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RM/12/033

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On the importance of indirect banking vulnerabilities in the Eurozone

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June 20, 2012

Abstract

This paper investigates banking and sovereign distress in the Eurozone and the importance of direct and indirect financial exposures. We use BIS cross-border direct banking flows to link member states in a GVAR framework and jointly model sectoral CDS premia. Based on balance sheet positions of an intermediate debtor country, we calculate indirect exposures and asses how the level of interconnectedness is impacted when indirect links are accounted for. We notice a general slowdown in financial integration and a reduction in cross-border assets in the hope of limiting international contagion. By differentiating between direct and indirect links, we show that the impact of reduced weights on core member states is insignificant and that deleveraging strategies are not able to successfully reduce risk.

Keywords: Financial integration; GVAR; Banking crisis; Sovereign debt crisis

JEL classification: G01; G21; F34; F36

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1 Introduction

A recent report of the ECB on "Financial integration in Europe" from April 2012 points to the slowdown in financial integration during the sovereign debt crisis. Following the increase in risk in the Eurozone, banks are trying to significantly reduce their ties to distressed sovereigns and their ailing banks.[1] Exposures to Greece and other peripheral countries have already brought significant losses for financial institutions and, through balance sheet channels fostered by cross-border banking, negative shocks have also been transmitted internationally to other sectors. The recent decline in cross-border credit activity and exposures to foreign sovereign debt has reversed some of the integration that the Single Market fostered. An important question to ask at this point is wether diminishing banking links are significantly decreasing the level of interconnectedness and are successful in eliminating risk. Are these deleveraging strategies reducing the effect of foreign shocks on the domestic economy? What is the role of globalized financial intermediaries in the transmission of shocks?

Our aim is to analyze international links and sectoral spillovers in the Eurozone arising from integrated banking systems. The paper relates to the extensive research on banking and debt crises (e.g. Reinhart and Rogoff, 2011) and to the balance sheet approach to financial crises literature (e.g. Allen et al., 2002). Based on cross-border banking data, we want to differentiate between direct and indirect exposures, i.e. balance sheet connections that are created through a third party. We believe that the aggregate risk of banks in the Eurozone is much higher than what direct asset or liability positions would imply. We expect indirect exposures to be a significant channel for risk transfer and we believe that disregarding such links would severely understate the vulnerability of a country's banking and sovereign sectors. By acknowledging these balance sheet connections we are able to better understand the channels of risk transfer during times of stress. Methodologically, our empirical analysis relies on the recent Global Vector Autoregressive (GVAR) methodology introduced by Pesaran et al. (2004). This framework allows us to jointly model sectoral Eurozone data and connect member states through links created via the balance sheets of financial intermediaries.

A key economic question during this period of increased risk and uncertainty would be whether strategies of deleveraging through balance sheet asset reduction are effective. Does moving away from risky positions insulate the domestic banks from negative shocks and, through balance sheet channels, the sovereign sector? Anticipating on our results, we find that indirect exposures are significant and that cumulated vulnerabilities of domestic banking sectors are much larger than expected. Considering the high level of interdependence across the Eurozone and the uncovered indirect balance sheet links, we find that decreasing financial exposures does not significantly reduce the effects of foreign shocks and that deleveraging strategies are not always successful in eliminating risk. We draw attention to the destabilizing role of cross-border banking: financial links between sectors and countries potentially have an important role in fostering the transmission of the crisis. The existing framework has not been able to

[1] Significant decreases in cross border banking claims between 2011:Q3 and 2011:Q4 had as counterparties financial institutions in Italy ($-65 billion) and Spain ($-45 billion). Total banking sector holdings of PIIGS government debt securities also experience a strong decline between July and December 2011, with France deleveraging by 18.5% and Germany by 9.4%.

detect the recent buildup in vulnerabilities and, through a deficient early warning mechanism, has to some degree enabled the escalation of the crisis. Supervision appears insufficient and significant deficiencies in regulation that were not obvious during good times have now been highlighted.

This paper is organized as follows. Section 2 reviews the recent literature on sovereign and banking distress in the Eurozone. Section 3 discusses direct and indirect banking links and Section 4 presents the GVAR framework. Section 5 describes the data used. Section 6 presents the results of our baseline and counterfactual analysis, with a series of robustness checks in section 7. Section 8 concludes.

2 Related literature

The on-going Euro debt crisis has brought attention to the strong links between the sovereign and the banking sector, inside as well as across borders. Regarding the origin of the distress, the causality can go in both directions: from sovereign to banking through balance sheet accumulation of risky domestic and foreign country debt[2] as well as from banking to sovereign, through a risk transfer after government bailouts (asset purchases, debt guarantees, liquidity injections) and the resulting fiscal deficits.[3] There is also a high level of uncertainty regarding future developments in the sovereign debt crisis, a possible systemic bank crisis and the balance sheet channels through which these shocks are transmitted across an integrated market.

The impact of banking-sovereign linkages can be evaluated and interpreted using the balance sheet approach (BSA) to financial crises approach. As summarized in Allen et al. (2002), the BSA offers a theoretical basis for the observed risk transfer. Inter-sectoral transmission channels within as well as across borders are highlighted in Rosenberg et al. (2005), with the authors pointing out that an asset for one sector is a liability for another one (domestic or foreign). In a globalized and integrated market, the "international finance multiplier" as described by Krugman (2008) highlights that distress and losses are transmitted internationally through the balance sheets of leveraged financial institutions. The paper of Ahrend and Goujard (2011) on systemic banking crises also defines a series of potential cross-border contagion effects transmitted through interconnected balance sheets of banks and other agents. They refer to "lending-country spillovers" and "common-creditor contagion shocks" to encompass possible channels of risk transfer, either directly through exposures to risky counterparts or indirectly through a reduced credit flow to other debtors respectively. Both of these last two papers identify financial institutions as the core source of interdependence between countries and markets.

There are a few empirical papers discussing the banking-sovereign connection during the on-going euro debt crisis. Studies focusing on sovereign risk, proxied by bond yields or credit default swap spreads (CDS), usually find a strong connection between the size and health of the financial sector and deteriorating country specific risk measures across the Eurozone (Gerlach et al., 2010, Diekmann and Plank, 2011, Mody and Sandri, 2011 inter alia). In a study on contagion in the government debt market, Gomez-Puig and Rivero (2011) track cross-border BIS banking flows and identify dynamically the strength of causal-

[2] For example in the case of Greece, Italy, Spain and more recently Belgium and France.

[3] Ireland is the most representative.

ity between pairs of countries and the determinants of contagion.[4] Papers on interaction and feedback effects in between the sovereign and banking sectors identify an increasing interconnectedness resulting from government interventions and the subsequent risk transfer (Achayra et al., 2011, Alter and Schuler, 2011). All of these papers deal with the inter and intra-sectoral risk interactions on a country by country or bivariate basis and are not suited for an integrated analysis of the Eurozone. Using an extensive panel of bank and sovereign CDS spreads, Ejsing and Lemke (2011) also analyze feedback effects in between the two sectors and observe a stronger comovement between banking and sovereign *after* the bailouts (Oct. 2008). Their estimation is however based on a strict homogeneity assumption, as the parameter capturing the strength of the relationship is not allowed to vary across countries. The paper of Bolton and Jeanne (2011) proposes a theoretical model for debt distress and contagion and take into account banking to sovereign exposures provided by the 2009 stress tests.[5] Their model however only includes two countries, one safe and one risky, and cannot capture the heterogeneity and complexity characterizing the Euro debt crisis.

Significant contagion effects from distressed peripheral member states have had without a doubt an important role in the on-going crisis. Based on balance sheet exposures and investor sentiment, economies with relatively sound fundamentals have been negatively influenced by foreign shocks originating in Greece and Ireland. At the same time, bank bailouts and purchases of sovereign debt has created strong links in between the banking and sovereign sector inside country borders. Considering these complex transmission channels, one can therefore not analyze country specific data independently and disregard cross-border and inter-sectoral spillovers. The recent debt crisis has helped emphasize the central role of these links in the transmission of negative shocks. Most of the papers cited focus on one sector at a time or use bivariate systems for country specific analyses. When dealing with an integrated common currency area, such segmented approaches are inappropriate and disregard significant transmission channels and co-movement properties of the data.[6] We would like to join countries and sectors in the Eurozone using balance sheet connections created by an integrated financial system. By modeling feedback effects inside as well as across borders we aim at joining together the inter and intra-sectoral connections highlighted in the literature.

An important contribution of our paper is the identification of direct and indirect risk factors in the balance sheets of banking institutions. To further motivate the central role of banking and inter-sectoral links, we now proceed with a more detailed description of cross-border banking in the Eurozone and with defining direct and indirect exposures.

[4]Significant increases in causality are interpreted as signs of contagion and a probit model is used for determining the contribution of debt (private and public) and the health of the financial system.

[5]The data provided by the stress tests is only partial considering that securities held until final maturity on the balance sheet were excluded from risk calculations.

[6]In an economic and monetary union, dynamics are mainly driven by common factors and the impact of idiosyncratic elements is significantly reduced, see for e.g. Bicu and Candelon (2011).

Direct and indirect banking links

We are interested in capturing cross-border banking exposures in between Euro area member states. Since the financial system in Europe is mainly bank-based, securing around 80% of all private credit, cross-border banking flows should cover a substantial proportion of financial exposures. The strong international character of banking activity in the common currency area is a direct result of policies and regulations promoted during the last 25 years. Most notably, the first and second banking directives[7] were aimed at eliminating restrictions to cross-border banking activity, coordinating laws as well as preventing any discriminatory treatment in host countries. A direct effect of such regulations is the surge in cross-border banking activity in Europe, with the well-documented positive effects observed during the last decade (an excellent summary of cross-border banking can be found in Allen et al., 2011).

