The Financial Connectedness between Eurozone Core and Periphery: A Disaggregated View

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Abstract

This paper examines the financial stress interconnectedness among GIIPS economies and Germany. Based on market level financial stress indices, it examines the stress transmission process as well as the causal network relationships in banking sector, bond, money and stock markets. The period under investigation, 2001-2013, allows to test the effects of financial crisis of 2008 as well as the subsequent European sovereign crisis. Using two alternative techniques for connectedness analysis, our evidence suggests that the peripheral economies of Italy and Spain play a highly significant role in the stress transmission in all markets, especially in the cases of banks and equity markets. Moreover, we visualize our results using network analysis. Contrary to common wisdom, Portugal, Ireland, and mainly Greece, do not seem to have an important role in amplifying stress levels.

Keywords: Eurozone, stress transmission, connectedness analysis, spillovers, networks

JEL Codes: C43, G15, F30

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1. Introduction

The recent Global Financial Crisis (GFC) and its multifaceted nature have seriously affected the global economy. As a rare event, sparsely happening to advanced economies, has taken by surprise the governments of the hardly hit economies. This was reflected on their delayed response, which in many cases did not prove adequate to tame the effects of the financial crisis. A crisis that started from a relatively minor US financial market soon became a major threat for the global financial stability. This tidal effect has seriously affected European markets, causing troubles to European banks and sovereigns. Interestingly, due to the heightening uncertainty, the European crisis emerged as an issue of excessive sovereign risk for the most debt-ridden countries.

On top of that, the GFC seriously influenced the real economy. Most countries went through a prolonged recessionary period. A number of them are still under severe macroeconomic strains, directly affecting their recovery prospects and causing social unrest. The lack of sustainable financial systems, along with the inability of banking markets to properly function and supply necessary credit for a fast recovery, sets the stage for rather gloomy conditions for the economies in trouble. Within this framework, it is reasonable to expect that recent research focuses on the identification of the potential contagion and interdependency channels among different economies. Especially for the case of Eurozone, it is even more interesting, given the importance of these economies on a global scale, the highly interconnected markets, the level of integration of these economies and the transformative nature of the financial meltdown in this region.

Aspired by the aforementioned events, we aim to identify empirically the potential risk transmission channels among the Euro Area economies. In order to achieve this task, we analyze the interactions among the peripheral and core countries' financial markets. This disaggregated, time-varying analysis, covering a wide number of markets (namely, four markets for each economy under consideration: banking sector, money market, equity and bond markets), is materialized on two levels: both within each group of financial markets, as well as on cross market level. In this way, further insights to the root causes of the Euro Area crisis are provided. Our study adds to the ongoing debate on which markets or countries contributed the most to the crisis exacerbation.

Spillover analysis is commonly used to identify and evaluate the effects of both monetary and fiscal policies (Caporale and Girardi, 2013; Chen *et al*., 2016). In this study, we focus on Euro Area financial markets. Considerable effort has been made in order to examine the interconnections and the volatility transmission effects for the US and Eurozone crisis. This literature is part of the research aiming to identify whether contagion and spillover effects truly exist among international financial markets (Ehrmann *et al*., 2011; Jung and Maderitsch, 2014; Dungey and Garujel, 2015; Dungey and Renault, 2017). For instance, Apostolakis and Papadopoulos (2014, 2015), analyse the G7 economies markets and identify some effects between banking, securities and foreign exchange markets. Chau and Deesomsak (2014) examine the US crisis underlining the negative effects of debt and equity markets. Eichengreen *et al*. (2012) provide evidence that global banking system risks commove and this intensifies during periods of heightening financial turmoil. Studying the sovereign risk transmission between US, US states and Eurozone economies, Ang and Longstaff (2013) manage to exhibit much stronger systemic risk effects among Eurozone countries, compared to the US case. Most of the studies for Eurozone are confined to sovereign risk or banking distress transmission (Fernández-Rodríguez *et al*., 2014; Gorea and Radev, 2014; Metiu, 2012), while others focus on the Greek case and its potential effects to the rest of the EMU countries (De Santis, 2014). VAR modelling is employed by some authors to analyze sovereign CDS for a number of European countries (Bruttin and Saure, 2015; Kohonen, 2014). Antonakakis and Vergos (2013) employ a similar to our method to show that each country's bond yields are mostly explained by their own forecast error variance. Claeys and Vasicek (2014) indicate that contagion is only evident during particular time periods for sovereign risk spillovers during the Euro Area crisis, something concurred by the work of Alter and Beyer (2014). Moreover, Minoiu *et al.*, 2015) show that connectedness can be used as a tool for predicting financial crises. Event study analysis has also been applied to assess the news effects for Greek sovereign debt on European banks (Mink and de Haan, 2013), or the euro crisis effects on non-financial firms around the world (Claessens *et al.*, 2015).

The present study adds to this literature. Its contribution can be summarized as follows. First, in contrast to most of the prior literature, we employ innovative, custom-made Financial Stress Indices (FSIs), representing a unique dataset able to capture the fluctuations of the markets financial stress level. These indices are aggregate indicators, the composition of which represents the most important characteristics of the financial markets under consideration. Such a metric is also useful as an indicator of forthcoming excessive market distress conditions. Second, our dataset covers a wide number of markets and Eurozone countries, offering the opportunity for more detailed exploration of the stress transmission channels. This disaggregated analysis is an important further step to identify the exact spillover effects within the common currency area and assess the relevant policy implications. Third, we employ two supplementary methodologies in order to analyze financial connectedness. Specifically, we use the Diebold-Yilmaz (2014, 2015) connectedness analysis as well as an innovative causality modelling approach introduced by Billio *et al.* (2012). Both frameworks are able to identify and accurately measure the degree of interconnectedness and the stress transmission effects among the examined economies and markets. To the best of our knowledge, this is the first time this framework is used for the Eurozone crisis co-movement and spillover effects analysis. Finally, we use network graph analysis to offer a visual representation of the interconnection channels among the European financial markets. In this way, the complex nature of the directional stress transmission effects can be properly understood and assessed. We also conduct a sub-sample analysis, in order to provide a detailed exposition of the evolution of interdependencies in the Eurozone financial markets and the ensuing financial stress effects.

The rest of the paper is organized as follows. In section 2, the FSIs construction method and the baseline econometric model are discussed. Section 3 presents the average and dynamic spillover analysis, based on the dynamic VAR-based framework. Section 4 applies several robustness checks. Section 5 presents further evidence based on the second methodological tool employed here, while Section 6 concludes.

2. Modelling Strategy

2.1 Measuring Financial Stress

The dataset of this study is based on financial stress indexes for Germany, as a proxy of Euro Area core and a set of Eurozone peripheral economies (namely Greece, Ireland, Italy, Portugal and Spain (GIIPS). In order to examine several financial markets, we construct four financial distress indices for each one of the aforementioned economies. These indexes are indicators of the financial conditions in four main financial markets: banking, bond, money and equity. The inclusion of several individual financial indicators in a composite index is the main advantage of these stress indexes. In this way, we manage to capture important market features that would otherwise be neglected. The relevant literature (e.g. Cardarelli *et al.*, 2011) has underlined the usefulness of FSIs as indicators for assessing financial stability and the degree of markets' financial distress.

The following table (Table 1) outlines the components of the market FSIs. Our choice relies on prior literature, the data availability on weekly basis, as well as the achievement of comparability for all sample economies. Data cover the period from 2001.1 to 2013.9, so that both pre- and post-crisis period are included. Weekly data are preferable, in order to avoid any mismatching issues, due to public holidays or different trading days (Yiu *et al.*, 2010).

Table 1 here

Based on the above assumptions, we end up with 21 variables in total. Seven indicators concern banking market, five for money and equity markets and four for the bond market. This set of metrics aims to provide full coverage of different types of financial risks. Turning to the banks case, the stand-alone indicators represent risks associated with their activities, as well as measures of profitability, market value and operational efficiency. In more details, volatility risk is captured by the bank equities realized volatility, the bank stocks' beta and the (negatively singed) equities returns. Profitability is also important indicator for banks' health and price-to-earnings ratio is used to exhibit this characteristic. Turnover volume indicates the investor's sentiment and uncertainty towards the developing market conditions. The level of default risk for banks is provided by the dividend yield and their market value.

Credit and counterparty risk, together with interbank liquidity conditions are represented to the money market index. TED spread (the spread between the 3-month Euribor from respective Treasury bills) is expected to increase in periods of worsening financial conditions. Moreover, changing liquidity conditions are evaluated based on the spreads of the main refinancing rate from the short term (2-year and 3-year) governmental bond yields. We use negative signs for these spreads, as their negative values exhibit higher financial stress. The realized volatility of treasury bill of the countries under investigation is indicator of volatility risk as the one mentioned in the banking sector. Finally, the inverted term spread is a metric of market perceived default risk and financial strains.

For the case of equity markets, we employ (negatively signed) stock returns, which are indicator of market uncertainty. Higher price variation coincides with heightening financial stress. Listed firms default risk and a measure of credibility are the Market value and dividend yields, as in the case of banking markets. P/E ratio is representative of firms' financial sustainability. Additionally, the equities realized volatility indicates the degree of historical risk perception for each stock market.

Metrics of the sovereign and the private sector default risks are the components of the bond sub-index. Specifically, sovereign spread is the spread between each country's 10-year government bond yields from the German bond, which is a safe haven investment proxy. The perceived level of volatility risk in this market is measured by the realized volatility, while government bond duration is an indicator of increasing financial stress and uncertainty. As Lee *et al.* (2011) show, bond duration decreases, especially for bonds with lower ratings. Hence, countries with low credit ratings and worsening macroeconomic fundamentals might exhibit decreasing bond duration.

The aggregate stress indices are calculated based on an equal-variance approach. According to this method, all individual indicators contribute equally to the final stress index. Before the aggregation, each one of the metrics is standardized by deducting each series mean and divide with the standard deviation. This is a necessary process, in order to avoid mis-measurement issues and potential problems with differences in units of measurement. This is the most popular aggregation method in the stress indexes literature. The reason is its simplicity in the calculation and the production of accurate FSIs. That is, the variance-equal stress indexes successfully represent the prevailing market conditions. This is also evident by the following diagrams, where the historical performance of the financial distress is depicted for our sample's economies.

Figures 1A-1D here

In order to further enhance the value and reliability of our baseline model findings, we decided to construct our FSIs, using and additional weighting scheme. In particular, we employ a principal component analysis (PCA) approach. PCA analysis is a multivariate statistical method aiming to reconstruct large datasets, by obtaining linear combinations of the variables in our dataset. This method decomposes series variability, ascending them in accordance to the dataset correlations. The series covariance matrix is decomposed, according to its eigenvalues, to the principal components that are orthogonal to each other. Based to this decomposition, each linear combination of the original variables (i.e. the principal components) is independent from the rest. They also provide a unique loading (weight) for each one of the original variables to the new dataset combinations. We employ the first principal component loadings as weight for each variable, since the first eigenvector interpret most of the initial series co-movement.

