.04	145.47				
from others	79.23	89.79	90.47				

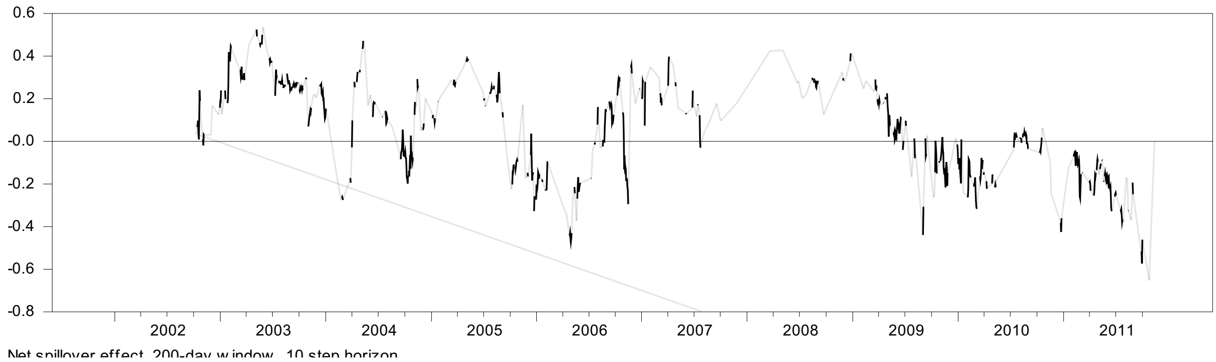
net spillover	-33.82	-35.04	-45.47	
net index	1.63	3.43	4.77	
S_i	0.28	1.87	1.63	
kurtosis	-0.60	4.27	2.91	

Both Spanish banks are the most strongly connected players on bond and banking markets in Europe, after controlling for the effect of the Spanish sovereign. Figure 6 shows that the total spillover between banks and sovereigns closely follows the spillover between banks. We can also explain now the dip in the total spillover in February 2011: the mutualisation of Greek debt by all Eurozone countries with the ESM increased the spillover between Eurozone sovereigns sharing this risk. Since this solution put the sovereign risk on the Eurozone countries, banks' risk became contemporaneously less correlated and stock markets started to appreciate banks' different positions.

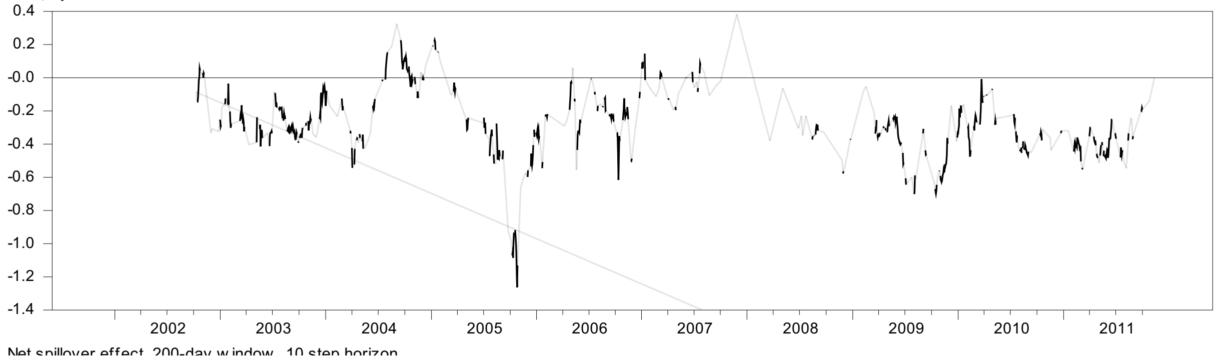
In Figure 11, we detail the net spillover effect of the Spanish bond market and both Spanish banks. While the Spanish sovereign does no start to contribute until 2009 to other EU bond markets and banks, Banco Santander and BBVA became net contributors early in 2008. While the outbreak of the Fiscal Crisis in May 2010 has made Spain a net contributor of shocks, the situation has remained rather stable for the Spanish banks. We confirm that both banks start to commove more closely, and this explains their strong bilateral link. The contribution of Spain to European markets has continued to grow over the crisis. Figure 11 shows that the impact of both bonds and banks on the other EU banks and sovereigns has become particularly strong since the July 2011 agreement on Greece, and as fiscal problems started to spread from Spain and Italy to the core EMU. The December agreement on the Fiscal Compact and the ECB intervention seem to have restored the net contribution of both the Spanish banks and the sovereign bond market. The intervention by the ECB has made the spillover of Spanish sovereign and bank risk to other Eurozone markets less acute. However, the position of Spain as a contributor to market shocks in Europe has still a long way to go back to the pre-crisis period.

