An Investigation of Systemic Stress and Interdependencies within the Eurozone and Euro Area Countries

Very Initial and Incomplete Draft – Please do not quote

Abstract

Eurozone is getting through its most serious financial crisis, since its creation. This situation put at stake the whole European integration project and set a number of crucial questions for the viability of the Eurozone as an economic and political entity and of the euro as a common currency. One of the most interesting aspects of this financial turmoil in Eurozone is the identification of the sources of the instability. More precisely, it is important for policymakers and market participants to be able to spot the channels through which the crisis has affected European markets. Such a work can help on the creation of the most appropriate policy framework, in order to establish the best possible framework for financial markets' regulation and supervision, along with the necessary macro-prudential policies. In order to achieve the aforementioned, we focus on the main source of this financial crisis, that is, the financial and banking markets. Here, instead of focusing to single indicators of financial instability, we move one step forward, by using financial stress indices, in order to have a clear-cut idea of the size and the severity of the financial turmoil through time. Using a wide number of series, we first proceed to the construction of financial stress indicators for the money market, bond market, banking sector and the stock market of each Eurozone country, while an overall index for each country and the Euro Area is also provided. By employing these indices, it is possible to have a clear narrative of the evolution of the current crisis for the whole Eurozone, as well as for each country and, even more important, for the markets that drove the crisis in each country. Moreover, in order to evaluate the long run relation of these markets and their interconnections, VAR modelling is employed. Based on this, countries are mostly responsive to their own financial shocks, while a degree of regionalism is evident, in the sense that peripheral countries are more susceptible to their financial stress, while the same holds for the core Eurozone countries. Finally, in contrast to common wisdom, financial conditions in Greece and Portugal do not seem to affect the rest of the Euro Area, at least in the degree that Italy and Ireland do.

JEL Classifications: C43, C58, G01, G15

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1. Introduction

Since 2007, the global economy is getting through one of the most unstable periods in the modern history. The problems that were raised in the sub-prime mortgage market in United States quickly spread to the global financial system and created an unprecedented financial crisis, which greatly affected the growth prospects of the world economy for many years. The interconnectedness of the various markets and national economies are so tight, that monetary authorities were forced to proceed to economic policies never applied before to such a wide scale and number of developed countries. It is not by accident that the current period is now known as the Great Recession.

The fundamental reason for reaching such levels of recession is the strong and perplexed interrelation of the financial system with the real economy. Moreover, the fact that financial markets consist of a number of actual different markets, like the banking market, the bond market, money market and so on, each one driven by its own distinctive forces, makes things even more complex and difficult for assessing the underlying causes of financial turmoils and deciding on the optimal policies for the alleviation of market instabilities. Central bank authorities employ monetary policy measures, in order to intervene and stabilize the economy, while the financial stability and financial stress assessment was a recent addition to their mandate. In any case, even the so-called monetary policy transmission channel is not, yet, thoroughly evaluated and tracked down the different ways through which it can affect the aforementioned. In order to perform such an evaluation, a measure able to identify financial system impairments is necessary. Hence, there is a need for using financial stress indices, able to clearly depict systemic risk.

Another reason, rendering the employment of such financial stress measures necessary, is the fact that the same nature of financial crises has been multifaceted. As it has been evident in the last few years, during Great Recession, the sources and causes of a financial crisis can significantly vary, in accordance to changes taking place in the financial market conditions and investors sentiment. For instance, the current financial crisis begun from a, relatively small, uninteresting, financial market, the sub-prime mortgage market in the United States. Soon, it has infected several markets and economies around the world, with this crisis reaching its peak with the

Lehman Brothers collapse in September 2008. This situation brought a major disruption in money markets, as well as the interbank funding market, leading to a drying up of liquidity in a global level. In turn, this had major repercussions on capital struggling companies, households and countries, brining up more transformation of this crisis into a banking one and, lately, a sovereign debt crisis. Thus, it is evident, as it is also emphasized by Sandahl et. al (2011), that the thorough study of each market, that is part of what economists call financial system, is of utmost importance and can easier be done using financial stress measures. In this way, a clear and timely depiction of the prevailing conditions in each financial market is possible, while it is also an efficient way to assess the market-wide systemic risk for the economy. Finally, as it was previously implied, these indices can be used to evaluate the effectiveness of the monetary policies followed by central banks, since tools used by the aforementioned are integral parts of the aggregate financial stress indexes.