2.2 Methodology

We use the spillover analysis originally developed by Diebold and Yilmaz (2012, 2014, 2015). The analysis is based on VAR modelling and the resulting estimation of variance decompositions. Specifically, this approach provides information about the contributions of variables' shocks to the forecast error variances of all the variables of the model. This model is briefly written as *N*-variable VAR:

$$Y_t = \sum_{k=1}^{K} \Phi Y_{t-k} + e_t \qquad (1)$$

where $Y_t = (Y_{1t}, Y_{2t}, ..., Y_{Nt})$ is the vector of the N endogenous variables and e_t is the vector of disturbances that are independently distributed over time. A useful alternative specification that is based on (1) is the moving average representation that is equal to

$$Y_t = \sum_{j=0}^{\infty} A_j e_{t-j} \qquad (2)$$

where $A_j = \Phi_1 A_{j-1} + \Phi_2 A_{j-2} + ... + \Phi_p A_{j-p}$. In this paper, we follow the work of Diebold and Yilmaz (2012; 2015) in which they use the generalized VAR modelling approach based on the previous work of Koop *et al*. (1996) and Pesaran and Shin (1998). Under this framework, the variance decompositions are invariant to the variable ordering. Specifically, the *ij* entry of the *H*-step-ahead variance decomposition is equal to

$$z_{ij}(H) = \frac{\sigma_{jj}^{-1}\sum_{h=0}^{H-1}(e_i^{'}A_h e_j)^2}{\sum_{h=0}^{H-1}(e_i^{'}A_h \Sigma A_h^{'} e_i)} \tag{3}$$

where σ_{jj} is the standard deviation of *e* for the j^{th} equation, Σ is the variance matrix of *e*. The drawback of the generalized VAR modelling is that the own and cross-variable variance contributions shares do not equal to one. This is circumvented by using the normalization;

$$\tilde{z}_{ij}(H) = \frac{z_{ij}(H)}{\sum_{j=1}^{N} z_{ij}(H)} \tag{4}$$

where $\sum_{j=1}^{N}\tilde{z}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N}\tilde{z}_{ij}(H) = N$.

Given the above the total spillover index is equal to

$$SI = \frac{\sum_{i,j=1,i\neq j}^{N} \tilde{z}_{ij}(H)}{\sum_{i,j=1}^{N}\tilde{z}_{ij}(H)}\cdot 100 \tag{5}$$

The number of this index shows the average contribution of spillovers from shocks to all variables to the total forecast error variance. Alternatively, the spillover index gives the degree of the connectedness of the *N*-variables system. The main advantage of this analysis is that the directional spillovers can be easily calculated. More precisely, the directional spillovers received by variable *i* from all the other variables are defined as

$$DSI_{i\leftarrow j} = \frac{\sum_{j=1,i\neq j}^{N} \tilde{z}_{ij}(H)}{\sum_{i,j=1}^{N}\tilde{z}_{ij}(H)}\cdot 100 \tag{6}$$

Also, the directional spillover transmitted by the variable i to all the other variables are defined as

$$DSI_{i\to j} = \frac{\sum_{j=1, i\neq j}^{N} \tilde{z}_{ji}(H)}{\sum_{i,j=1}^{N} \tilde{z}_{ij}(H)} \cdot 100 \tag{7}$$

The merit of this analysis is shown by the fact that its basic results can be summarized in one single table. Such a summary-table is demonstrated in Table 1. The main panel of the table contains the contribution of shock in variable j (shown in column j) to the forecast error variance of variable i (shown in row i). In this way, the last column shows the total effects (spillovers) received by i (variable shown in row i) from all the rest. Correspondingly, the bottom row shows the contribution of each variable shown in column j to the rest variables. Finally, the total spillover index (*SI*), which is the average measure of connectedness, appears in as the bottom right number of the table.

Another interesting feature of this method is the computation of net spillovers. These indicators are useful as they show whether a variable is net shock receiver or transmitter. They are defined as the difference between the total spillovers from i to j and the total spillovers from j to i; that is,

$$NSI_i = DSI_{i\to j} - DSI_{i\leftarrow j} \tag{8}$$

In this paper we mainly focus on total and net spillovers. Interestingly, we do not restrict ourselves to the above-mentioned measures. Their main feature is that they are static. This means that they are calculated for the whole period under study. However, the period that we examine in this study contains certain sub-periods of special interest. Therefore, static analysis may omit several aspects of stress transmission. For this reason, we calculate the dynamic version of spillover analysis using rolling estimation with a 200-weeks window[1].

3. Results

3.1 Static Spillover Analysis

The average spillover effects among Euro Area markets are presented in Table 2. Results are illustrative of the particular significance of each economy's market to the stress transmission to the rest. For instance, Italy's and Spain's effects are pronounced in all markets. Their values in the last row of each table are the highest suggesting that they are the major risk transmitters. To start with, the case of the banking sector is indicative of this evidence. More precisely, we see that the highest stress transmission to others stems from Italian and Spanish banking sectors. Specifically, a stress shock in Italian (Spanish) banks is responsible for 76% (67%) of the forecast error variance of the distress level to other bank markets. German and Portuguese banking stress have also significantly high contribution with values of 51% and 48%, respectively.

On the other hand, Greek contribution is the least important. This evidence is in accordance with Mink and de Haan (2013), indicating the limited exposure of European banks to Greece. The average spillover index is 50%, showing a high degree of interdependence in this sector. The opposite is true for bond market; the total degree of interconnectedness is equal to 13.8%. Furthermore, the contribution of each specific market is much lower. However, still the highest values come from Italy and Spain. Specifically, both Italian and Spanish bonds contribute 29% to the variance of other bonds included in the analysis. Regarding the core economy, German bond stress only explains 12% of the overall risk transmission. It is interesting to underline the negligible effect of the debt-ridden countries (Greece, Ireland and Portugal). In contrast to common wisdom, they do not either transmit to or receive from the rest of

[1] We also use 300 and 400-weeks as window. The results remain the same.

the peripheral economies or Germany. Interestingly, Italian and Spanish bond markets demonstrate strong bidirectional effects.

Table 2 here

In accordance to our last finding for the bond market, the money markets from/to Italy and Spain show the highest directional spillovers. This is clear evidence of the interdependence between the two largest peripheral economies, as well as their exposure to common liquidity problems. Another important outcome is the moderate, though relatively important, stress transmission between the aforementioned economies and Germany. This reflects the importance of these three economies within Euro Area and their high degree of interconnectedness. As it is evident from the dynamic analysis that follows, "flight to quality" phenomenon occurs within the examined period.

The most interdependent marketplace is the stock market, with an average spillover index of 67.5%. A stress shock in Italian equity market contributes as high as 83% to the forecast variance error of the remaining five variables. A similar behavior is identified for the Spanish case, with the corresponding percentage being equal to 82%. Contrary to the previous sectors, a stress shock in Eurozone core has a high, though less than the Italian and Spanish, contribution (74%). As in the previously examined markets, the Greek, Irish and Portuguese contribution is significantly less important. Overall, it is fair to argue that the equity markets seem to be more interconnected, given the faster information flow and absorption from investors' sentiment. This sentiment reflects on stock prices and their swift adjustment to changing market conditions.

An alternative depiction of the above results is the usage of network graphs. Based on the work of Demirer *et al*. (2017) and Diebold *et al*. (2017), we visualize the connectedness found by the spillover analysis. Figures 2-5 show relationships as an interrelated network based on Table 2. Each node indicates each unit under examination (banking FSIs in graph A, bond FSIs in graph B, money FSIs in graph C and stock FSIs in graph D). The edge thickness (and color) indicates the average pairwise directional spillovers. This means that a thicker (blue or darker grey in greyscale) edge shows a higher spillover. On the other hand, a thinner (red or lighter grey in greyscale) edge shows a lower spillover. In a similar fashion, the arrow size indicates the pairwise directional connectedness "to" and "from". Each node location is determined by using the ForceAtlas2 algorithm of Jacomy *et al*. (2014) in Gephi. This algorithm finds a steady state, where repelling and attracting forces balance each other. Each node is attracted by others according to average pairwise directional connectedness "to" and "from". The network graphs show with a quite straightforward way the significant role of Italian, Spanish and German indexes in all the markets. At the same time, the reader can easily identify the less significant roles of the remaining countries, as their corresponding nodes are more isolated and linked with darker color edges.

Figure 2 here

Figure 3 here

Figure 4 here

Figure 5 here

3.2 Dynamic Spillover Analysis

The above findings are the first part of spillover analysis. Although they provide us with useful insights, the main drawback of the analysis is that the percentages remain the same throughout the examined period. In other words, the spillover tables give an average picture without being able to grasp the potential changes. In order to have a dynamic analysis, we repeat the same analysis using rolling estimates for a 200-week window. Figure 6 shows the dynamic total spillover indexes for each individual market[2]. Several interesting outcomes are found. Firstly, both bank and stock markets exhibit a substantial increase during mid-2008, reaching a maximum of roughly 64% and 74%, respectively. This means that the total variance of the forecast errors for these two markets is explained by the markets' own shocks. Until the end of the sample, both markets' spillovers remain elevated, with a slight decrease during mid-2012 and 2013. Bond market interconnectedness follows an increasing trend, even though it deescalates at the end of the sample. We observe three major peaks; in the beginning of 2006, second half of 2008 and in 2011. The last two upswings coincide with two major events of financial meltdown: the Lehman Brothers collapse and the Euro Area sovereign crisis outbreak. On contrary, money market is the least volatile, following a constantly declining trend. Through time, the shocks in this market are gradually explained by other factors than those represented by the money and interbank funding markets.

Figure 6 here

Turning now to the market level analysis, we begin by examining the dynamic net spillover effects in the banking sectors of the economies under consideration (Figure 7). A major difference on markets' behavior is identified between the period before and after the GFC. In effect, the variation for all banking sectors remained relatively stable, up until the third quarter of 2008. Then, for most cases, a significant increase on the value of spillover indexes is observed. The most pronounced case is the Irish one, where the index climbed on an unprecedented level. This is evident of the degree of exposure Irish banking system had on the US crisis contamination. Moreover, similar behavior is evident for economies with seriously troubled banks, especially Italy, Portugal and Spain. In fact, these countries form a group that exhibits

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[2] These indexes are the dynamic version of the average total spillover number in the bottom right of each panel of Table 2).

substantial hike to their net spillovers and remain in such a level until the end of the sample period.

On the other hand, Ireland's index swiftly plummeted, indicating the efforts exercised to improve banks' health there. The Greek and German cases behave differently from the rest of the banking system examined here. Their indexes have only started to increase towards the end of the period, even though they still follow the financial events. For instance, the Greek banking system is highly volatile in 2011, a period of heightening uncertainty, due to the evolving sovereign crisis and the devastating effects of the PSI program applied by the economic authorities[3]. Germany's case is justified, since it is the main receiver of financial stress transmission from the more troubled economies in Europe.

Figure 7 here

Regarding the bond markets (Figure 8), Italian and Spanish connectedness remains positive for most of the sample period. Especially since the beginning of the GFC, both of these economies are the main shock transmitters in the bond market. Similar pattern is observed for Ireland, up until the second quarter of 2010. Since then, there is a significant decline, coinciding with the bail-out program agreed with the EU authorities. As expected, Germany constantly remains a net receiver, as indicated by the negative values of its net interconnectedness index. On the same vein, Greece and Portugal exhibit a similar behavior to the German case. Nevertheless, when the Eurozone crisis emerged, they both turned into net stress transmitters. Overall, countries that participated to official financial support programs (Greece, Portugal and Ireland) tend to have a net positive contribution to the remaining economies.

Figure 8 here

In the case of money market (Figure 9), it is interesting to note the dominant role of Germany and Spain, as major stress transmitters. Even though, particularly for

[3] PSI (Private Sector Involvement) programme refers to the Greek government's debt restructuring taken place in early 2012.

the case of Germany, the contribution to this markets' instability sharply decreases since 2010, we can identify a gradually increasing positive effect towards the end of the sample period. All economies examined were susceptible to the credit crunch effect, stemmed from the US crisis peak in 2008. As in the case of bond markets, Greece and Portugal turned into transmitters since the onset of the sovereign crisis in Europe. Italy's behavior is also ambiguous, as its index switches from positive values into negative and, then, again to positive ones.