Calculations of cross-border **direct exposures** by Claessens et al. (2010) show that European banks have foreign assets in total of around 65% of all assets, with numbers as high as 82% for Deutsche Bank, 60% for Santander and Unicredit and 40% for BNP Paribas. Furthermore, cross-border bank flows account for around 50% of total external liabilities in the balance of payments of Belgium and around 20% for France, Italy and the Netherlands. Disaggregation of flows at sectoral level shows a significant increase in interbank lending as a proportion of total loans after the introduction of the Euro, up from 15.5% (1997) to 23.5% (2008).[8] The balance sheets of financial institutions also include significant holdings of foreign bank securities, amounting to 12.1% (1997) and 31.3% (2008) of total assets. Banks are important buyers of government debt[9], with a strong home bias. According to the 2009 stress tests and as calculated by Bolton and Jeanne (2011), 30% of total Eurozone government debt is held in bank portfolios, with significantly higher numbers for Spain (55%) and Germany (47%). Disaggregating between foreign and domestic, the highest foreign sovereign exposures are observed in the domestic banking sector of the Netherlands (75%), Belgium (70%) and France (58%).

Moving beyond the summarized direct cross-border links, we define **indirect exposures** as balance sheet connections through an intermediate debtor country. In a GVAR using trade links, Cesa-Bianchi et al. (2011) identify similar secondary channels and conclude that the higher synchronization in between Latin American countries and China are due to increasing trade integration of China with Latin America's major trade partners (US, Canada). Using the same intuition of Cesa-Bianchi et al. (2011), we also notice that indirect banking exposures significantly impact the degree of interconnectedness and represent a significant channel for risk transfer. In Figure 1 we elaborate on the idea of first and second round effects in the Eurozone. The diagram bellow gives an example of how a core country, e.g. Germany, can be exposed to distressed countries through third parties that have significant foreign assets in the form of claims on PIIGS.[10] The direction of the arrow indicates that Core has a claim on PIIGS and Germany on Core while x and y represent the "strength" of the exposure. In the data section, after defining country links, we will calculate the resulting indirect vulnerabilities.

[7] First directive 77/780/EEC, Second directive 89/646/EEC

[8] Relative to the interbank market, credit to the non-bank sector is on the other hand substantially lower.

[9] Banks can use debt instruments issued by *any* member state government as collateral when borrowing from the ECB.

[10] Portugal, Ireland, Italy, Greece, Spain.

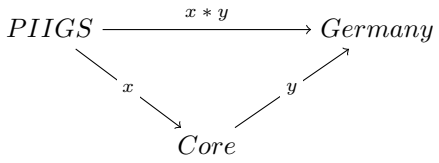

Figure 1: Indirect effects through an intermediate debtor

In a monetary union with highly integrated financial systems, the risks of cross-border banking activity become apparent. Bolton and Jeanne (2011) argue that alongside advantages of diversification and liquidity injection in foreign markets, these links also increase systemic risk as distress in one country is quickly transmitted to another. Considering the size and level of interdependence of banking sectors as well as the potentially significant indirect links, a complete and correct assessment of risk is essential. We believe that highlighting these "hidden" exposures is crucial for understanding the relative "success" of recent deleveraging strategies. Following the announcement of the European bank recapitalization plan in October 2011, a large number of banks are feeling the pressure to reach a specific capital requirement relative to risk weighted assets.[11] Since meeting the 9% requirement can also be achieved by an asset reduction[12], banks might become more likely to decrease balance sheet exposures especially relative to risky counterparts. The BIS and ECB already report a decrease in the level of financial integration following the start of the sovereign debt crisis. Based on the identified indirect exposures and recent patterns of deleveraging, we want to dynamically investigate how the transmission of shocks and the level of interconnectedness are influenced by a decrease in cross-border links. We expect a lower response of the domestic economy to foreign shocks. However, the effects of the desired decoupling might be significantly undermined by the strength of indirect exposures.

To evaluate the relative importance of direct and indirect links, we opt for a GVAR methodology. We now continue by briefly describing the GVAR.

3 Methodology

We would like to join countries and sectors across the Eurozone and model the observed interconnectedness. By jointly modeling domestic and foreign risk measures we are trying to account for the cross-sectional correlation observed in the data.[13] The GVAR developed by Pesaran et al. (2004) and Dees et al. (2007) is able to capture the links described in the cited literature. Furthermore, the GVAR can be used with nonstationary data and can account for possible cointegration relationships both between and within the country specific and foreign variables groups. The GVAR methodology is in this respect superior to similar approaches like factor-augmented models that require a stationary transformation of the data and therefore disregard any information on long-run properties.

[11] The national banking systems do not face liquidity problems, thanks to essentially unlimited cheap credit from the ECB, but rather experience a substantial capital shortage.

[12] The EBA discourages asset cuts due to potential destabilizing effects on credit/securities markets.

[13] Fig. C.23 calculates rolling window correlation for banking and sovereign risk measures.

The GVAR stacks country specific VARX*(p_i,q_i)[14] structures and links them in a global model. A typical VARX*(p,q) has the following representation:

$$x_{it} = a_{i0} + a_{i1}t + \Phi_{i1}x_{i,t-1} + ... + \Phi_{ip}x_{i,t-p} + \Lambda_{i1}x^*_{i,t-1} + ... + \Lambda_{iq}x^*_{i,t-q} + u_{it}, \quad (1)$$

$$x^*_{it} = \sum_{j=1}^{n} w_{ij}x_{jt}, j \neq i, \quad (2)$$

where x_{it} and x^*_{it} are domestic and foreign variables respectively; w_{ij} captures the strength of bilateral links in between countries i and j.

The country specific models are stacked and we obtain the (reduced form) GVAR model, where r is the maximum of (p_i,q_i) over all countries i:

$$x_t = b_0 + b_1t + F_1x_{t-1} + ... + F_sx_{t-r} + \epsilon_t. \quad (3)$$

Most GVAR studies use trade flows when calculating the strength of bilateral links w_{ij}. While these are the main driver behind real sector synchronization (international business cycle), we expect financial/banking links to be more appropriate when dealing with high frequency financial data during the recent crisis. Krugman (2008) highlights the increasing importance of the "international finance multiplier" for the transmission of shocks in a globalized world economy. Our detailed description of banking activity in the Eurozone and its core role in providing liquidity also strengthens our case. Galesi and Sgherri (2009) are the first ones, to out knowledge, to consider the importance of financial/banking links in a GVAR, although their analysis follows a completely different scope and is not restricted to the Eurozone. Eickmeier and Ng (2011) carry out forecasting exercises using several weighting schemes. Using an updated version of the dataset in Dees et al. (2007), the authors conclude that FDI[15] flows perform the best when it comes to forecast accuracy. They also make the important distinction in between Assets and Liabilities exposures when calculating country weights. We will touch on this subject in the data section.

Following the GVAR literature, a series of preliminary analyses and specifications tests need to be performed. Besides checking stationarity and cointegration properties for the time series considered, we also need to perform a series of additional tests for all variables we want to include in our country models. One of the main assumption of the GVAR is that all foreign variables included in the VARX* are weakly exogenous. As described in Dees et al. (2007), the null of exogeneity implies that the cointegrating relationships found for a country model do not significantly enter the marginal model of any x^*_{it} included in that specific VARX*. We can check the validity of this assumption via an F-test, with degrees of freedom depending on the cointegrating space dimension. The exact specification of our model following the output of these specification tests will be presented in the results section.

Based on our VARX* country models, our main interest is the strength of the relationships we are trying to model. The dynamic analysis in a GVAR is performed using the Generalized Impulse Response Function (GIRF), tracking the effects of specific shocks on variables of interest. Based on Koop et al.

[14] p_i and q_i are the lag lengths for domestic and foreign variables in country i.
[15] Foreign Direct Investment.

(1996) and Pesaran and Shin (1998), Appendix B describes how the GIRF are constructed. Note that the shocks are not orthogonalized and, therefore, the interpretation of the impulse responses should be made with care. While we could argue for a specific ordering of the variables included in each country model, there is no economic intuition that would justify how *countries* should be ordered in the GVAR. These issues have been discussed intensively in Pesaran et al. (2004) and Dees et al. (2007).

4 Data

4.1 Sovereign and banking risk

For our empirical analysis we include 10 Eurozone member states: Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. As measures of risk for the sovereign and banking sector, we follow the literature and use Credit Default Swaps with a 5 year maturity.[16] The BIS gives the following definition of a CDS contract: "Credit default swaps are credit protection contracts whereby one party agrees, in exchange for a periodic premium, to make a contingent payment in the case of a defined credit event.[17] The contract implies a credit risk transfer, from the holder of the underlying security to the seller of the CDS contract. Data is expressed as an yearly percentage of the notional principal that the protection buyer needs to pay the seller. This premium offers information regarding default probability of the underlying contract and can therefore be interpreted as the perceived creditworthiness of the security issuer, either a central government or bank. Our data is weekly, covering November 2008 to January 2012.

Table 1 contains the banks in the Eurozone included in our banking sector CDS measures. Considering trading volume in the European credit derivative market and data availability, we have decided to use data on CDS contracts with a Modified Modified Restructuring option (MM) which are based on senior debt instruments. Exact definitions and disaggregation of contracts are available in Appendix C. After collecting CDS series for individual banks we can create averages for each country of interest. We can choose in between calculating simple averages and constructing weighted country wide measures of risk using total assets of each bank. Most papers using CDS series for the banking sector are based on simple averages of all banks whose head-office is located in the reporting country. We believe that weighted averages are more informative regarding the aggregate state of the sector.

[16] CDS contracts with a 5 year maturity are the most traded credit derivative products.

[17] http://www.bis.org/publ/qtrpdf/rqt0312g.pdf.