As it has been clear from the previous discussion, there is great scope for the implementation of financial stress indices, especially in the present situation, where the need for accurate and timely indicators of systemic-wide financial instabilities is extremely important. In this chapter, we are going to construct a series of financial stress indicators, in order to analyze the current Eurozone crisis. This is an important motivation for this piece of research, since the unprecedented level of financial and sovereign turmoil in the Euro Area should be investigated and scrutinized. In order to do it, we employ a wide number of indicators, originated from the most important financial markets. These are the banking sector, the money, equity and bond market of each one of the eleven original Eurozone countries[1]. In this way, we construct five stress indices for each country (four sectorial, one country-wide), while an index for the whole union is also provided. Three different approaches are used to aggregate the individual indexes, namely the equally weighted, the first principal component from a principal components (PCA) analysis and, finally, the weighted loadings approach, again stemming from a PCA analysis.

In the second stage of this empirical assessment of the Eurozone crisis, we provide initial evidence on the implied interrelation between the markets and the countries financial (in)-stability. The existence of trade and tight financial connections

[1] Luxembourg is not included, since it is a small economy, without major interactions with the other core Eurozone countries. Also, even though Greece joined the common currency a bit later (2001), its alleged contribution to the current crisis renders its inclusion to the analysis quite important.

between euro currency countries, along with the existence of a unified monetary authority (the European Central Bank), deciding on the kind of monetary policies followed by all these countries, justifies and strengthens the necessity of such an econometric investigation. The provision of such empirical evidence leads to the establishment of interactions among the markets and the countries under exploration, providing further evidence in one of the hottest debates of concurrent financial literature. That is, the existence of channels of interdependence and contagion of the financial crisis from one country to another. With our work here, we expand the literature in many ways. First, it is possible to examine channels of crisis transmission using aggregate indexes of systemic risk, both in country level, as well as in individual markets. Thus, a more detailed analysis of potential stress sources and markets interactions is possible. Additionally, such an empirical evaluation of intra-Euro area interdependencies is useful for policy purposes, since the detailed and exhaustive indagation of the aforementioned indices and interrelations prove the necessity of different kind of policies in different markets, countries and cases of financial upheavals. Moreover, these stress indexes are ideal as early warning indicators of forthcoming financial abnormalities, since their advantage is the timely information they provide for the current state of the financial markets.

The empirical work involves the usage of vector autoregressive (VAR, hereafter) models, specifically impulse response analysis, in order to examine the interrelations of the aforementioned economies, through the financial stress indices. Through all this analysis, it is fair to say that a plethora of empirical indications is provided, regarding the Euro area financial crisis interrelations, the driving forces behind it and the main propagators that should be blamed for.

This paper is organized as follows. In section two, a discussion of the most important papers, dealing with the measurement of European countries financial stress is provided. Then, in the third section, the dataset employed is presented, emphasizing the usefulness and importance of the indicators included in the systemic stress indexes. Also, the econometric methodology adopted is presented. In section four, the constructed index is discussed, together with its features, its effectiveness as tool of financial system safeguarding and the potential implications stemming from each country index's decomposition to its constituents. Then, the next sub-section provides an exposition and justification of the econometric results, while the last one recaps and concludes.

2. Financial Stress Measures for Eurozone and European Countries: An account of the relevant literature

The literature on financial stress (or, as some of the authors call them, financial fragility) indices (FSI), has mushroomed the last decade. It is a branch of the research developed as a continuation of the early warning indicators (EWI) literature, models that have been used in previous empirical work on, mainly, currency and banking crises episodes. As it will be made clear, these two approaches on modeling periods of financial crises look similar, although, they have quite distinctive characteristics. First of all, previous models were models analyzing country-specific or only specific types of crises episodes (either, currency, banking or balance of payments crises). The most recent periods of turmoil (especially, the sub-prime crisis beginning on 2007) showed that crises are systemic-wide and are not confined to a single market of the economy anymore. Also, exactly because of this nature of financial crises, there is a need to alter the modeling approach followed up to now, in order to be able to capture this special feature of modern financial abnormalities. Before, wide use of binary choice models (either probit or logit ones) has been made, predetermined in this way the outcome (being a choice between a crisis or non-crisis state) for each time period under consideration. With the FSI approach, a series with continuous values is provided, offering a timely illustration of the market conditions, thus, better monitoring of the financial system is possible. Moreover, most of the work done was focused on developing economies, something justifiable by the fact that these economies were the most vulnerable to periods of financial instability. Recent abnormal periods showed that new tools of monitoring the stability of the financial system are needed, able to anticipate the sources of financial stress and, most importantly, to be easily implementable and used as forecasting tools, in order to provide accurate and swift indication of forthcoming periods of instability. The relevant literature, discussed here, provides some answers to these complex and interesting issues. The papers discussed here are those with the European and Eurozone countries in the epicenter of the authors' interest.