Figure 11. Net spillover from …

(a) Spanish sovereign bond market



(b) Banco Santander



(c) BBVA

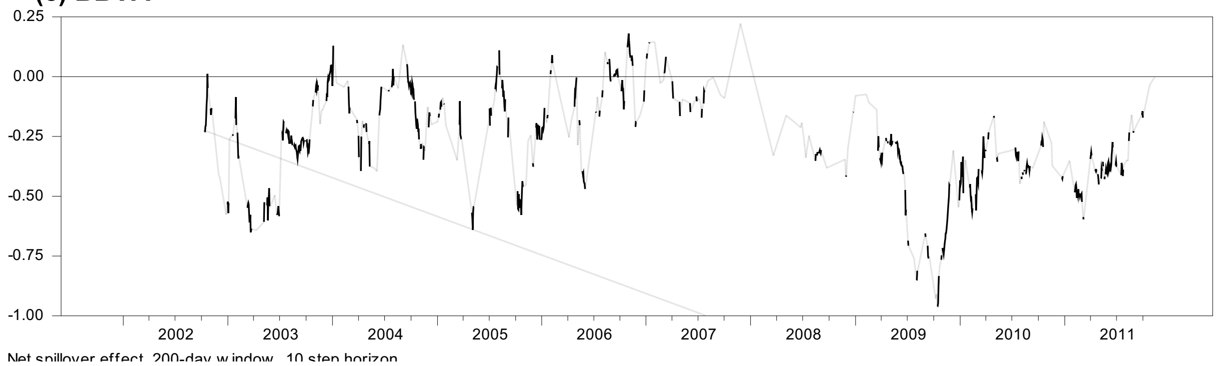
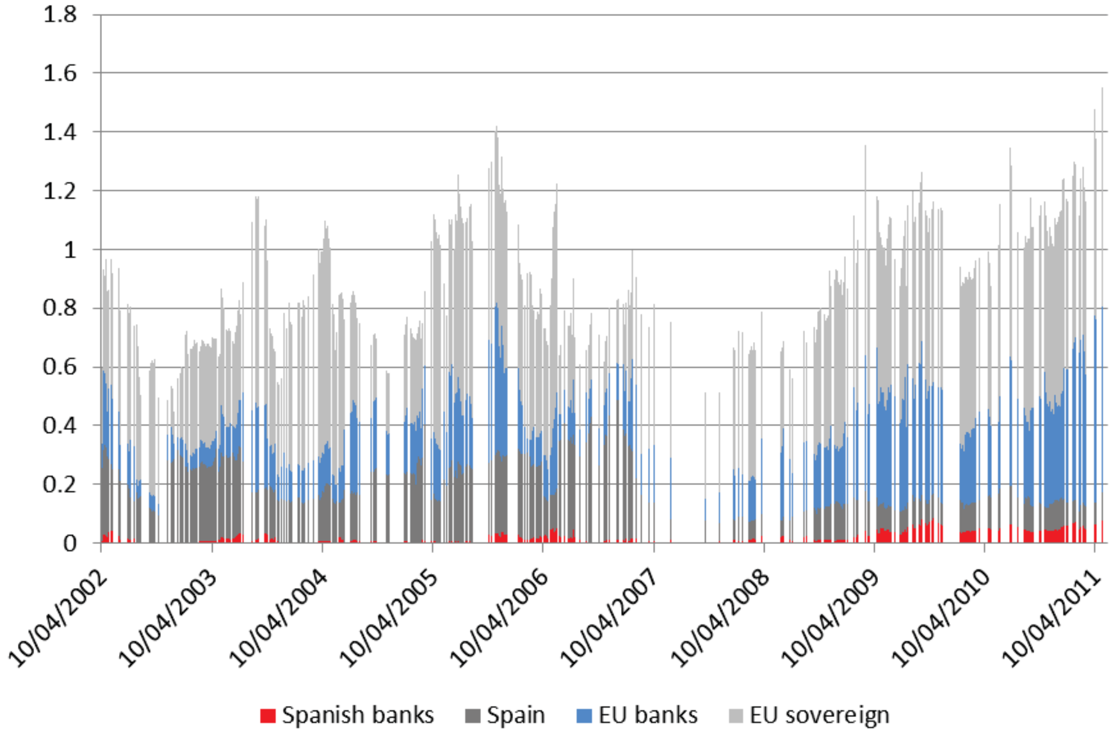