Figure 9 here

For the case of equity markets (Figure 10), Germany, Italy and Spain are the major shock transmitters throughout the whole period. This indicates the significance of these markets, as it is evident from their market value and contribution to the market risk transmission. At the same time, Greece and Portugal remain net receivers, indicating their limited influence to the Euro Area stock markets. Nevertheless, at the peak of the GFC in 2008, all markets exhibit a significant increase to their stress transmission. Furthermore, in post-2007 period, noticeable changes take place. Firstly, Spain and Italy, along with Portugal, constitute the new group of shock transmitters, underscoring the significance of European periphery to the Euro crisis. Secondly, the role of German shock is almost eliminated as the net spillover index oscillates around zero. Ireland and mainly Greece remain the net receivers for all the post-crisis period. This is an indication of their greater exposure to external market shocks. Overall, apart from a small jump of the stress spillover indices around the time of Eurozone sovereign crisis outbreak, the indexes behavior remains unaltered.

Figure 10 here

4. Robustness

For the baseline analysis, we employed a set of financial stress indexes computed using the variance-equal approach. With the aim of testing the robustness of our results, we re-estimate our Diebold-Yilmaz spillover model, using an alternatively constructed group of stress indices. As explained in section 2, these indicators are composed using weights produced from a principal components analysis. For the shake of brevity, we only present the average connectedness matrix in Table 3[4].

Overall, results remain qualitatively the same. For the case of bonds, money and stock markets, the estimated spillovers are very similar. The only exception is bank market, where the connectedness is only 16%. However, inference is in accordance with our main results, since the main stress transmitters are still Italy and Spain.

Table 3 here

So far, the analysis is restricted to the case of Euro Area interconnectedness. In other words, the examined system consists of stress transmissions coming from European markets exclusively. To test potential effects from the Global Financial Crisis, we incorporate a proxy for the global financial conditions. It is reasonable to examine this effect, as the GFC was initiated from US. It is also assumed in the literature (Arghyrou and Kontonikas, 2012) that US financial conditions represent investors' sentiment towards global risk pricing. For this purpose, we add the St. Louis FED FSI in our model. Among the different FSIs constructed by US Federal Reserve Banks (Kliesen *et al.*, 2012), we choose the St. Louis index, as it resembles ours in several ways. It consists of 18 weekly data series, covering different types of markets and financial instruments (Kliesen and Smith, 2010). These series represent several types of risks, such as default, liquidity and sovereign risk, as well as interbank funding conditions, matching the characteristics of our dataset. In brief, the US

[4] The dynamic spillover results are provided in an online appendix.

markets do not have any significant effect to the Euro Area case. In all examined cases, the structure of interactions and their major sources remain the same. US has a very marginal contribution to the German and Italian banks and money markets variation. This is evident that Euro Area markets are more exposed to financial risk and shifts in fundamentals coming from the rest of the Eurozone markets. It is also an indication of the significant degree of integration that took place within this monetary union in recent years.

Table 4 here

5. Further Evidence: Cross-market connectedness

Having completed the market level analysis, we embark on the presentation and discussion of the cross-market stress spillover effects. The focus here is on the potential interconnections that can be identified among the different markets and countries discussed individually before. In this way, a more accurate and detailed exhibition of the disaggregated stress spillovers is provided, something conducted for the first time on the empirical research of financial stress transmission in the Euro area. Table 3 depicts the whole range of possible interdependences across Eurozone financial markets. Overall, the cross-market interconnectedness is 58%, with significant variation depending on the markets. In more details, the equity markets, as well as the banking systems, are proved to be the sectors with the strongest bidirectional effects to each other. In accordance to the previous section, stock and banking sectors are the main stress transmitters to the rest of the markets. For the equity markets case, the average transmission to others is about 102%, while the corresponding percentage for bank markets is 66%. In contrast, sovereign risk transmission is not that evident for all cases under investigation.

In particular, for the case of the banking sector, we can identify that Italian and Spanish banks are the major sources of instability for the Euro Area financial markets. Additionally, they transmit increasing stress to their own equity markets, while their effect on the German banks is noticeable. Germany is also influenced by the equity market conditions in Italy and Spain. In total, Greek, Portuguese and Irish banking systems are highly integrated and exposed to their own stress shocks. On the other hand, German markets are not influenced from financial stress variations in the three aforementioned economies. Overall, it is evident that a certain degree of segregation, in terms of the share of forecast error variance explained due to shocks elsewhere, appears in Eurozone markets. The core economy is more interconnected with the largest peripheral economies of Italy and Spain. A distinctive group of market interactions, within the smaller peripheral countries (Greece, Ireland, Portugal) is formulated. This can be conceived as a call for policy makers to pay particular attention to these economies' special characteristics.

Table 5 here

The case of bond markets is rather distinctive, in the sense that no conclusive evidence of its importance to stress transmission is identified. In fact, it is the market with the lowest degree of interconnectedness among the examined markets. It is interesting to underscore the Greek case. There is limited evidence that the transmission from the Greek bond market affects all the remaining Eurozone sectors; quite the contrary, it is a net stress receiver. At the same time, the Greek banking system is mainly exposed to Greek bond stress level. The outcome of the Greek sovereign risk and Greek banks' connection reflects the negative effects from the PSI program and the resulting recapitalization needs of these financial institutions. In terms of bond stress transmission, we observe that Italy and Ireland are the main shock transmitters. Spanish case is also important, while regional shock effects are present in the interrelation of the Italian and Spanish bond stress. Regarding the Irish bonds spillover effect, they are present towards the money markets of the same country and Portugal. Overall, the Irish markets are mainly influenced from domestic shocks (i.e. shocks stemming from the examined Irish markets).

Similar conditions prevail to the last two markets under scrutiny. Money market stress transmission is acute, for the case of Spain, Italy and Portugal. These effects are reflected in the same peripheral economies. For instance, the Spanish and Portuguese funding conditions (level of money market stress) have a direct influence to the Italian case and vice versa. Additionally, there is some evidence of strong ties between the German, Italian and Spanish money markets. For the rest of the countries of our sample, the conditions are rather tranquil. Finally, the case of equity markets is the one exhibiting the strongest spillover effects. In accordance to the results from the within-market level analysis, this sector demonstrates significant multidirectional effects among the stock markets. Again, the Spanish, along with the Italian and the Portuguese markets, are those with the most intensive stress transmission to the rest. Interestingly, they also have an effect to the German banking sector. On top of that, the interrelation of these three equity markets with the Italian and Spanish banks is also identified.

The above analysis is visualized in the cross-market network in Figure 11. Despite the large number of examined units (nodes), the main findings described above are quite evident. The banking and the stock market nodes are quite interconnected as it is evident from the lower bottom nexus group. Also, one can identify the closed interlinks between Italian and Spanish nodes and the limited role played by the Greek ones.

Figure 11 here

Additional to the cross market static results, we also provide their corresponding dynamic version. Due to the great number of markets, we only present the total dynamic spillover index[5]. The dotted line in Figure 12 shows that the value of total spillover index remains high for the whole period with a jump taking place in the beginning of the financial turmoil in late 2008. As an alternative way to test the robustness of our results we use an alternative measure of connectedness; that is, the causality index developed by Bilio *et al*. (2012). Contrary to the Diebold-Yilmaz methodology, it is based on pairwise Granger causality tests. The causality index is the ratio of pairwise combinations for which a Granger-causality exists to the total number of pairwise combinations. A high percentage means that the system under examination is highly interconnected. In other words, the value of causality can be interpreted as a measure of spillover effects among the examined markets. The main advantage is that there is no need for any assumption regarding VAR modelling that, subsequently, affects the variance-covariance matrix. On the other hand, the drawback of this measure is its pairwise nature that neglects cross sectional effects. Overall, we consider this measure as a complement to the Diebold-Yilmaz spillover index. In a similar vein with the analysis performed in the previous section, we calculate both the static and the dynamic causality index.

Figure 12 here

In our case of 24 markets, we examine all the $n!/(n-2)! = 552$ pairwise combinations and we find that the causality index is 17.2%. The dynamic causality index (dci) presents excessive variation (solid line of Figure 12). From 2004 until mid-2007 the dci is around 17%. After that there is a small increase and the dci reaches 20%. Interestingly, the index reaches its maximum of 28% during the last months of 2008. For the remaining period until 2013, dci follows a declining trend, oscillating around 20%, without reverting to its lower pre-crisis level. Despite the differences in these two measures, the conclusion remains the same; the examined markets remain

[5] All the gross and net indexes are available upon request.

interconnected in a certain extent, irrespective of what measure we use. Moreover, the variations of this interconnectedness follow similar patterns for both proxies. After the peak of late 2008, both indices follow a slow de-escalating trend. Until the end 2013, they do not seem to have reached the pre-crisis levels.

In order to shed more light on the complex nature of market linkages, we employ Granger-causality network plots. Each plot illustrates the whole amount of Granger causal relations in a specific point of time. This is a visualization of connectedness of Euro area financial markets. Each statistically significant Granger causal relation is depicted with a line connecting the two markets (nodes). Since the dci calculation is based on 200-week rolling window, we result with more than 460 observations of this index. Due to this large amount, we present a network graph for only two points in time. Figure 13 is drawn for the pre-crisis period, while Figure 14 is drawn for the post-crisis period. A first comparison of these two network plots show that the markets are more interdependent in the second period. Specifically, the money, bank and bond markets show a significant increase to their interconnections with markets of both peripheral and core economies. The increasing interconnectedness is rather intensive for the bond markets in Italy and Spain. A similar effect is identified for the same countries' banking sectors. The equity markets remain highly interlinked, as they were in the period before the GFC outbreak. In total, these plots clearly show that, through time, the Euro Area markets' integration and susceptibility to financial distress level has increased.

Figure 13 here

Figure 14 here

6. Discussion and Concluding Remarks

This study provides a thorough and detailed examination of the interdependencies and stress transmission channels between the Euro Area core and peripheral economies. This research is carried out using a set of financial stress indices, representing the prevailing financial conditions for a number of different financial markets for the GIIPS and Germany, as a representative of the core Euro Area. Using a battery of modern econometric tools, we provide a detailed overview of the linkages between the European markets and an identification of stress diffusion channels.

The results are in a certain extent challenging of the concerns policy makers expressed back at the time of the Eurozone crisis peak. Overall, the Italian and Spanish markets are the most influential ones, in terms of their risk transmission effect to the rest of the European markets. Especially, for the case of equity market and banking sector, this effect is prominent, exhibiting these countries' importance and sizable effect to the common currency area. The sovereign risk transmission, as represented by the bond market analysis shows no different results. Once again, Spain and Italy are the major variation transmitters, towards both the core and the peripheral countries. It is noteworthy that Greece, along with the rest of the small peripheral markets, do not constitute an influential contributor to the stress transmission. Their role is negligible, making their effects slightly more evident in cases of extreme financial events, such as the initial period of Euro Area crisis. These findings concur to the recent literature (for instance, González-Hermosillo and Johnson, 2014).

On top of the above, further empirical insights are identified. Beyond the importance of banks and equity markets as risk transmitters, we highlight their strong bidirectional effects. Their role is important, as well as their susceptibility to increasing distress effects. Additionally, money market stress spillovers from Spain and Germany are evident, with the Italian and Portuguese case becoming more influential in the period after the GFC outbreak. Notably, the examination of the post-crisis period shows a significantly increasing degree of interconnectedness among the examined Euro Area markets. Especially, for the case of GIIPS countries, it is fair to say that they are mainly affected by their own shocks. This is important, as they seem to react to the changing nature of financial stress transmission as a distinctive region. These results are verified by a series of robustness checks.