Table 1: Banks included

Bank	Country	Bank	Country
Erste Group	Austria	Raiffeisen Zentralbank	Austria
BAWAG P.S.K	Austria	KBC Bank	Belgium
Dexia	Belgium	BNP Paribas	France
Crédit Agricole	France	Credit Lyonaise	France
Societe Generale	France	Natixis	France
Deutsche Bank	Germany	Commerzbank	Germany
Bayerische Landesbank	Germany	Landesbank Baden-Württemberg	Germany
Nord Landesbank	Germany	West Landesbank	Germany
Landesbank Berlin	Germany	DZ Bank	Germany
IKB Deutsche Industriebank	Germany	Alpha Bank	Greece
Eurobank EFG	Greece	Allied Irish Banks	Ireland
Anglo Irish (up to 2011)	Ireland	Unicredit	Italy
Intesa Sanpaolo	Italy	Banco Popolare	Italy
Banca Monte dei Paschi di Siena	Italy	Unione di Banche Italiane	Italy
Mediobanca	Italy	Banca Italease	Italy
Banca Popolare Milano	Italy	ING	Netherlands
Rabobank	Netherlands	ABN Amro	Netherlands
SNS Bank	Netherlands	Banco Comercial Português	Portugal
Banco Espírito Santo	Portugal	Caixa Geral de Depósitos	Portugal
Banco Santander	Spain	BBVA	Spain
Bankia (Caja Madrid + Bancaja)	Spain	Banco Popular Español	Spain
Banco Sabadell	Spain	Bankinter	Spain
La Caixa	Spain		

Note: Domestic banks are those which have their head-office located in the reporting country

Although our main focus is the dynamics of domestic and foreign CDS time series, we are also interested in augmenting our bivariate systems with other country specific variables capturing economic developments. Sovereign and banking CDS will be jointly influenced by the stance of the economy. We choose to introduce country specific spreads as the difference in between long term bond yields and a short term interest rate.[18] This variable captures the risk premium as a direct measure for country distress and contains significant information regarding present and future economic developments.

4.2 Banking exposures

For calculating weights, we use Table 9B "Consolidated claims - immediate borrower basis"[19] from the BIS for the period 2008:Q3-2011:Q4. This covers quarterly balance sheet positions of reporting banks, including loans, deposits, securities and derivative contracts. The stock of claims in the balance sheet

[18] Spread = 10 year sovereign bond yield - 1 month EURIBOR

[19] Allocated to the country where the original risk lies. More detailed explanations are provided in Appendix C.

of a bank have as counterparty a foreign debtor in either bank, non-bank, private or public sector.[20] We opt for asset side positions when calculating our weights, i.e. during a specified period w_{ij} is the proportion of total claims of banking sector in country i on residents of country j, $w_{ij} = \frac{C_{ij}}{\sum_{k=1}^{n} C_{ik}}$, where n is the total number of countries. A more detailed discussion about interconnected balance sheets and possible risk transfers through assets and liabilities positions can be found in Appendix D. We also look at the dynamic behavior of weights and bilateral claims across our sample (2008:Q3-2011:Q4) and notice a decrease in total banking intermediation for all the countries in our sample. Considering that a decline in total claims for a country i ($\sum_{k=1}^{n} C_{ik}$) will understate the change in w_{ij}, weights do not vary as much as bilateral claims C_{ij} and are in general rather stable over our sample.[21] The weights that we use for our GVAR analysis are fixed.[22] After averaging the data, we calculate for every member state in our sample the relative contribution of each debtor. Table 2 includes the banking weights calculated using cross-border claims of country i (column) on country j (line). Each column sums up to one.

Table 2: Cross-border banking weights

Country	Austria	Belgium	France	Germany	Greece	Ireland	Italy	Ned	Portugal	Spain
Austria	0.000	0.022	0.016	0.085	0.018	0.030	0.216	0.015	0.006	0.019
Belgium	0.025	0.000	0.141	0.035	0.026	0.035	0.012	0.211	0.012	0.030
France	0.091	0.200	0.000	0.180	0.157	0.121	0.080	0.163	0.092	0.144
Germany	0.427	0.120	0.193	0.000	0.352	0.320	0.529	0.286	0.055	0.190
Greece	0.033	0.015	0.045	0.034	0.000	0.034	0.012	0.013	0.109	0.004
Ireland	0.042	0.230	0.041	0.139	0.070	0.000	0.036	0.044	0.239	0.051
Italy	0.172	0.124	0.319	0.160	0.047	0.208	0.000	0.094	0.044	0.154
Ned	0.129	0.168	0.095	0.144	0.294	0.074	0.049	0.000	0.125	0.086
Portugal	0.017	0.014	0.023	0.036	0.009	0.027	0.010	0.014	0.000	0.321
Spain	0.063	0.106	0.126	0.186	0.027	0.150	0.056	0.159	0.319	0.000

Note: Proportion of claims of country i (column) on country j (line) in total claims of i with respect to all countries in our sample.

Recent patterns and the observed decrease in banking intermediation draw our attention to future deleveraging strategies. The slowdown in financial integration is mainly directed at weak peripheral states: in the hope of insulating the economy from foreign negative shocks, core countries appear to be eliminating risky assets and generally trying to minimize real links to peripheral member states. In real terms, significant decreases in cross border claims between 2011:Q3 and 2011:Q4 had as counterparties banks in Italy ($-65 billion) and Spain ($-45 billion). Calculations by Angeloni and Wolff (2012) based on EBA[23] data show also a contraction in total holdings of PIIGS government debt securities, with banking

[20] Interbank lending and holdings of sovereign debt represent the major bulk of such cross-border activity, as highlighted in our description of direct banking links. These BIS claims are therefore representative for characterizing banking-sovereign connections. Disaggregated data is only available for a limited number of countries, making a more clear separation of individual inter-sectoral claims not feasible.

[21] Appendix C provides a more detailed discussion on the impact of deleveraging on weights. In Table C.10 we calculate on actual changes in flows and weighs across our sample.

[22] The quarterly frequency of BIS data would not allow us to use time varying weights and take advantage of the extra information captured in the dynamics of weights.

[23] European Banking Authority.

sectors of France and Germany deleveraging by 18.5% and 9.4% respectively between July and December 2011.

A key economic question during this period of increased risk and uncertainty would be whether strategies of deleveraging through balance sheet asset reduction are effective. Does moving away from risky positions insulate the domestic banks from negative shocks and, through balance sheet channels, the sovereign sector? Before answering these questions through our dynamic analysis, we first proceed with calculating indirect exposures.

In the motivation of our paper, we have mentioned the potentially important indirect banking links. We focus on exposures of core countries to counterparties located in any of the PIIGS states. Based on the balance sheet connections described in Figure 1, we calculate cumulated (average) indirect exposures to peripheral countries through an intermediate debtor country. It is of course possible to continue this calculation using third round effects, we however expect these to be insignificant and only focus on links as described in the diagram. Table 3 summarizes total weaknesses when taking into account indirect exposures. Data is expressed in relative contributions of each PIIGS counterparty to total exposures of core member states. The percentages indicate the contribution of second round effects to cumulated vulnerabilities, e.g. 28.4% of Austria's links to Italy are resulting from indirect balance sheet exposures. Note that these calculated "weights" no longer sum up to 1.

Table 3: Cross-border banking - Total exposures and contribution of indirect exposures

Country	Austria		Belgium		France		Germany		Netherlands	
Italy	0.241	28.4%	0.271	54.4%	0.369	13.6%	0.275	41.8%	0.243	61.1%
Spain	0.163	61.2%	0.215	50.6%	0.162	22.2%	0.252	26.3%	0.255	37.7%
Ireland	0.117	64,0%	0.263	12.7%	0.105	60.9%	0.165	15.5%	0.140	68.4%
Greece	0.054	38.6%	0.031	52.2%	0.056	18.9%	0.048	28.1%	0.034	60.9%
Portugal	0.037	53.8%	0.026	45.0%	0.034	31.2%	0.044	18.3%	0.031	56.1%

Note: Total exposures through third parties are cumulated based on the links described in Figure 1

The data reveals significant weaknesses and exposures to all PIIGS countries. A series of observations can be made. First of all, the contribution of indirect links is significant, doubling the initial cross-border bank assets relative to the original BIS data. It appears that the countries in our sample are much more interconnected than what simple bilateral weights would imply. The largest "hidden" weaknesses are identified for the banking sectors of Belgium, Austria and the Netherlands. Secondly, Italy and Spain are the countries with the largest impact on core Eurozone. This is not surprising considering the size of their banking sectors and total government debt. Considering the general small exposures as well as the size of Greece and Portugal relative to the rest of countries in Table 3, the "significant" contribution of indirect is actually of a reduced magnitude.

Having defined our data, the weights to be used as well as indirect exposures, we now move on to estimating country specific models and performing our dynamic analysis.

5 Results

5.1 Preliminary analysis

We rely for our empirical analysis on the GVAR Toolbox 1.1 developed by Smith and Galesi (2011) and use banking weights as defined in Table 2. We start our analysis by checking the data properties of all our time series. All sovereign and banking CDS series are found to be I(1). The term spread, depending on the deterministic terms included, is mainly stationary for core countries and Spain. This is not surprising considering the relatively stable long term yields. For the remaining peripheral states, the spread is $I(1)$. We next test for cointegration in each country model. We allow for a maximum lag length of 4 and use the optimal p and q as suggested by the AIC criterion.

Table 4: VARX lag order and cointegration properties

Country	VARX*(p,q)	Cointegrating space
Austria	2,2	3
Belgium	1,1	1
France	3,3	1
Germany	2,2	3
Greece	2,2	1
Ireland	2,2	1
Italy	4,3	1
Netherlands	4,2	3
Portugal	2,2	1
Spain	2,2	1

We now continue with weak exogeneity tests. Table 5 reports 5% critical values and test statistics for all foreign variables. When adding all foreign variables in the German and French country specific model, the test rejects the null of exogeneity for the term spread. We therefore decide to leave it out in both country models. At the 5% level the CDS^*_{sov} is also endogenous for the Portugal VARX*. We however decide to still include this variable considering the much stronger rejections of the null obtained for Germany and France. Note that finding the correct specification of each country model implies a constant updating process in between weak exogeneity, cointegration and standard residual testing.

Table 5: Test statistics for the Null hypothesis of weak exogeneity

Country	F-test	critical 5%	$CDS^*_{sovereign}$	$CDS^*_{banking}$	Spread*
Austria	F(3,147)	2.666	0.532	0.689	0.653
Belgium	F(1,155)	3.902	0.004	0.112	0.242
France	F(1,141)	3.908	0.023	0.185	-
Germany	F(3,149)	2.665	0.353	1.728	-
Greece	F(1,149)	3.904	0.566	0.227	0.009
Ireland	F(1,149)	3.904	3.885	0.714	0.720
Italy	F(1,125)	3.917	0.186	0.203	0.792
Netherlands	F(3,129)	2.675	0.543	0.422	2.106
Portugal	F(1,149)	3.905	0.840	1.098	4.102
Spain	F(1,149)	3.905	1.031	0.324	0.059

Note: We do not include the spread for France and Germany since first round tests were significantly above the critical value.