Figure 12. Total contribution of spillover between bond markets and banks in Spain and EU



5. Spain is systemic

Events since the start of the Fiscal Crisis in May 2010 – with a very rapid rise in bond spreads and the downgrading of all EMU countries but Germany – shows that Europe is not immune to contagion on sovereign bond markets. Trouble in the financial sector have contributed importantly to these linkages. We develop a real-time indicator to follow the degree of spillover between sovereigns and banks on a daily basis.[26] Our real-time indicator to measure systemic risk is but one in a list of risk measures developed at institutions like the European Systemic Risk Board (ESRB) and the ECB or research institutes like the NYU Stern Risk Laboratory.

Spain has run into fiscal trouble after the implosion of a housing market bubble. Spain is now suffering the fall-out of a domestic financial crisis with a strong fiscal cost, both directly through the fiscal cost of restructuring its savings banks, and indirectly through the drop in tax revenues. Spain also has a few global banks, Banco Santander and BBVA that are well integrated into Eurozone banking markets. Banking integration exposes Eurozone countries to the domestic financial and fiscal problems of

[26] The indicators in this paper are available at www.aqr.es

Spain. Spain therefore has all the characteristics to be of systemic risk for the Eurozone. Its fiscal problems expose it to trouble in sovereign bond markets of the other Club Med countries, whereas its internationally grown banking sector transmits domestic economic trouble to the rest of Europe. This spillover has substantially increased since the outbreak of the Fiscal Crisis in the Eurozone in May 2010.

Spain is not alone with these problems. Large EU cross-border banks in Germany, France or Italy creates systemic interdependencies within the Eurozone banking system. As these banks hold important portfolios of domestic and Eurozone sovereign debt, they are also strongly exposed to fiscal problems throughout the Eurozone.

Solutions to the European sovereign debt crisis are mainly based on domestic solutions to tackle fiscal imbalance. Given the systemic importance of Spain in the Eurozone – next to some other EMU countries – the stakes of pursuing this policy are very high both for Spain and the EMU. Success in fiscal consolidation and the restructuring the financial sector will determine the success of similar policies in other EMU countries.

Purely domestic solutions to restore fiscal imbalances are a necessary, but not a sufficient condition to restore calm on sovereign bond markets. The large spillover of domestic policy choices also raises concerns on the legitimisation of European policies domestically and of domestic policies at European level. Since Eurozone sovereign bond markets and banks are so closely linked, and are a structural feature of European integration, an EMU-wide solution would probably come cheaper in stemming the crisis. Given the strong linkages between markets, a credible solution can even in the short term have a large stabilising impact. The agreement on the Fiscal Compact and the ECB intervention should be accompanied with a European financial and banking regulation, a restructuring of the Eurozone banking sector, a European macro-prudential policy that takes into account banking issues when tackling macroeconomic problems, and some form of Eurozone economic policy (Allen *et al.*, 2011).

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