Based on our analysis, a couple of useful policy recommendations can be made. Firstly, the spillover analysis of financial stress indexes, as applied here, can be used as a tool for evaluating markets' financial instability. Their value added can be advantageous for both central bankers, as well as markets participants. Moreover, the necessity to monitor financial stance in a wide number of financial markets is imperative, as suggested by the increasing complexity in markets interrelations. This increasingly intensified stress diffusion is a clear call for a multidimensional and internationally coordinated regulatory framework, able to accommodate the adverse effects of financial crashes.

Despite the multifaceted nature of crisis episodes, the key role of banking sector and money market conditions underscore the importance of liquidity, funding availability and the maintenance of sound capital base for financial institutions. It is reasonable to put forth the importance of the full implementation of regulatory capital requirements, as prescribed by Basel Accord and the European supervisory authorities. Macroprudential policies, facilitating the multidirectional nature of adverse financial episodes, should be fully applied, with the aim of enhancing financial stability. In order to do this, it is also necessary to adjust monetary policy, by setting clear targets on financial shocks accommodation. Until now, most monetary authorities still have no such a policy mandate update. Nevertheless, the policies implemented during the recent crisis (namely, emergency liquidity assistance, quantitative easing) aim to overcome liquidity and uncertainty issues and seem to be to the right direction. Finally, another implication of our study is the degree of regionalism of the examined peripheral economies. This brings the discussion of the desirability of "one size fits all" policies to the fore.

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Tables

Table 1: Components of Financial Stress Indices

Variables Used in Financial Stress Indices	
Banking Sector	***Money Market***
Dividend Yield	TED Spread
Market Value	Inverted Term Spread
Turnover by Volume	Treasury Bill Realized Volatility
Price/Earnings ratio	Main Refinancing Rate - 2yr Government Bond Yield
Bank Equities Realized Volatility	Main Refinancing Rate - 5yr Government Bond Yield
Banking Sector Beta	
Bank Equities Returns	
Equity Market	***Bond Market***
Stock Returns	Sovereign Spread
Dividend Yield	Government Bond Realized Volatility
Price/Earnings ratio	Corporate Spread
Stocks Realized Volatility	Government Bond Duration
Market Value	

Table 2: Average Spillovers for Euro Area markets

A-Banking Sector

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	45	4.4	6.1	18.5	9.9	16.1	55
Greece	5	68.3	4.2	9.3	6.3	6.9	32
Ireland	6.1	3.7	53.7	11.8	8.7	16	46
Italy	14.9	5	8.5	39	13.4	19.3	61
Portugal	10.6	5.8	6.9	13.4	54.2	9.1	46
Spain	14.4	2.3	10.8	22.8	9.5	40.1	60
Contribution to others	51	21	36	76	48	67	***50.00%***

B-Bond Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	84.9	0.5	1.2	4.9	1	7.5	15
Greece	0.5	96.2	1	2	0.1	0.3	4
Ireland	1.4	1.2	94.6	0.7	1	1.1	5
Italy	3.9	1.9	1.1	72.1	1	19.9	28
Portugal	1.2	0.5	0.4	0.7	96.8	0.3	3
Spain	5.2	0.5	1.1	20.4	0.5	72.3	28
Contribution to others	12	4	5	29	4	29	***13.80%***

C-Money Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	58.2	4.1	1.6	11	6.3	18.8	42
Greece	5.6	92.1	0.3	0.5	0.4	1	8
Ireland	2.2	0.5	69.8	7	12.5	7.9	30
Italy	10	0.1	6	53.5	9.9	20.6	46
Portugal	6.6	0.1	10.4	11.4	60.5	11	39
Spain	15.5	1	6.7	18.2	8.2	50.3	50
Contribution to others	40	6	25	48	37	59	***35.90%***

D-Equity Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	27.3	8	13.8	19.5	12.8	18.6	73
Greece	11	42.9	9.9	12.5	12	11.7	57
Ireland	14.9	9.3	35.7	14.8	11.4	13.8	64
Italy	17.7	7.8	12.5	27.7	13.5	20.8	72
Portugal	13.9	9.4	10.9	15.8	33.1	16.9	67
Spain	16.7	7.7	11.9	20.7	14.8	28.2	72
Contribution to others	74	42	59	83	65	82	***67.50%***

Note: Total, directional and pairwise spillovers are summarized in each Table. Table A refers to banking sector, Table B refers to bond market, Table C refers to equity market and Table D refers to money market.

Table 3: Average Spillovers for Euro Area markets using PCA-based FSIs

A-Banking Sector

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	84.3	3.2	0.5	0.6	0.1	11.2	16
Greece	2.6	90.1	1.4	1.8	1.6	2.6	10
Ireland	0.6	2.3	88.4	1.1	1.9	5.7	12
Italy	0.4	1.7	1	77.9	2.6	16.3	22
Portugal	0.2	2.1	1.2	2.7	90.4	3.3	10
Spain	4.3	2.8	3.1	15.6	1.5	72.7	27
Contribution to others	8	12	7	22	8	39	***16.00%***

B-Bond Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	95.4	3.1	0.6	0.1	0	0.8	5
Greece	2.4	91.5	0.5	3.1	1.7	0.8	9
Ireland	0.2	0.7	94	1.3	1.4	2.4	6
Italy	0.1	2.1	1	67.8	2.5	26.5	32
Portugal	0	2.9	0.6	3.5	91.6	1.3	8
Spain	0.5	0.9	1.9	26.8	0.8	69.1	31
Contribution to others	3	10	5	35	6	32	***15.10%***

C-Money Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	69.4	2.8	0.7	13.2	1.2	12.7	31
Greece	2.7	82.7	1.7	5.8	3.5	3.6	17
Ireland	1.1	1.7	59.1	12.3	15	10.8	41
Italy	8.2	3.4	10.9	43.1	7.4	27.1	57
Portugal	1.6	3	14.7	10.5	61.7	8.5	38
Spain	8	2	11.4	28.3	6.1	44.3	56
Contribution to others	22	13	39	70	33	63	***40%***

D-Equity Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	Contribution from others
Germany	30.4	8.8	13.3	18.4	12	17.1	70
Greece	12.2	43.3	9.7	11.9	11.3	11.5	57
Ireland	15.8	8.7	39.7	14	9.4	12.4	60
Italy	17.4	8.3	11.5	30.9	12.6	19.4	69
Portugal	13.7	9.5	9.7	15.8	36.2	15.1	64
Spain	16.6	8.1	10.6	20.3	12.6	31.8	68
Contribution to others	76	43	55	80	58	76	***64.60%***

Note: Total, directional and pairwise spillovers are summarized in each Table. Table A refers to banking sector, Table B refers to bond market, Table C refers to equity market and Table D refers to money market.

Table 4: Average Spillovers for Euro Area markets including US FSI

A-Banking Sector

	Germany	Greece	Ireland	Italy	Portugal	Spain	USA	Contribution from others
Germany	44.3	4.3	5.8	17.9	9.6	15.6	2.6	56
Greece	5	68	4.1	9.3	6.3	6.9	0.4	32
Ireland	6.1	3.7	53.8	11.8	8.7	16	0.1	46
Italy	14.6	4.9	8.3	38.7	13.2	18.9	1.5	61
Portugal	10.4	5.7	6.8	13.2	53.7	8.8	1.5	46
Spain	14.3	2.3	10.7	22.7	9.4	40.1	0.4	60
USA	2.7	3.8	0.2	2.8	3.7	0.4	86.4	14
Contribution to others	53	25	36	78	51	67	6	***45%***

B-Bond Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	USA	Contribution from others
Germany	84.4	0.5	1.2	4.4	0.9	7.3	1.3	16
Greece	0.6	95.8	1	2.1	0.1	0.3	0.1	4
Ireland	1.4	1.2	94.6	0.7	0.9	1.1	0.2	5
Italy	3.5	2	1	70.5	0.9	19.4	2.8	29
Portugal	1.1	0.4	0.4	0.7	96.5	0.3	0.7	4
Spain	5	0.5	1.1	20.2	0.5	72.2	0.6	28
USA	0.2	0.2	0.5	3.8	1.3	0.2	93.7	6
Contribution to others	12	5	5	32	5	29	6	***13.20%***

C-Money Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	USA	Contribution from others
Germany	58.4	4.1	1.6	10.8	6.2	18.6	0.3	42
Greece	5.4	91.7	0.3	0.5	0.4	0.9	0.8	8
Ireland	2.2	0.5	69.5	7.2	12.5	8	0.1	30
Italy	9.6	0.1	6	52.2	9.7	20	2.5	48
Portugal	6.4	0.1	10.4	11.5	60.3	10.9	0.3	40
Spain	15.2	1	6.8	18	8.1	50.3	0.6	50
USA	1.2	0.4	0.1	0.9	0.7	0.4	96.3	4
Contribution to others	40	6	25	49	38	59	5	***31.60%***

D-Equity Markets

	Germany	Greece	Ireland	Italy	Portugal	Spain	USA	Contribution from others
Germany	26.8	8	13.6	19.1	12.4	18.1	2	73
Greece	11.2	42.1	9.8	12.7	12.1	11.7	0.5	58
Ireland	14.8	9.2	35.1	14.7	11.2	13.6	1.3	65
Italy	17	7.7	12.2	26.9	13	20.1	3.2	73
Portugal	13.3	9.3	10.7	15.3	32.3	16.3	2.8	68
Spain	16.3	7.7	11.7	20.4	14.5	27.8	1.7	72
USA	5.5	5.8	5.1	8.4	7.3	4.3	63.7	36
Contribution to others	78	48	63	90	71	84	11	***63.60%***

Note: Total, directional and pairwise spillovers are summarized in each Table. Table A refers to banking sector, Table B refers to bond market, Table C refers to equity market and Table D refers to money market.