After estimating VARX*(p,q) models for all countries in our dataset, we still find signs of left-over heteroscedasticity in the residuals of some CDS equations. The specific lines of the VECM correspond to sovereign CDS for Greece and Belgium and banking CDS for Ireland and Italy. Because it is not computationally tractable to use a very high lag length, we have limited our maximum lag to 4. Since countries like Greece and Ireland have experienced extreme values and high volatility in their sovereign and banking credit default swap valuations respectively, it is not surprising that the four lags used are not enough to fully characterize their behavior.

As a model check, we report correlation coefficients for the original series (levels and first differences) and the unexplained component after the VARX* fitting. We notice that the common pattern in the data is considerably reduced after accounting for international factors, with most coefficients declining significantly. We also performed a series of structural stability tests[24] which, with a few exceptions, did not reject the hypothesis of constant parameters.[25]

[24]CUSUM statistic of Ploberger and Kramer (1992), Nyblom(1989), sequential Wald statistics etc. Detailed descriptions of these tests can be found in the User Guide of Smith and Galesi (2011)

[25]The CUSUM based test of Ploberger and Kramer (1992) identifies some instabilities at the $\alpha = 1\%$ confidence level for CDS^S in the Greek country model. The heteroscedasticity-robust statistic of Nyblom (1989) also rejects at $\alpha = 1\%$ the null of stability for Greece CDS^S, as well as for Italy and Netherlands CDS^S and Austria CDS^B.

Table 6: Average cross-sectional correlation

Country	CDS	Levels	Differences	Residuals	CDS	Levels	Differences	Residuals
Austria	S	0.581	0.542	0.104	B	0.460	0.490	0.222
Belgium	S	0.852	0.606	0.107	B	0.792	0.553	0.272
France	S	0.861	0.611	0.166	B	0.808	0.607	0.328
Germany	S	0.828	0.540	0.127	B	0.728	0.611	0.367
Greece	S	0.765	0.250	-0.205	B	0.774	0.314	0.097
Ireland	S	0.685	0.436	-0.081	B	0.330	0.061	-0.251
Italy	S	0.849	0.594	0.011	B	0.814	0.614	0.265
Netherlands	S	0.658	0.574	0.103	B	0.704	0.611	0.325
Portugal	S	0.780	0.383	-0.045	B	0.738	0.492	0.280
Spain	S	0.777	0.585	0.030	B	0.772	0.636	0.277

Note: For each country variable and VARX residuals, we report an average of all correlation coefficients with remaining countries.

After estimating each country specific VARX*, we stack all models into our GVAR and move on to our dynamic analysis. We focus on the deleveraging patterns recently observed in BIS data. Does moving away from risky positions insulate the domestic banks from negative shocks and, through balance sheet channels, the sovereign sector? As Cesa-Bianchi et al. (2011) point out, we can estimate country specific VARX* models and afterwards solve the GVAR using *any* weighting scheme. For each weighing scheme we obtain a different set of impulse responses. With banking sectors reducing their asset position with respect to selected countries, we would like to address the issue of decreasing weights and to understand how/if the transmission of shocks through the channels uncovered by the GVAR is impacted.

5.2 Do deleveraging strategies decrease risk?

According to the IMF[26], inadequate capital buffers, low economic growth and the escalation of sovereign risk at the end of 2011 are intensifying the pressure on European Banks to deleverage. Based on recent trends, we have decided to decrease further the average BIS (direct) banking exposures of core Eurozone with respect to peripheral countries (PIIGS). While we observe reduced banking intermediation across *all* members states, the decline in cross-border lending was mainly initiated by Western Europe and is overwhelmingly aimed at distressed countries.[27] We would like to "exaggerate" the observed pattern and decrease by 50% the existing (average) claims on counterparties located in PIIGS countries. This is a realistic scenario, strong enough to capture recent deleveraging trends and extrapolate for following periods. With high uncertainty regarding the future of Greece as well as recent downgrading of banks in Italy and Spain[28], we expect that the contraction in financial intermediation and asset deleveraging is likely to accelerate. The IMF[29] estimates that total asset deleveraging for banks in the Eurozone will amount to $2 trillion by 2013.

After reducing direct banking claims to one half of their original values, we calculated the retained

[26] Global Financial Stability Reports from September 2011 and April 2012.

[27] as highlighted in Table B.10, as well as by more recent 2012 BIS data.

[28] On May 14, Moody's downgraded 26 Italian banks; A few days later, a series of Spanish banks were also downgraded

[29] Global Financial Stability Report, April 2012 and September 2012.

total exposures as percentages from initial total weights as calculated in Table 3.

Table 7: Decrease direct claims on PIIGS by 1/2, percentage of total exposures remaining

Country	Austria	Belgium	France	Germany	Netherlands
Italy	71.2%	84.8%	73.5%	82.2%	84.4%
Spain	84.4%	83.4%	76.2%	77.5%	75.1%
Ireland	85.6%	71.2%	88.2%	74.3%	87.4%
Greece	75.4%	83.6%	75.3%	77.9%	84.5%
Portugal	81.5%	81.3%	78.9%	75.0%	82.5%

Note: Percentages are calculated as share of total exposures from Table 3 after reducing direct cross-border claims by 50%

Table 7 shows that it is not sufficient for a country to reduce its exposures in order to isolate itself from risky counterparties. The decline in total links is very limited when taking into account the contribution of indirect exposures. From a core country's perspective it is possible to unilaterally affect only direct banking claims, since indirect ones are to a large extent decided by third parties. Taking this into consideration, cutting in half *total* exposures implies a much more drastic decrease in direct banking flows. In some situations, with significant indirect links, the optimal claims would need to fall bellow zero in order to ensure that total exposure is reduced by 50%. We recalculate new weights using the diminished direct cross-border flows and set negative ones to zero. Since the columns of our modified matrix still need to sum up to 1, we have redistributed the left-over weight proportionately to the remaining counterparties.

Table 8: Decrease total exposures by 1/2, new banking weights

Country	Austria	Belgium	France	Germany	Netherlands
Italy	0.052	0.000	0.134	0.023	0.000
Spain	0.000	0.000	0.045	0.060	0.031
Greece	0.017	0.007	0.023	0.017	0.007
Ireland	0.000	0.107	0.007	0.070	0.000
Portugal	0.008	0.000	0.007	0.018	0.007

Note: Weights based on direct cross-border claims after reducing total exposure to 1/2; All negative values have been set to 0

Our counterfactual analysis implies without a doubt a severe reduction in cross-border claims to all PIIGS countries. With a few exceptions, all weights are bellow 5% and more than half are zero. This might appear drastic and even not-tractable. However, the severity of the decrease in financial links in the light of our impulse responses underlines important features regarding interdependence and risk sharing in the Eurozone.

Our main interest is understanding which strategy is most advantageous for a core country. Would a decrease in banking activity in between Germany and Italy yield stronger results than just focusing on Greece? We perform this analysis for each core country, i.e. modifying the weights w_{ij} according to Table 8 for each country i (Austria, Belgium, France, Germany, Netherlands) at a time. This allows us to understand the optimal strategy for different member states. We look at differences in between GIRF and their confidence bounds before and after modifying the GVAR weights. If the bounds do not overlap

then they are significantly different from each other and we can conclude that the impact does change when decreasing weights.

We want to trace the cross-border effects of shocks to country specific risk measures. Based on the VARX* estimated coefficients and the implied dynamic multipliers we calculate responses to a unit (one standard error) shock in CDS measures of peripheral states (Greece, Italy, Spain and Ireland for banking only). We also create a composite shock to the PIIGS group (Portugal, Ireland, Italy, Greece, Spain) using GDP weights. Figures A.3 to A.22 in Appendix A show the GIRF of domestic to foreign CDS, both for sovereign and banking sectors. The black lines trace the point estimates and 90% bootstrap confidence bounds using the original weight matrix from Table 2 while the red impulse responses are obtained using modified weights as calculated in Table 8.[30]

For sovereign to sovereign (S to S) shocks, Figures A.3-A.7, we first notice that all GIR are positive, implying an increased risk aversion across the Eurozone. Considering the flight-to-quality effects observed in the bond market and record low borrowing costs for Germany, we might have expected to find a negative relationship in between the foreign shock and core response. There are however some pricing differences in between the bond and CDS markets, with swaps being generally less impacted by flight-to-safety factors. Regarding the magnitude, responses are rather small, with some degree of heterogeneity when comparing all countries. The GIRF becomes insignificant after 4 weeks in a few cases (Greece to Belgium and The Netherlands). The strongest reaction to foreign shocks is exhibited by Belgium, a small open economy with a large banking sector, while German swaps exhibit the smallest changes. One of the most interesting result is that although the point estimates after reducing exposures are in fact smaller, the IR are not significantly different from each other in any country. Considering that we redistributed the remaining weight gap among core countries, our deleveraging strategy is accompanied without a doubt by increases in indirect links through stronger core interconnectedness.[31] There are however a few notable examples where the responses become insignificant at specific horizons: Spain and Greece to Austria, Greece to Germany. The sovereign to banking (S to B), Figures A.8-A.12, effects mimic the country patterns observed in the S to S graphs. We however obtain even larger magnitudes in most cases. Again, reducing weights does not significantly alter our results.

For banking to sovereign (B to S), Figures A.13-A.17, our results show a negative relationship for shocks originating in Spain and Italy. This is consistent with a risk transfer from banking to sovereign across borders. Achayra et al. (2011) observed such pattern after a bailout announcement, although their analysis follows the sectoral interconnectedness inside a country's borders. Considering the positive correlation and impulse responses characterizing sovereign CDS spreads, the cross-border results are intuitive. We must again interpret this negative relationship with care considering that the responses are significantly different from zero for only a few weeks after the original shock. We have also traced the effect of a banking shock to foreign banking sectors, Figures A.18-A.22, but the results are in almost all cases not significant.

The observed balance sheet interconnectedness has been driven by the process of financial integration

[30] The new weights with respect to the remaining core countries are have also been updated and are not presented here.