Table 5: Average Cross-Market Spillovers

	GE_BANK	GR_BANK	IR_BANK	IT_BANK	PO_BANK	SP_BANK	GE_BOND	GR_BOND	IR_BOND	IT_BOND	PO_BOND	SP_BOND	GE_MONEY	GR_MONEY	IR_MONEY	IT_MONEY	PO_MONEY	SP_MONEY	GE_STOCK	GR_STOCK	IR_STOCK	IT_STOCK	PO_STOCK	SP_STOCK	From others
GE_BANK	21.3	2	2.8	8.6	4.5	7.9	0	0.4	0.1	0.1	0.4	0.1	1.6	0.3	0.3	0.2	0.2	0.2	**10.3**	4	6.6	**11.3**	6.3	**10.7**	79
GR_BANK	2.6	35	2.5	5.4	3.7	4.3	0.3	1.7	0.5	0.1	0.1	0	0.9	0.8	0.3	0.1	0.7	0.4	3.9	**18.7**	3.2	4.9	5.3	4.7	65
IR_BANK	3	2.4	29.2	6	4.6	8.3	0.3	0.1	1.2	0.2	0.3	0.7	0.5	0.1	0.5	0.8	0.3	0.5	5.2	5.3	**9.3**	6.8	7	7.6	71
IT_BANK	6.5	2.5	3.6	18	6.4	8.5	0.1	0.4	0.6	0	0.1	0.1	0.6	0.3	0.7	1	0.7	0.9	7.1	5.1	6.2	**12.8**	6.5	**11.2**	**82**
PO_BANK	5.5	3	3.6	7.5	28.1	5	0.3	0.3	1.3	0.2	0.5	0.2	0.9	0.3	0.6	0.7	0.9	0.7	4.5	5.3	3.6	7	**11.7**	8.3	72
SP_BANK	6.9	1.3	5.1	**10.8**	4.6	19.7	0.1	0.2	0.6	0.1	0.1	0.1	0.5	0.1	0.3	0.9	0.3	0.9	7	5.3	5.5	**9.8**	6.7	**13.2**	**80**
GE_BOND	0.4	1.4	0.3	0.3	0.4	0.3	73.9	0.4	1.5	3.8	0.6	6.9	1.1	0.3	0.9	0.6	1	1.8	0.5	1	0.4	0.8	0.8	0.7	26
GR_BOND	1.3	0.7	0.5	2.2	0.2	0.7	0.4	82.3	0.8	1.9	0.1	0.2	0.3	1.8	1.1	0.4	0.5	0.3	0.8	0.3	0.4	1.2	0.8	0.9	18
IR_BOND	0.4	0.7	1.6	0.3	1.8	0.6	1.3	0.7	63.2	0.7	1.3	0.8	0.5	0.6	**11.6**	1.3	7.1	1.8	0.2	0.7	0.2	0.4	0.9	1.1	37
IT_BOND	0.7	0.8	0.8	1.4	0.2	0.6	2.6	1.6	1.2	53.5	0.8	**13.2**	2.1	0.8	0.8	1.4	1.7	1.5	1.5	2.8	2.3	3	2.2	2.4	47
PO_BOND	0.2	0.5	0.2	0.2	1.7	0.4	0.7	0.4	1.1	0.6	84.7	0.3	1	0.4	1	0.1	4.1	0.2	0.3	0.3	0.8	0.1	0.5	0.1	15
SP_BOND	0.3	0.2	0.7	0.8	0.2	0.3	4.7	0.4	1.1	**16.3**	0.5	64.9	0.3	0	0.4	1.3	0.7	2.3	0.6	0.9	1.1	0.7	0.6	0.7	35
GE_MONEY	2	0.5	1.5	1.5	1	1.1	0.6	0.1	0.1	0.8	0.5	0.3	45.8	3	1	8.3	5.2	**14.2**	1.7	0.9	3.3	3.2	1.5	2	54
GR_MONEY	0.3	1.5	0.2	1.4	0.5	0.2	0.1	1.9	0.2	0.2	1.1	0.1	4.7	79.6	0.2	0.3	0.6	0.9	0.3	1.1	1.8	1.4	0.7	0.7	20
IR_MONEY	0.8	0.2	0.7	0.8	0.9	0.5	0.5	0.7	**9.6**	0.7	0.6	0.3	1.5	0.3	54.8	5.3	**10**	6.1	0.4	0.9	0.7	1	1.2	1.6	45
IT_MONEY	1.2	0.5	0.7	2.5	1.7	1.5	0.5	0.3	1.3	0.4	0.1	0.2	7.7	0.1	4.3	42.1	8.1	**16.7**	0.7	1	1.2	2.4	2.4	2.4	58
PO_MONEY	1.2	0.2	0.3	1.6	2	1.3	0.6	0.2	4.4	1.7	1.1	0.5	5	0.1	7.9	8.5	45.6	8.6	1	1.1	1	1.2	3	1.7	54
SP_MONEY	0.8	0.6	0.5	1.2	2	0.9	1.2	0.2	1.9	0.6	0.1	0.5	**12.5**	1	5.4	**15.9**	7.7	41.6	0.3	0.9	0.6	0.7	1.5	1.5	58
GE_STOCK	6.9	1.6	3.2	7.3	2.9	6.5	0.1	0.1	0	0.2	0.2	0.2	0.8	0.1	0.1	0.2	0.1	0.1	19	5.4	**9.6**	**13.6**	8.9	**12.9**	**81**
GR_STOCK	3.3	**12.7**	2.5	6.2	4.7	4.9	0.3	0.2	0.2	0.2	0.2	0.1	0.8	0.4	0.6	0.2	0.3	0.5	6.6	26.1	6	8	7.6	7.4	74
IR_STOCK	3.6	1.7	6.3	6.4	2.8	5.3	0.1	0.1	0.2	0.4	0.3	0.5	1.4	0.4	0.2	0.3	0.1	0.3	**10**	6.1	25.1	**10.6**	8.1	**9.7**	75
IT_STOCK	6.5	1.7	3.2	**10.2**	4.2	6.6	0.1	0.2	0.1	0.1	0.2	0.1	0.9	0.2	0.4	0.8	0.2	0.4	**11.2**	5.1	8.3	17.6	8.5	**13.2**	**82**
PO_STOCK	4.3	2.2	3.6	6.1	8.3	5.3	0.2	0.2	0.3	0.4	0.2	0.2	1.3	0.3	0.4	1.1	1	0.6	8.8	6.2	7.3	**10.2**	20.8	**10.8**	79
SP_STOCK	5.9	1.6	3.5	8.8	5	8.8	0.1	0.2	0.3	0.1	0.1	0	0.9	0.2	0.5	0.8	0.2	0.6	**10.4**	4.9	7.8	**12.8**	**9.1**	17.6	**82**
to others	**65**	**40**	**48**	**97**	**64**	**80**	15	11	29	30	10	26	48	12	40	51	51	60	**93**	**83**	**87**	**124**	**101**	**126**	***57.90%***

Note: Total, directional and pairwise spillovers are summarized in this Table. The most important effects are highlighted in bold. GE stands for Germany, GR stands for Greece, IR stands for Ireland, IT stands for Italy, PO stands for Portugal, SP stands for Spain. BANK refers to banking sector, BOND refers to bond market, MONEY refers to money market and STOCK refers to equity market.

Figure 1A: Banking Sector FSIs

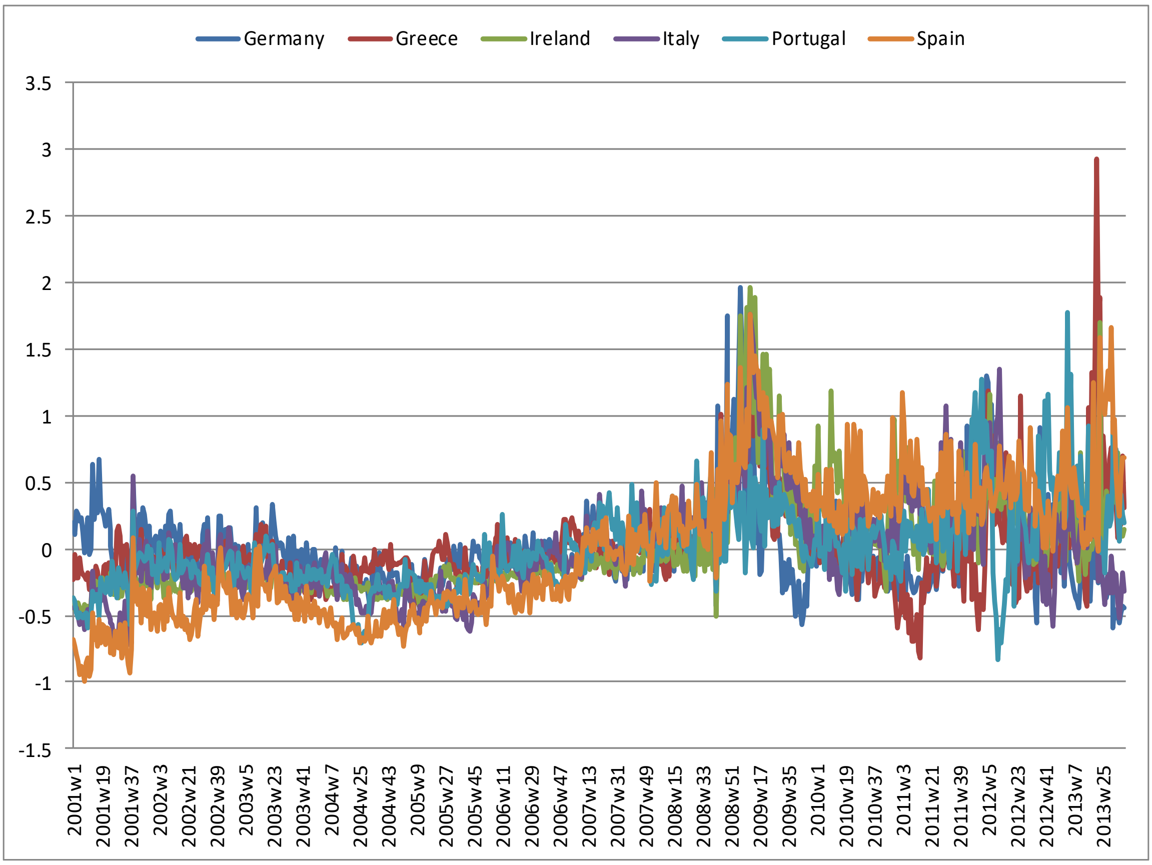


Figure 1B: Bond Markets FSIs

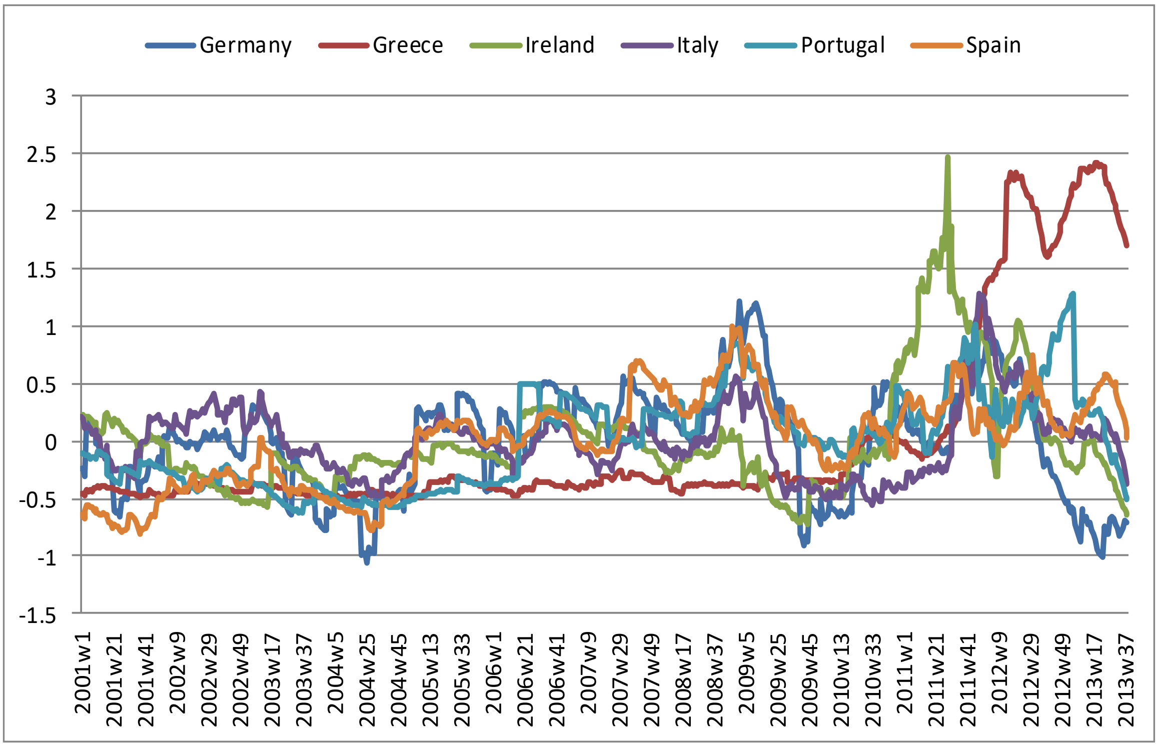


Figure 1C: Money Markets FSIs

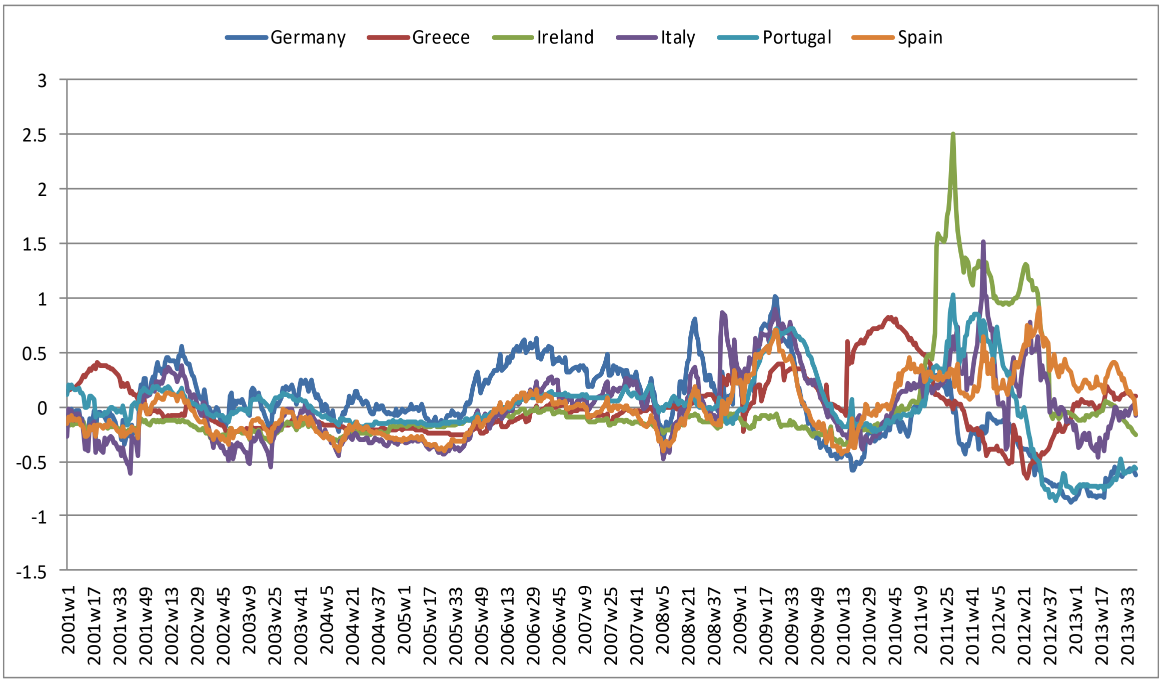


Figure 1D: Equity Markets FSIs

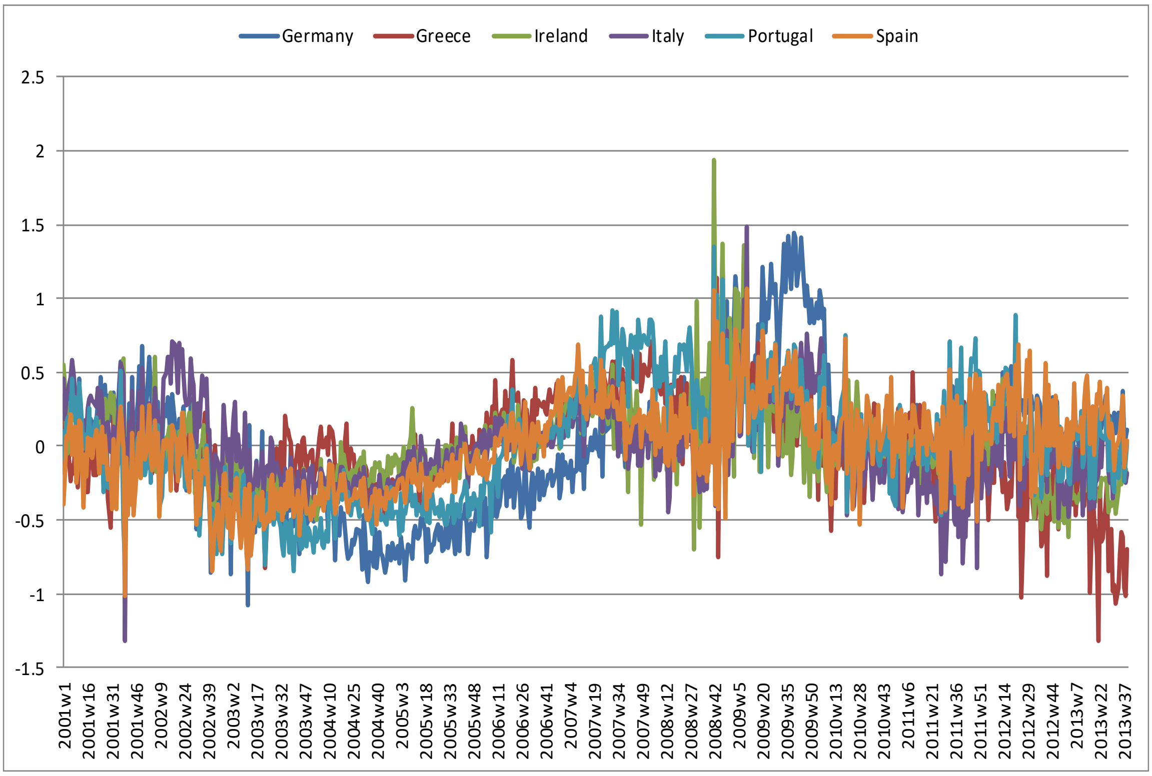
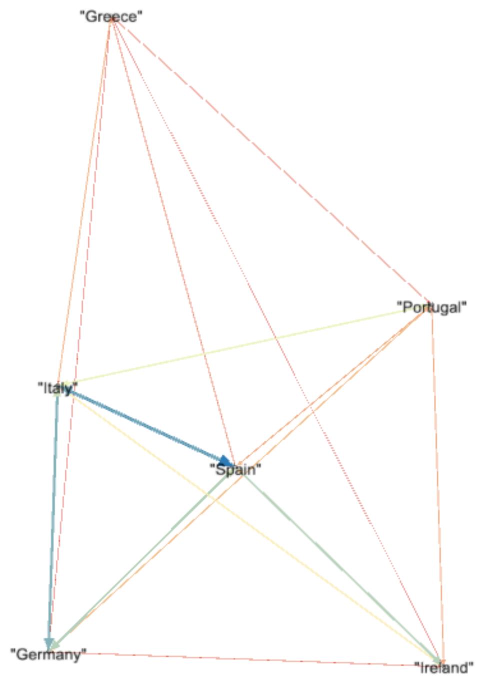
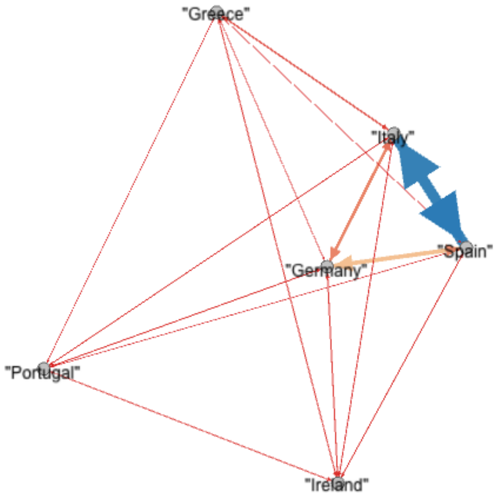


Figure 2: Banking sector network graph



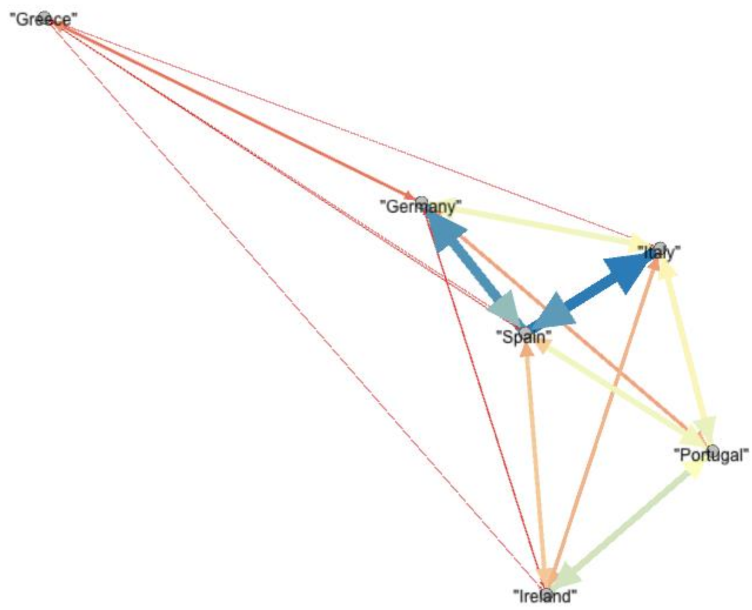
Note: Each node represents the stress index of each economy's index. Red (light grey in greyscale) shows a lower spillover, while a blue (dark grey in greyscale) shows a higher spillover. Each thickness indicates average pairwise directional connectedness.

Figure 3: Bond markets network graph



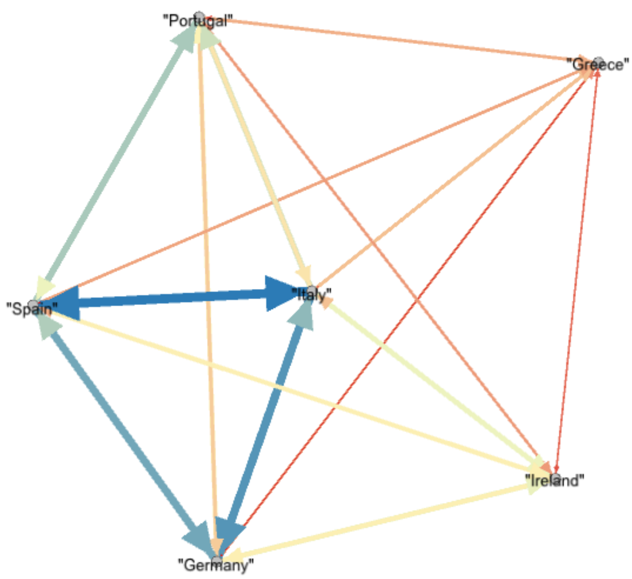
Note: Each node represents the stress index of each economy's index. Red (light grey in greyscale) shows a lower spillover, while a blue (dark grey in greyscale) shows a higher spillover. Each thickness indicates average pairwise directional connectedness.