[31] Although indirect links increase artificially, the insignificant change in impulse responses strengthens the validity of the postulated indirect channels.

and liberalization of financial services across borders. Credit institutions were enabled to broaden their activity almost without limits. The transfer of risk and potential threats of cross-border exposures were however not fully taken into account when designing the framework for the "Single Market". The role of the banking sector in fostering the transmission of the crisis and the strength of spillovers across borders are much stronger than one would have anticipated. Our results show consistently that a negative shock to perceived creditworthiness is transmitted to all other member states and that risk can not be contained inside national borders. Not even aggressive deleveraging strategies are able to significantly reduce the impact of the analyzed shocks. Despite a series of other directives aimed at early interventions and risk supervision[32], these potential problems were never fully addressed.

In the light of our results, directives aimed at monitoring large exposures[33] of credit institutions and limiting them to 25% of total funds do not appear to be sufficient. Our counterfactual analysis emphasized the importance of indirect vulnerabilities and stressed that these should also be taken into account when calculating total portfolio risk. At the same time, while the reduced exposures used in our counterfactual analysis were far bellow the 25% threshold, they where nonetheless sufficient for recreating the initial pattern of most impulse responses. It is also important to note that central government debt is exempt from these limits and given a 0% risk weight. We therefore stress that it is not possible to properly asses the strengths and vulnerabilities of banking activity without correctly pricing the risk of all relevant instruments.[34]

6 Robustness checks

We would also like to perform a series of robustness checks regarding the choice of data and sample size. Our sample covers weekly data from November 2008 up to and including January 2012. While a larger span is available for most banks and central governments, we wanted to restrict our analysis to the period around the sovereign debt crisis. We believe that the multivariate system before 2008 is governed by significantly different dynamics, as we move from a period of common behavior and low variability to one of high volatility and divergence. It is very likely that risk pricing prior to 2008 was very different and not very informative about the normal dynamics in a more mature market. Moreover, data for most banks is only available starting the beginning or mid 2008. The choice of weekly time series allows us to limit the noise relative to the use of daily data while still providing us with a substantial number of high frequency observations.

Regarding our choice of variables, we could potentially consider other measures of sovereign and banking risk. CDS series are widely used in the recent literature on sovereign debt and banking distress in the Eurozone. Investors do not have to hold the underlying asset which makes the swap market very liquid. Since a CDS is an extensively traded high frequency financial instrument it is subject

[32] Directive 92/121/EC on monitoring of large exposures as well as Directive 2006/48/EC, aimed at prudential supervision by creating buffers and imposing strict requirements for financial institutions.

[33] Exposures to a client above 10% of funds.

[34] There is a large literature on sovereign bond market dynamics in the Eurozone. Convergence of yields was misinterpreted as increased integration while actually resulting from incorrect risk pricing.

without a doubt to investor sentiment and speculation and might not always fully reflect real structural problems. We can argue that, due to their speculative character, these derivative contracts have a rather destabilizing influence on the correct pricing of risk.[35] CDS premia might therefore not be able to correctly assess the health of the issuing entity. While we do recognize the existing issues, we believe that these credit derivatives are informative regarding creditworthiness[36] and represent a valid measure of risk.[37] Regarding the use of bond yields, we have already included a (sovereign) spread variable in our GVAR. Another valid option would be to consider ratings for both types of debt issuers. The frequency and lack of variability for many issuers are two unappealing characteristics for the purpose of our analysis. Using balance sheet positions encounters similar drawbacks: while they offer a real image of financial stability, such data is only available at a yearly frequency for the sovereign and banking sectors. This makes a real time dynamic analysis difficult. As an additional robustness check, we have also compared results using weighted and unweighted bank CDS series. Our conclusions are not affected by the choice of averaging.

Regarding cross-border banking activity as reported by the BIS, we only consider claims across the 10 largest Eurozone members.[38] It is also relevant to ask if the banks considered are significantly exposed to other debtors not included in our sample. This would imply that controlling for intra-Eurozone influences is not sufficient and that the importance of shocks originating in other countries may be overwhelmingly larger than any other links we are trying to capture in our empirical analysis. The transmission of risk channeled by integrated banking sectors is also at work with respect to the rest of the world: CDS premia for other countries should also be controlled for. Table 9 summarizes cross-border BIS data with respect to all major counterparties.

Table 9: Disaggregated cross-border banking

Country	Austria	Belgium	France	Germany	Greece	Ireland	Italy	Ned	Portugal	Spain
Europe	91.59	87.48	60.90	63.80	90.58	83.17	88.16	60.61	76.21	50.75
Developed	42.30	63.58	54.67	58.87	35.71	82.32	66.96	54.23	65.02	47.49
EU-10	22.57	48.19	39.52	31.48	6.29	32.18	52.37	38.29	55.01	17.03
UK	4.40	10.29	7.90	16.48	10.26	47.22	5.93	10.38	4.66	28.33
Developing	49.30	23.90	6.23	4.93	54.87	0.84	21.20	6.37	11.19	3.25
World	8.41	12.52	39.10	36.20	9.42	16.83	11.84	39.39	23.79	49.25
Developed*	2.83	3.30	10.84	10.88	2.63	6.64	3.65	14.93	5.01	2.21
US	3.27	7.72	18.01	18.96	1.79	9.90	3.91	18.07	4.00	14.93
Developing	2.31	1.50	10.26	6.36	5.00	0.29	4.27	6.40	14.77	32.11

Note: Data in percentages for 2011:Q3. EU-10 represents cumulated claims for our sample. Developed for World does not include the US

First of all, disaggregated data shows that our sample covers a significant proportion of balance sheets positions. Secondly, other important counterparties are UK, US as well as developing European

[35] New EU regulation from Feb. 2012 is aimed at restricting "naked" CDS contracts with an underlying sovereign debt instruments.

[36] A large number of papers address the relationship between CDS spreads and bond yields. CDS spreads and bond yields contain, in the long run, the same information regarding the risk of the issuer. A few more recent papers identify however some important changes in the information structure of the CDS market after the crisis.

[37] CDS spreads are less sensitive to factors relatively unrelated to default risk, e.g. flight-to-quality effects.

[38] Cumulated GDP of sample countries represent 96% of aggregate size of Eurozone and 68% of the EU in 2010.

countries (mainly Eastern Europe). We look at the behavior of corresponding UK and US time series in order to trace potential causal links that our application disregards. Figure 2 plots sovereign and banking CDS spreads for these two countries alongside PIIGS and an average of core member states.[39] The UK and US risk measures do not show significant increases that might trigger the strong observed reaction in peripheral Europe. The movements in PIIGS spreads are much larger and have been consistently identified in the recent literature as the main source of distress. We believe that for the purpose of our analysis shocks outside the Eurozone are not important and that the origin of possible disturbances is correctly assigned in our empirical application.

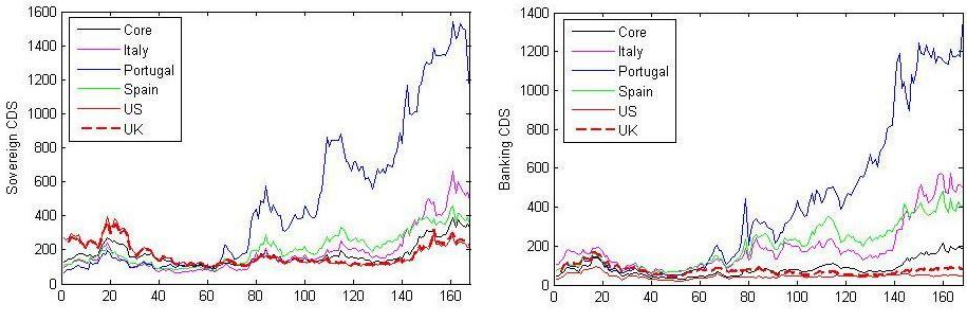

Figure 2: Banking and Sovereign CDS for the Eurozone, US and UK

7 Conclusions

The on-going Eurozone debt crisis has created strong links in between the sovereign and banking sectors, inside as well as across borders. The first signs of distress in the region were banking problems due to either international exposures to the US subprime crisis or the burst of domestic housing bubbles. Shortly after, revelations about Greece and its fiscal situation as well as concerns regarding other distressed member states helped fuel negative expectations and start the sovereign debt crisis. A significant number of papers have addressed the issue of country risk in the context of a monetary union and the transmission of sovereign distress through real and contagion channels. The interconnectedness in between sovereign and banking sectors has also become very strong, with causal links running in both directions. The observed feedback effects are not surprising considering the important bail-out funds used by governments and massive purchases of sovereign debt.

The aim of our paper was to jointly model banking and sovereign distress in the Eurozone using the GVAR methodology. Based on banking sector links and balance sheet exposures we find significant spillovers in between sovereign and banking distress measures, inside the country but also across borders. Usually an increase in CDS spread in one country is followed by worsening borrowing conditions in between sector and across countries. There are some examples where the response has an opposite sign relative to the initial shock, indicating a risk transfer from banking to governments. This pattern has been observed by a series of authors (Achayra et al. (2011) inter alia) and can be explained by the government's perceived status of ultimate insurer.

[39] With a strong common behavior, the average is a representative measure for behavior in core countries.

Taking into account the recent deleveraging strategy of countries in the hope of insulating the domestic economy, we have performed a series of counterfactual analyses by decreasing financial links. We started by calculating direct and indirect exposures and observed that the total exposure of core member states to distressed economies is much larger than what direct credit flows and purchases of debt securities would imply. In the light of these findings, we find that not even substantially decreasing direct exposures is sufficient to insulate the domestic economy from negative foreign shocks. The impulse responses using initial and modified weighting matrices are in most cases not significantly different from each other. The indirect transmission channels fostered by cross-border banking activity are, therefore, much more important than one would expect.

Our findings contribute to the literature of financial integration in a monetary union as well as the on-going policy debate aimed at improving the supervision and regulation of cross-border activity. The destabilizing role of banking institutions and weaknesses in regulation have been highlighted by the on-going crisis. Within the current institutional setting of the Eurozone, our empirical analysis indicates that negative shocks to sovereign and banking borrowing costs are transmitted through extensive balance sheet channels in between sectors as well as to all other member states. With most Eurozone members in a downturn phase of the economy, diversification of the banking sector and high levels of financial integration fail to achieve the positive effects observed during periods of economic growth.[40] The banking sector appears instead to foster the transmission of the crisis through direct and indirect channels and exposures. Considering that the supervisory authorities were unable to identify in real time the increasing vulnerabilities of banking institutions, the existing framework for risk-assessment appears to be inadequate. In times of financial stress when discussions about "too-connected-to-fail" institutions are at the core of policy debates, the implications of our results are particularly dire.