Figure 4: Money markets network graph



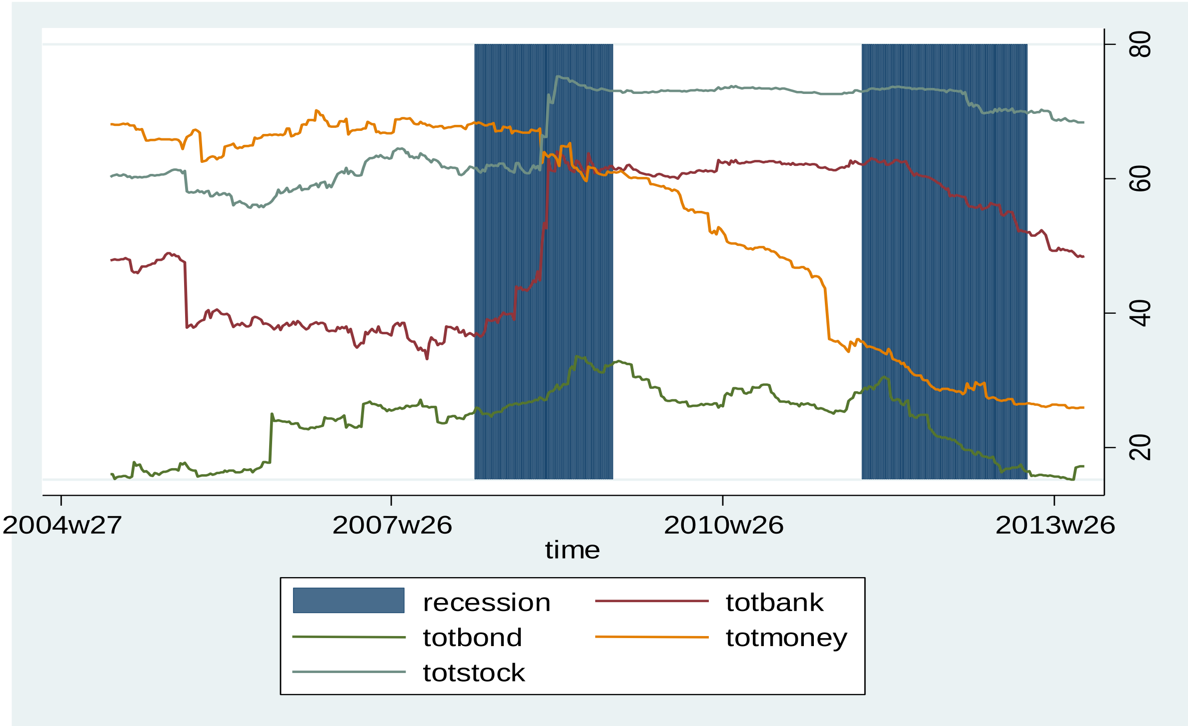
Note: Each node represents the stress index of each economy's index. Red (light grey in greyscale) shows a lower spillover, while a blue (dark grey in greyscale) shows a higher spillover. Each thickness indicates average pairwise directional connectedness.

Figure 5: Equity markets network graph



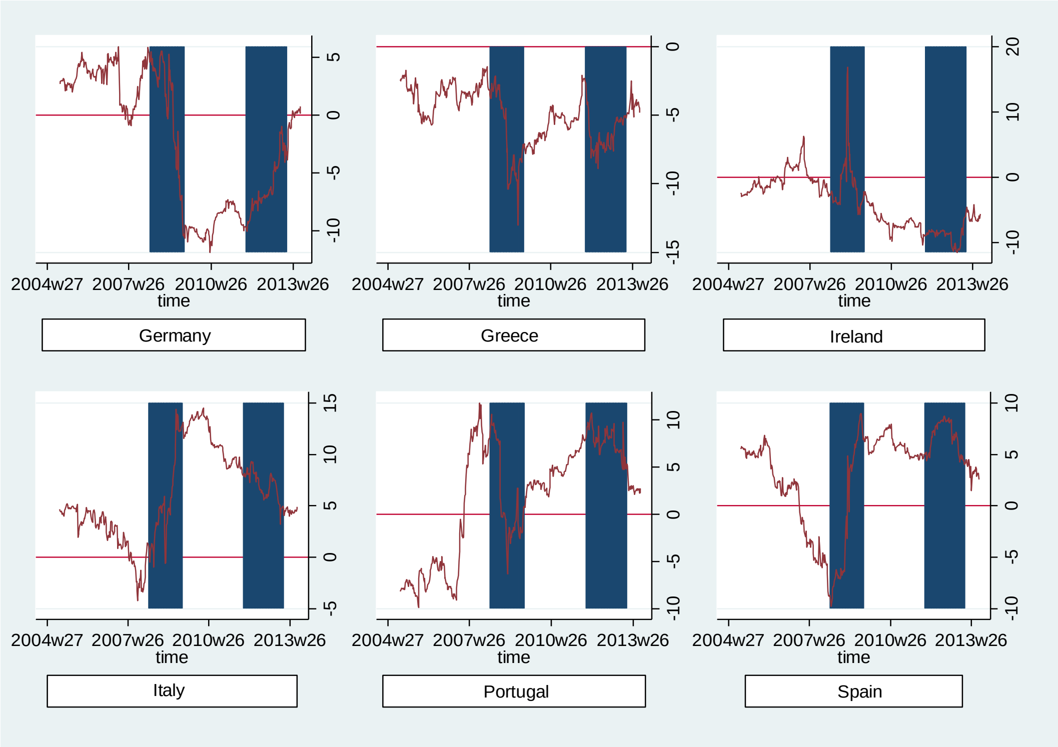
Note: Each node represents the stress index of each economy's index. Red (light grey in greyscale) shows a lower spillover, while a blue (dark grey in greyscale) shows a higher spillover. Each thickness indicates average pairwise directional connectedness.

Figure 6: Dynamic Spillover Indexes



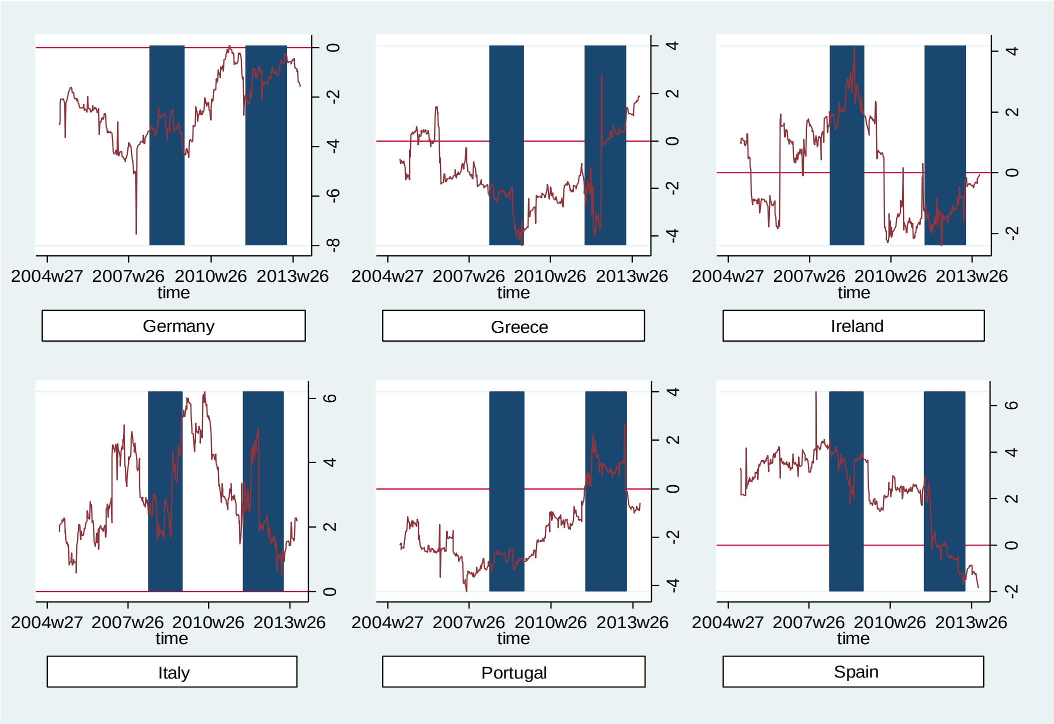
Note: Plot of dynamic total spillover indexes estimated using 200-week rolling windows. Bar areas indicate Eurozone recessions as calculated by CEPR business cycle dating committee.

Figure 7: Dynamic Net Spillover Indexes-Banking Sector



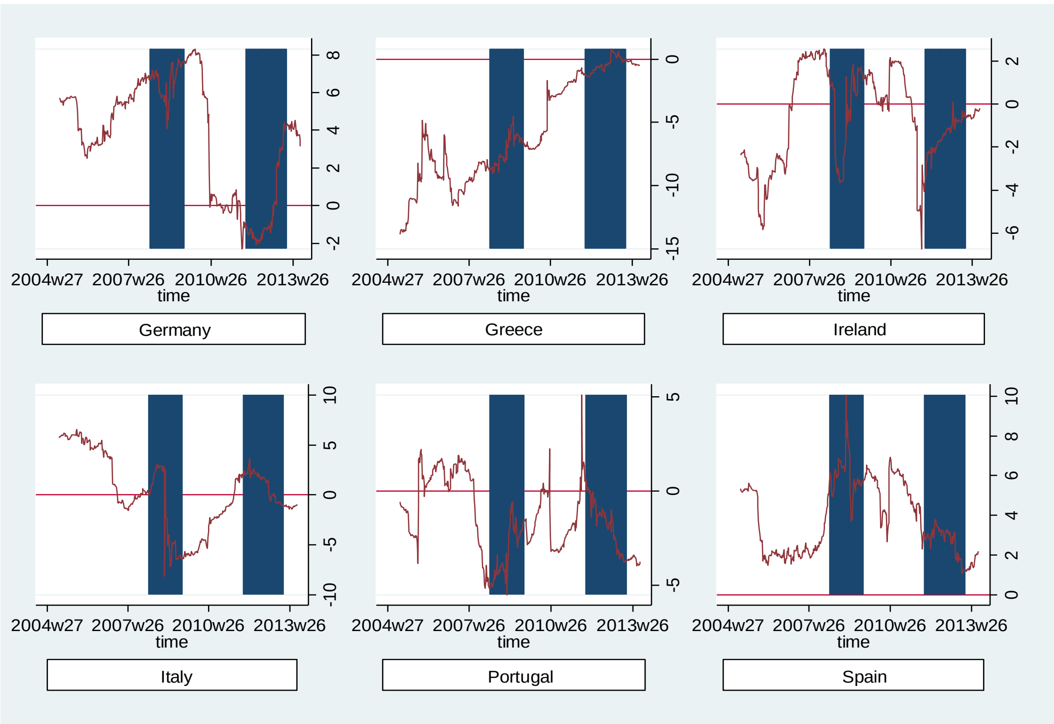
Note: Plot of dynamic net spillover index estimated using 200-week rolling windows. Bar areas indicate Eurozone recessions as calculated by CEPR business cycle dating committee.

Figure 8: Dynamic Net Spillover Indexes-Bond Markets



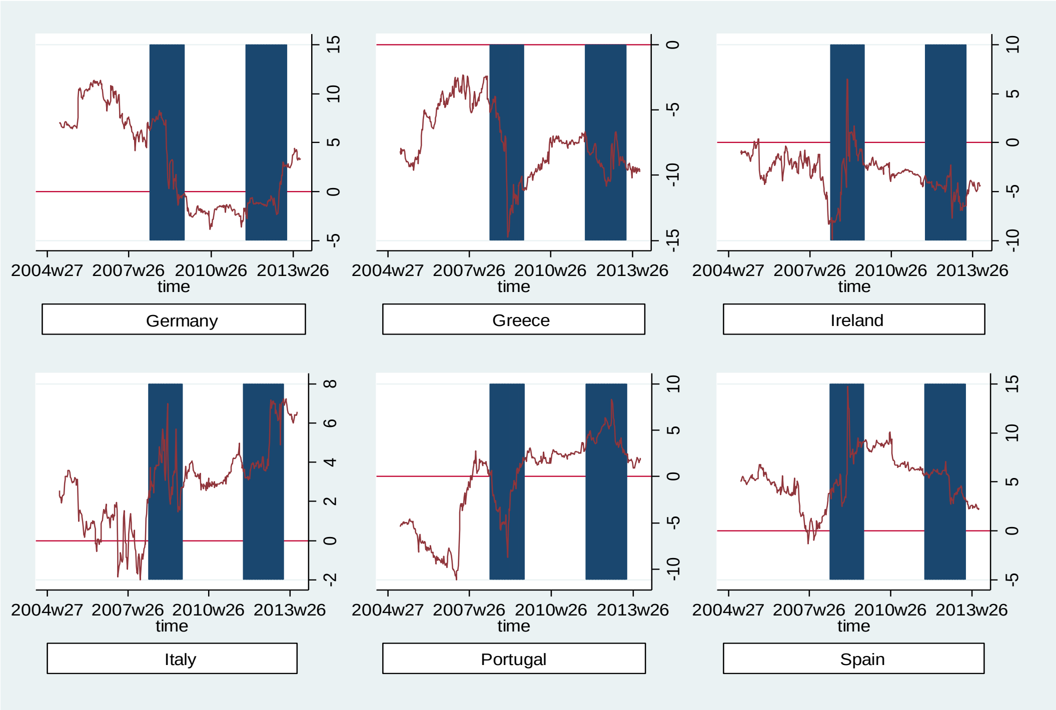
Note: Plot of dynamic net spillover index estimated using 200-week rolling windows. Bar areas indicate Eurozone recessions as calculated by CEPR business cycle dating committee.

Figure 9: Dynamic Net Spillover Indexes Money Markets



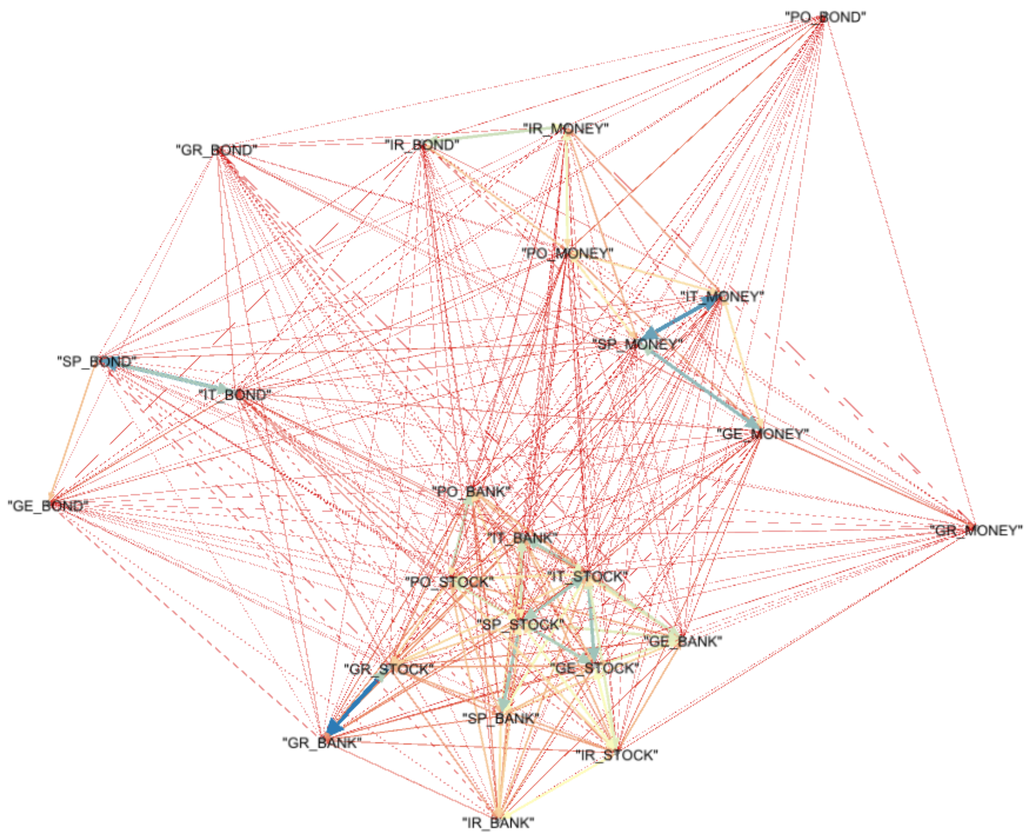
Note: Plot of dynamic net spillover index estimated using 200-week rolling windows. Bar areas indicate Eurozone recessions as calculated by CEPR business cycle dating committee.

Figure 10: Dynamic Net Spillover Indexes-Stock Markets



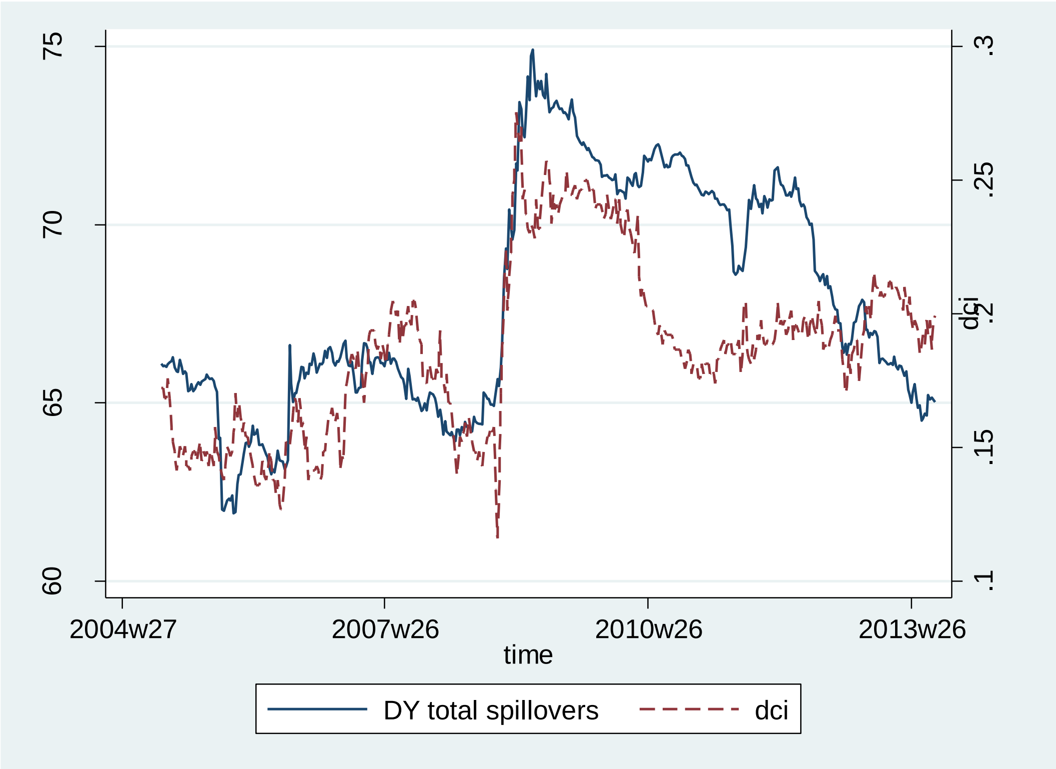
Note: Plot of dynamic net spillover index estimated using 200-week rolling windows. Bar areas indicate Eurozone recessions as calculated by CEPR business cycle dating committee.

Figure 11: Cross-Market network graph



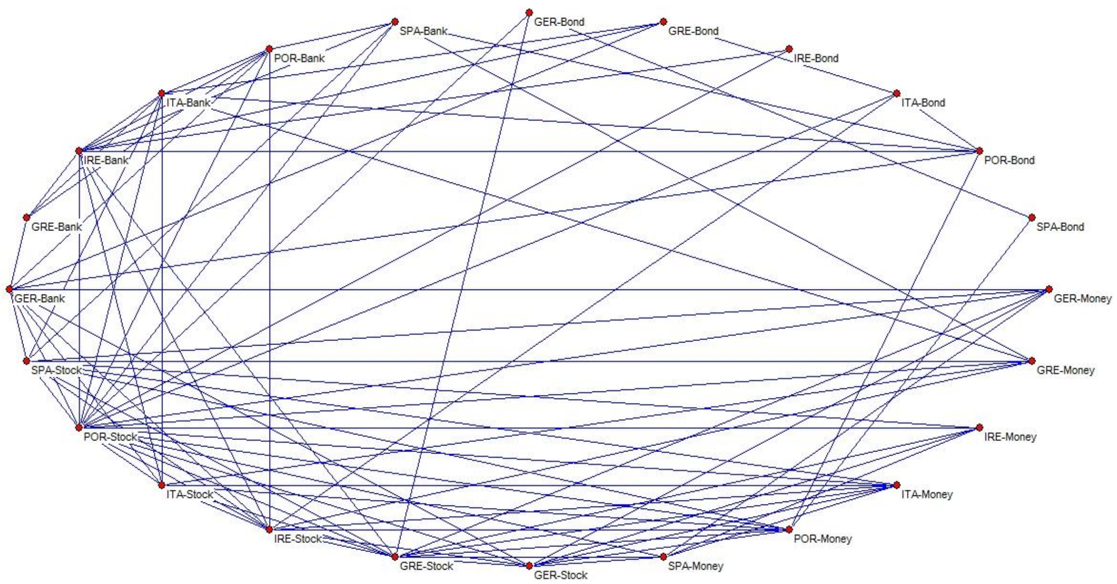
Note: Each node represents the stress index of each market's index. Red (light grey in greyscale) shows a lower spillover, while a blue (dark grey in greyscale) shows a higher spillover. Each thickness indicates average pairwise directional connectedness.

Figure 12: Dynamic Spillover Index & Dynamic Causality Index



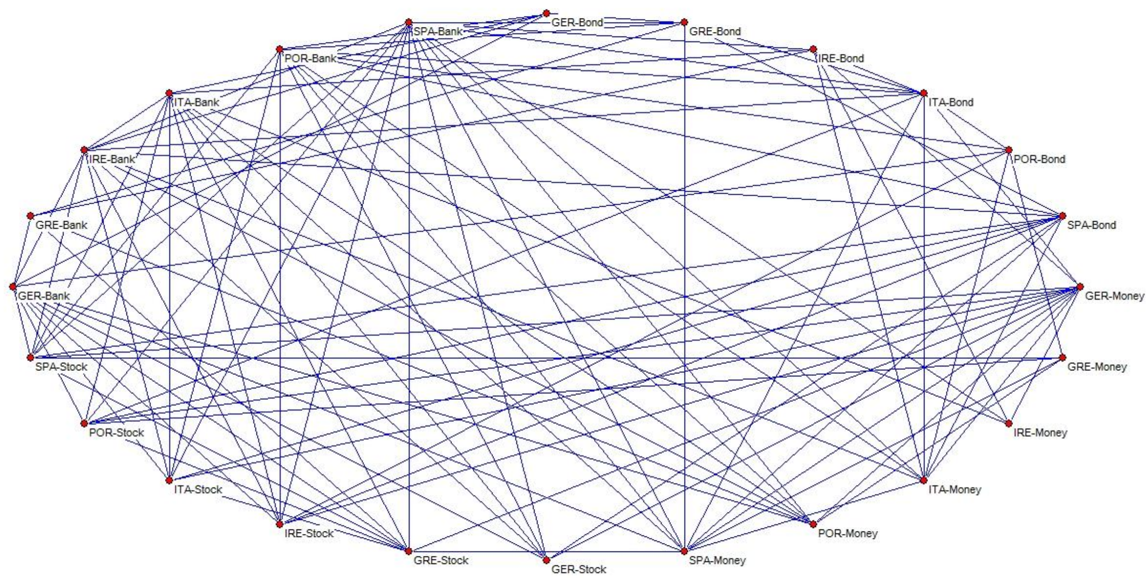
Note: Solid line depicts the dynamic total spillover indexes estimated using 200-week rolling windows (left scale). Dotted line shows the dynamic causality index (right scale).

Figure 13: Granger Network before crisis



Note: Each line represents a causal relation between two nodes/markets.

Figure 14: Granger Network after crisis



Note: Each line represents a causal relation between two nodes/markets.