We are not arguing for less integration, but rather for a correct and complete risk assessment. We would also like to stress the importance of banking distress early warning systems based on a common framework and cooperation in between all member states of the Eurozone. In order to address the weaknesses uncovered by recent developments in the financial and sovereign debt markets, there is an on-going discussion about crisis management[41] and a new European supervisory framework.[42] Creating more appropriate regulation is without a doubt extremely difficult, as it implies a constant updating and fine-tuning of existing arrangements. Simply setting strict rules and limiting exposures to arbitrary numbers cannot guarantee the healthy functioning of financial institutions and, through the lender of last resort quality, of the government. It is also crucial to distinguish between the risk of sovereigns and banks and to limit the ensuing differentiation in country specific credit conditions that is hindering economic recovery.[43]

[40] e.g. better credit conditions, availability of funds independent of idiosyncratic market characteristics.

[41] European Commission COM(2010).

[42] A series of macro and micro supervisory authorities have been created, inter alia the European Systemic Risk Board (ERSB) and European Banking Authority (EBA).

[43] The crisis related divergence in credit/deposit interest rates is heavily related to country fundamentals and does not always reflect the risk of individuals, either firms or households. Stricter credit conditions in the periphery are detrimental for investment, consumption and GDP growth.

Appendix A

S to S: Response of core sovereign CDS to a one standard error shock to PIIGS sovereign CDS

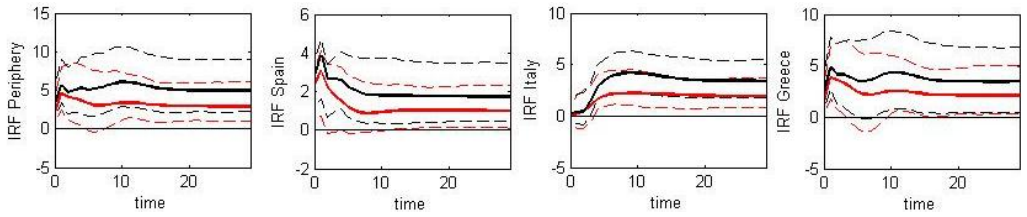

Figure 3: Austria

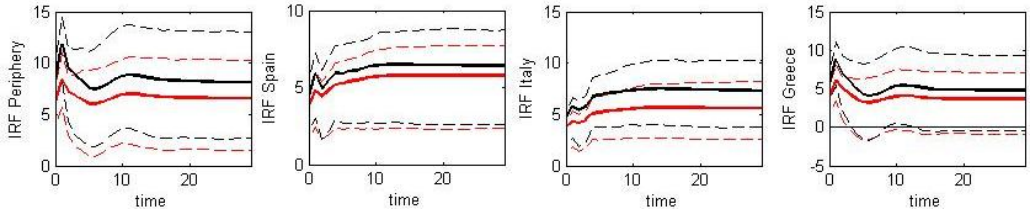

Figure 4: Belgium

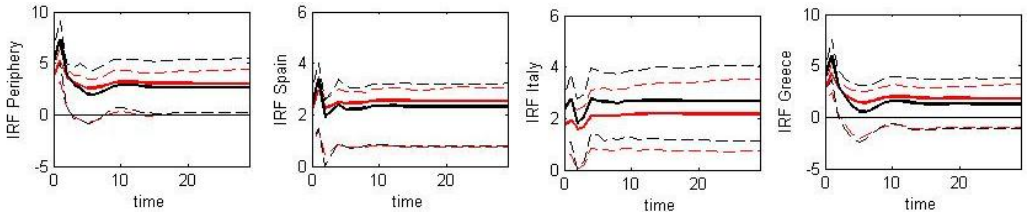

Figure 5: France

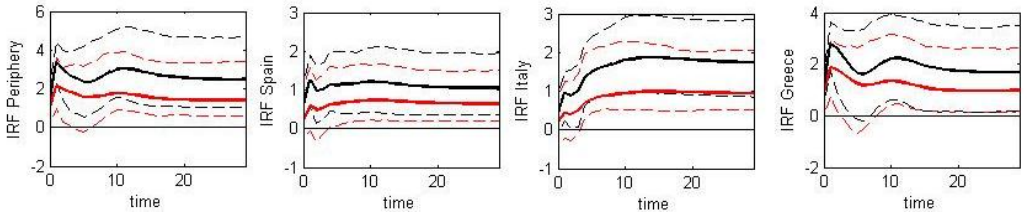

Figure 6: Germany

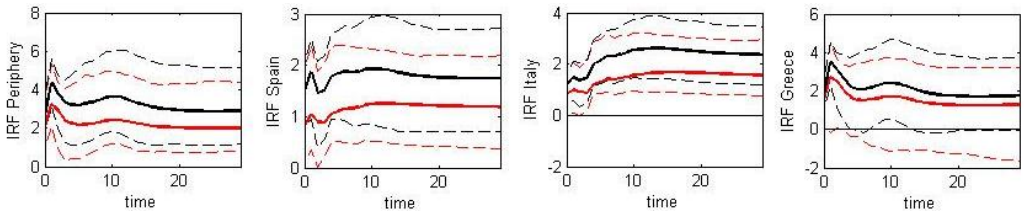

Figure 7: Netherlands

S to B: Response of core sovereign CDS to a one standard error shock to PIIGS banking CDS

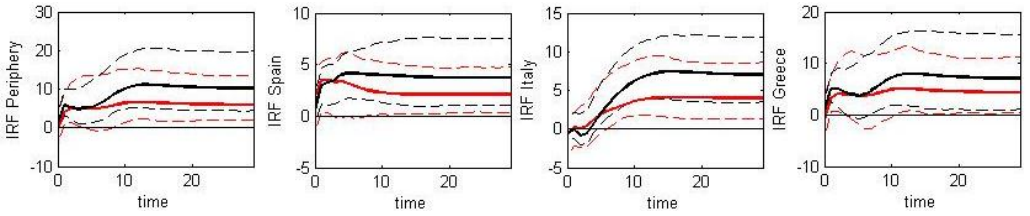

Figure 8: Austria

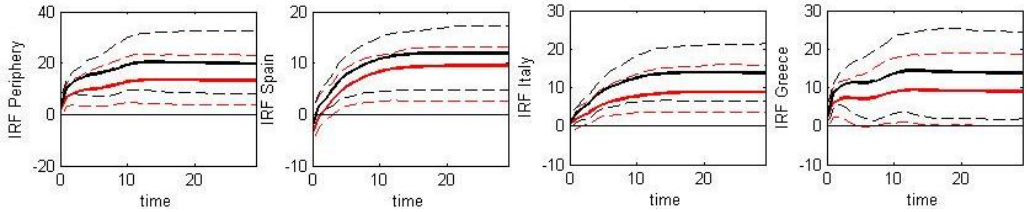

Figure 9: Belgium

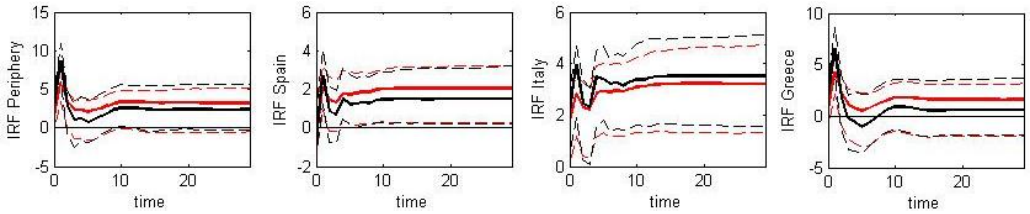

Figure 10: France

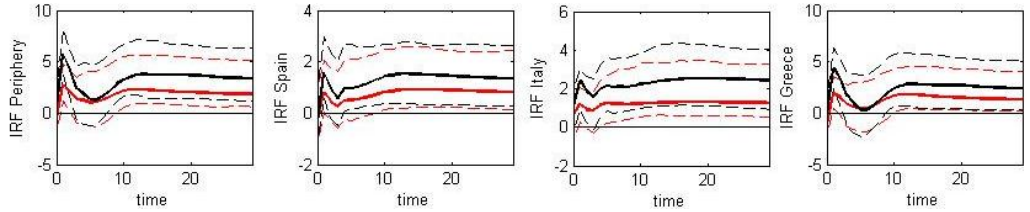

Figure 11: Germany

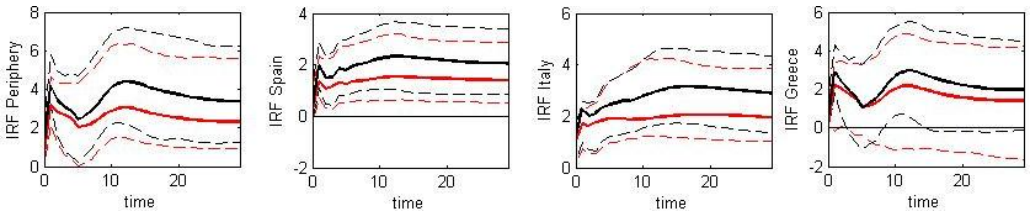

Figure 12: Netherlands

B to S: Response of core banking CDS to a one standard error shock to PIIGS sovereign CDS

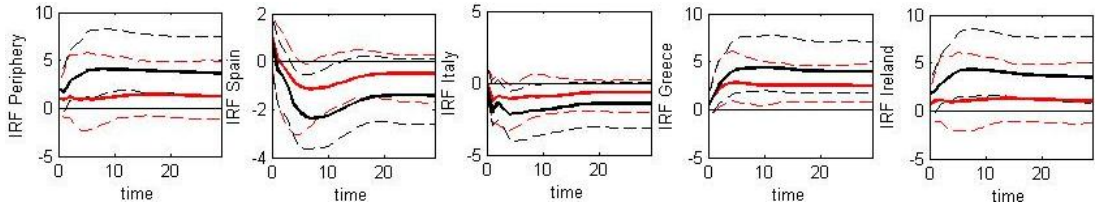

Figure 13: Austria

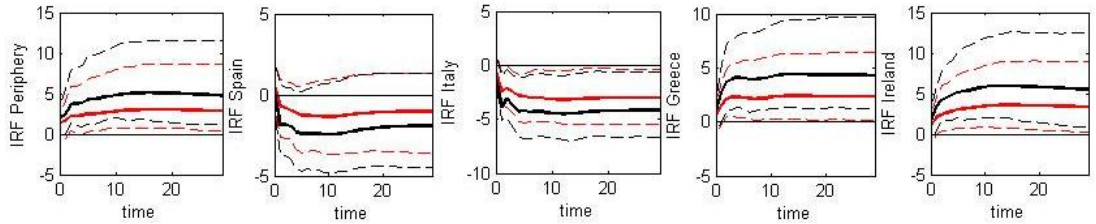

Figure 14: Belgium

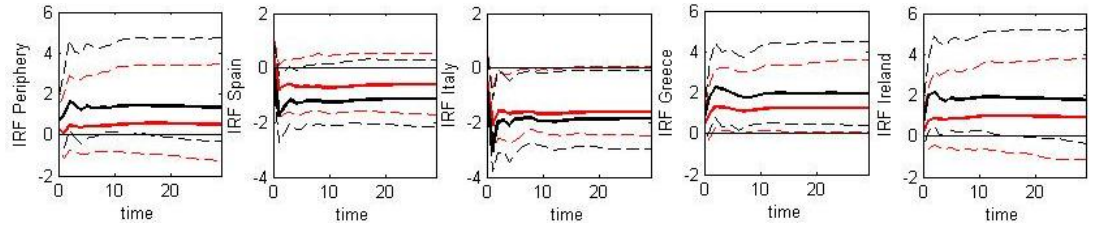

Figure 15: France

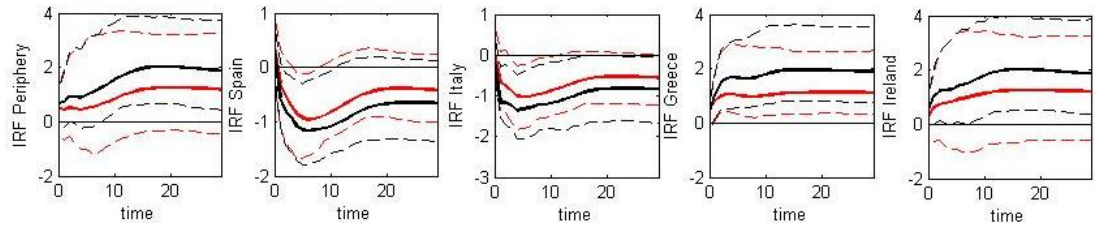

Figure 16: Germany

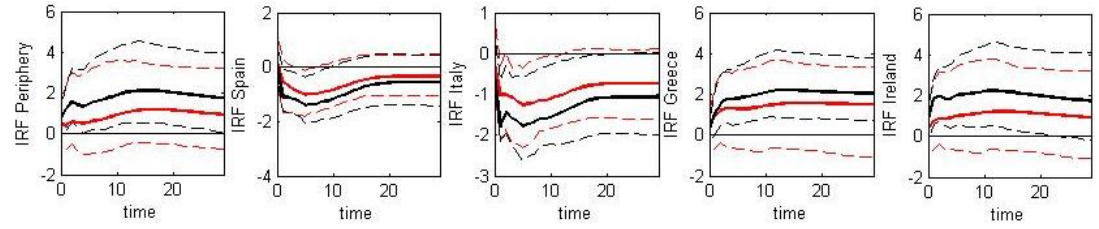

Figure 17: Netherlands

B to B: Response of core banking CDS to a one standard error shock to PIIGS banking CDS

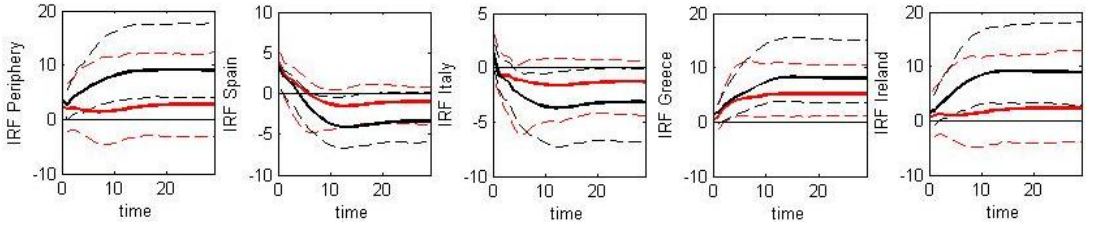

Figure 18: Austria

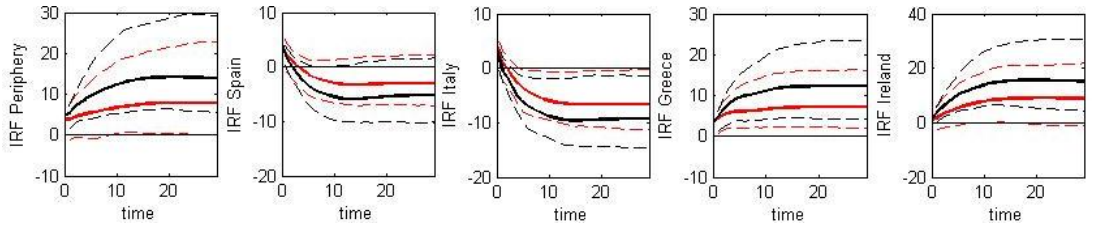

Figure 19: Belgium

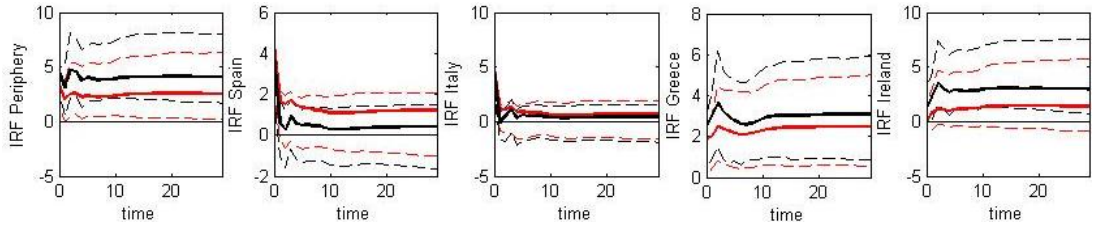

Figure 20: France

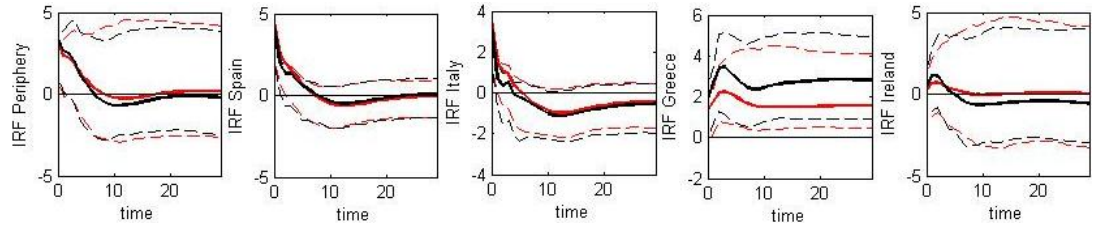

Figure 21: Germany

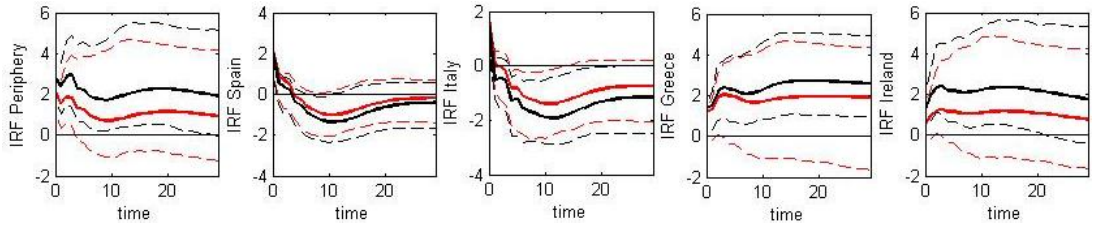

Figure 22: Netherlands

Appendix B: Generalized Impulse Responses

In a simple VAR(p) setting with n variables and ϵ as the reduced form residuals, the response of a shock of size $\sqrt{\sigma_{ii}}$ at time t to the i^{th} equation after n periods is expressed in the following conditional expectation form:

$$GIRF(n, \epsilon_{it} = \sqrt{\sigma_{ii}}, \Omega_{t-1}) = E[Y_{t+n}|\epsilon_{it} = \sqrt{\sigma_{ii}}, \Omega_{t-1}] - E[Y_{t+n}|\Omega_{t-1}]. \tag{4}$$

In this setting, Ω_{t-1} is the information set available up to time $t-1$. Taking into account the correlation structure in the residuals and assuming a multivariate normal distribution, a shock of size $\sqrt{\sigma_{ii}}$ to the $i'th$ innovation also creates changes in all other innovations. Disregarding again any country index, in the same VAR(p) setting we have the following set of shocks:

$$E[\epsilon_t|\epsilon_{it} = \sqrt{\sigma_{ii}}] = (\sigma_{1i}, \sigma_{2i}, ..., \sigma_{ni})'\sqrt{\sigma_{ii}} = \Sigma e_i.\sqrt{\sigma_{ii}}. \tag{5}$$

Since we are modeling systems of I(1) variables containing stochastic trends, some shocks $(n-r)$ will have permanent effects. We therefore expect the GIRF to tend to a non-zero constant. The response of a one standard error shock at time t to the l^{th} equation on the j^{th} variable at $t+n$ is the j^{th} element of:

$$GIRF(n, u_{it}, \Omega_{t-1}) = \frac{e_j' A_n G_0^{-1} \Sigma_u e_l}{\sqrt{e_l' \Sigma_u e_l}} \tag{6}$$

The A_n represent the dynamic multipliers obtained recursively form the GVAR representation and e_l is a vector that assigns the shock to the the l^{th} equation. element

Appendix C: Data description and definitions

C.1: Data and sources

Variable	Name	Source
Sovereign risk	CDS sovereign	Datastream
Banking risk	CDS banking	Datastream
Cross-border exposures	Banking claims	BIS
Bank size	Bank assets	Stress tests
Long interest rate	10 year bond yield	Datastream
Short interest rate	EURIBOR	Datastream

C.2: CDS underlying debt contract and restructuring clause (definitions from ISDA[44])

A sovereign CDS contract represents protection against the inability of a government to repay its debt obligations, offering a direct valuation of default risk. Similar to the sovereign case, the premium paid on bank CDS contracts quantifies the perceived health and stability of the issuer. The underlying

[44] International Swaps and Derivatives Association

debt instruments issued by the banking sector are disaggregated according to their level of subordination while the CDS contract is also differentiated based on the restructuring clause specified.

Senior Debt = Debt that is repayed first.

Subordinated Debt = Debt repayed after senior debt has been serviced; more risky.

No restructuring (NR) = Excludes the restructuring option, eliminating the possibility that the protection buyer suffers a "soft" credit event, i.e. not resulting necessarily in losses for the protection buyer.

Full Restructuring = Allows the buyer to deliver bonds of any maturity after restructuring of debt in any form occurs.

Modified Restructuring = Deliverable obligations are limited to bonds with maturity of less than 30 months after a restructuring; popular in North America.

Modified Modified Restructuring = Deliverable obligations are limited to bonds with maturity of less than 60 months after a restructuring; popular in Europe.

C.3: BIS consolidated claims

The BIS consolidated banking statistics are based on the nationality of the reporting bank and net out intragroup positions. Domestic banks are those which have their head-office located in the reporting country BIS claims on an immediate borrower basis are allocated to the country where the original risk lies. This type of claims bypasses any other third parties that might either extend guarantees or enter hedge strategies with the debtor country or whose securities are being used as collateral. For monitoring transfer risk exposures, the most appropriate data are those on an immediate borrower basis. BIS defines foreign claims as international claims plus local claims in local currency booked by foreign affiliates.

C.4: Weights and deleveraging

Table 10: Percentage change for claims and weights between 2011:Q3 and 2008:Q3

Country	Austria		Belgium		France		Germany		Ned	
	Claims	Weights	Claims	Weights	Claims	Weights	Claims	Weights	Claims	Weights
Austria	-	-	-55.01	30.34	-36.96	-26.98	-26.54	5.79	-2.05	31.38
Belgium	-34.13	-17.10	-	-	98.55	129.99	-29.91	0.94	-9.66	21.17
France	-17.90	3.32	-59.47	22.31	-	-	-6.91	34.07	-34.59	-12.25
Germany	-17.76	3.5	-79.80	-33.27	-14.41	-0.86	-	-	6.65	43.07
Greece	-56.30	-45.00	-92.55	-66.89	-46.36	-37.86	-12.50	26.03	-75.81	-67.55
Ireland	-69.88	-62.09	-63.24	27.03	-67.04	-61.82	-55.23	-35.52	-52.26	-35.96
Italy	3.39	30.12	-57.19	18.34	-21.69	-9.28	-38.03	-10.75	-47.74	-29.90
Ned	-7.89	15.92	-90.63	-30.52	4.83	21.43	-6.62	34.49	-	-
Portugal	-60.77	-50.62	-85.63	-61.29	-17.15	-4.03	-37.33	-9.73	-61.10	-47.82
Spain	-31.91	-14.39	-60.31	10.10	-25.48	-13.67	-42.55	-17.25	-46.28	-27.93

Considering that weights are calculated as a ratio between bilateral claims and total claims, we would

like to look closer at their dynamics during our sample (2008:Q3-2011:Q4). We define the percentage change in bilateral weights between countries i and j as $\frac{w_{ij,t}-w_{ij,t-1}}{w_{ij,t-1}} = \frac{\frac{C_{ij,t}}{\sum_{k=1}^{n} C_{ik,t}} - \frac{C_{ij,t-1}}{\sum_{k=1}^{n} C_{ik,t-1}}}{\frac{C_{ij,t-1}}{\sum_{k=1}^{n} C_{ik,t-1}}}$, where $w_{ij,t-1}$ and $w_{ij,t}$ are the starting and ending weights respectively. The behavior of the ratio $w_{ij,t}$ is affected by both numerator and denominator, with the weight reflecting changes in both bilateral ($C_{ij,t}$) and total claims ($\sum_{k=1}^{n} C_{ik,t}$). How is a decrease in total claims affecting the dynamics of the weight? After some algebra, the percentage change in weight is simplified to $\frac{C_{ij,t}}{C_{ij,t-1}} \frac{\sum_{k=1}^{n} C_{ik,t-1}}{\sum_{k=1}^{n} C_{ik,t}} - 1$. $\frac{\sum_{k=1}^{n} C_{ik,t-1}}{\sum_{k=1}^{n} C_{ik,t}}$ represents the contribution of the change in total claims, while $\frac{C_{ij,t}}{C_{ij,t-1}}$ reflect the change in the bilateral cross-border links. Considering that, for all countries, total cross-border activity has decreased, $\frac{\sum_{k=1}^{n} C_{ik,t-1}}{\sum_{k=1}^{n} C_{ik,t}}$ will be larger than one and, hence, $\frac{C_{ij,t}}{C_{ij,t-1}} \frac{\sum_{k=1}^{n} C_{ik,t-1}}{\sum_{k=1}^{n} C_{ik,t}} - 1$ will be larger than $\frac{C_{ij,t}}{C_{ij,t-1}} - 1$. Since most changes in weights are negative, this implies a less severe decrease in weights relative to actual bilateral claims. Table 10 confirms that the decline in weights is much less substantial than change in bilateral BIS data and that weights are relatively more stable in comparison to C_{ij}.

C.5: Correlation between banking and sovereign CDS

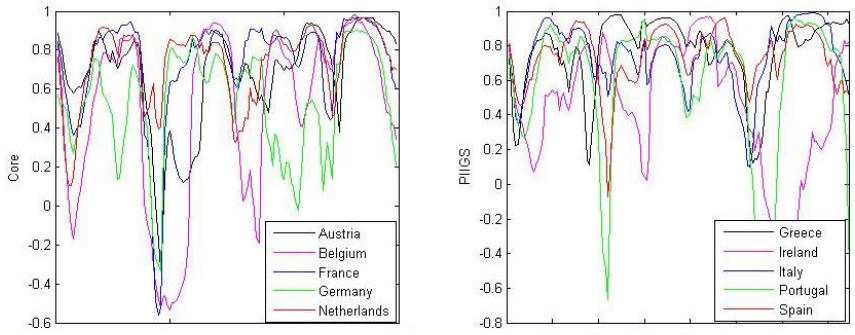

Figure 23: Dynamic correlation coefficients between sovereign and banking CDS spreads. The coefficients are based on a rolling window of CDS series over the past 20 consecutive weeks. The (lagged) correlations shown correspond to March 2009 up to Jan. 2012.

Appendix D: Asset vs. Liabilities for BIS data

Should one use claims on a counterparty or obligations towards a creditor? As we already mentioned, the BIS data covers banking data with respect to foreign entities in *any* sector. Since our data includes banking and sovereign CDS, we are limiting our interest to these two sectors. Considering that interbank lending and sovereign debt purchases account for most of the cross-border flows, other balance sheet positions should represent a limited fraction of BIS data. We simulate a negative shock to bank/sovereign risk in peripheral countries and would like to trace its impact on other countries when balance sheet exposures are taken into account. We describe a simple model that can help understand how to proceed.

Consider a three country (C=core, P=periphery, O=other) two sector model (S=sovereign and B=banking). The model can be easily extended to include more countries and sectors, mimicking more

closely our Eurozone sample. There are two contracts being traded, credit default swap (CDS) for S and for B in each country, denoted by $CDSsector_{country}$. Based on Asset (A) and Liabilities (L) banking exposures and using a VARX*/GVAR setting we would like to calculate the effect of a negative periphery shock ($CDSS_P$ and $CDSB_P$) to $CDSS_C$ and $CDSB_C$. On the A side, a component of the weight matrix w_{PC} represents the proportion of total claims of P banks that are held by residents in C. On the L side, w_{PC} is the amount of total debt of P banks that is due to all sectors in C. Weights for a country sum up to 1, i.e. $w_{CP} + w_{CO} = 1$. The connection created in between the balance sheets of the two countries of interest can be expressed using the following 4 examples, with the appropriate weighting scheme in parenthesis.

[1.]B_P owes money to C, B_C+S_C (L: w_{PC}). B_C owes money to P, B_P+S_P (L: w_{CP}). B_P lends money to C, B_C+S_C (A: w_{PC}). B_C lends money to P, B_C+S_C (A: w_{CP}).

We can see that the situations where C can be negatively influenced are those where significant claims on P could potentially not be recovered. These are represented by cases 1 and 4. Disregarding the time subscript and any deterministic terms we have the following VARX* for banking and sovereign CDS:

$$\begin{aligned} CDSB_C &= \alpha_1 CDSS_C + \alpha_2 CDSB_C^* + \alpha_3 CDSS_C^* + u_{C1} = \alpha_1 CDSS_C + \alpha_4 w_{CP} CDSB_P \\ &\quad + \alpha_5 w_{CO} CDSB_O + \alpha_6 w_{CP} CDSS_P + \alpha_7 w_{CO} CDSS_P + u_{C1} \end{aligned} \tag{7}$$

$$\begin{aligned} CDSS_C &= \beta_1 CDSB_C + \beta_2 CDSB_C^* + \beta_3 CDSS_C^* + u_{C2} = \beta_1 CDSS_C + \beta_4 w_{CP} CDSB_P \\ &\quad + \beta_5 w_{CO} CDSB_O + \beta_6 w_{CP} CDSS_P + \beta_7 w_{CO} CDSS_P + u_{C2} \end{aligned} \tag{8}$$

We notice that foreign CDS enter the dynamics of $CDSS_C$ and $CDSB_B$ through the elements $w_{CP}CDSB_P$ and $w_{CP}CDSS_P$. A significant impact of periphery through balance sheet weaknesses is consistent with an **asset** side wight matrix, as exemplified by case 4.

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