A first attempt to construct an FSI for the Euro area has been made by Grimaldi (2010). Based on the indicators proposed by Nelson and Perli (2006), the author has a threefold intention: to specify the actual stress period for the Euro zone

markets, to compute relevantly accurate indices and test whether her index can work as a leading indicator of stressful events. For the first goal, the author employs information contained in European Central Bank's communication (using ECB's Monthly Bulletins) to help her measuring financial market stress. In this way, she indicates periods that seem to reflect periods of financial upheaval[2]. In order to verify these findings, a financial fragility index is built, using sixteen variables from the bond, banking, equity and money markets. Specifically, the difference between each Euro zone's country long term bond yields from the German one represents the sovereign bond spreads. Then, for the banking sector, bank equity prices index and the AA-rated corporate bond spreads are used as proxies of the conditions prevailing in this sector. General equity index, actual earnings per share and equities risk premium were chosen for the equity market component of the indicator. Finally, regarding money markets, one and three month Euribor-EONIA rates spreads, together with the spread of the main refinancing rate and the two year bond yield were utilized. Moreover, a string of risk aversion measures have been included, like implied bond, stock and futures volatility. All these variables were then integrated into two indices, the first being the weighted (by the inverse of each variable's variance) average of them, while the second one is the rate of change. Finally, these two indexes were combined into a single indicator, with the help of a logit model, so that extraction of information on stressful periods to be more effective. The logit model is of the following form:

$$S_{t+h} = L\left(\beta_0 + \beta_1\lambda_t + \beta_2\delta_t\right), h \geq 0 \qquad (1)$$

where λ_t and δ_t are the weighted and the rate of change indices respectively, L is the logit probability distribution function, β's are the model's coefficients and S_{t+h} is a binary (0,1) variable, representing stress or tranquil periods. As it is obvious, whenever h is equal to zero, the model exhibit the contingent FSI, otherwise, the estimated model provides a forward indicator. Using weekly data for the period July 1999 to October 2009, the contingent financial stress index works well and captures crises periods of the last 10 years. Grimaldi confirms the good functionality of her FSI, comparing its performance with the VSTOXX index[3] and the signaling methodology,

[2] This has been done by counting how many times specific words appear in the bank's bulletin.
[3] It is an implied volatility index, based on equity option prices.

popularized by Kaminsky, Lizondo and Reinhart (1998). The last of the previously mentioned goals of this research (testing whether this index can be a leading indicator for stressful events) was accomplished by using the forward indicator version of the logit model, together with a slight transformation of the dependent variable of it. Now, the regressand has the following form:

$$S_{t+h} = \begin{cases} 1 \text{ if } \exists h = 1,...k \ s.t. \ S_{t+h} = 1 \\ 0 \text{ otherwise} \end{cases} \quad (2)$$

stating that the occurrence of a stress event can be at any point within a specific time frame. The author uses this model for a time window of 24 periods and figures out that it performs efficiently in this task as well.

Beyond the construction of aggregate Eurozone- wide financial stress indices, some economists have proceeded to the creation of country – specific indices. Especially for countries that are in the centre of the current debt crisis, the interest in examining their financial conditions is quite intensive. For instance, Louzis and Vouldis (2011) compute an FSI for Greece, using both market and balance sheet data, which is the novel feature of their index. According to the authors, such an index is useful for, both, policy design (through the identification of the state of the financial system), as well as for the dating and prediction of financial stress. Additionally, such measures offer a unique chance to study the potential propagation channels of a crisis, mainly by inspecting the stress index components. In more details, they follow the framework proposed by Hollo et al. (2012), who use the components' correlation, in order to assess systemic stress. Moreover, they extend this approach, by using multivariate GARCH modeling, so that they can be able to capture time-varying correlations of the index components. In this way, it is expected to improve the index performance, in terms of identifying financial crises episodes. The choice of the variables that are included in their analysis is based on their relevance to economic theory and the respective empirical literature. Thus, they focus on series capturing systemic stress, increased uncertainty and chancing expectations in the financial markets. Their set of variables consist of the following segments. First, they include variables related to the fundamentals of the Greek economy. These are, the sovereign bond spread (the yield difference of the long-term Greek governmental bond from the

German one), the realized volatility of the Greek government bond and the correlation of the Greek stocks returns with the German Bund. These are indicators, able to capture liquidity risk, uncertainty in the assets prices, together with potential flight to quality phenomena. Then, these economists include variables from the Greek banking sector, such as the banks stock index from the Greek stock exchange (a series, indicative of the investors' expectations on banks performance and health). Additionally, the realized volatility of the banks index is included, as well as the idiosyncratic risk of bank stock prices (modeled as the bank equities' beta). Another interest rate spread that is included here, is the bank bond spreads (that is, the spread of the bond yields issued by Greek banks from the German governmental bond). This is considered as an indicator of the risk in the banking sector, while it is also a good proxy for the funding cost of the banks. Regarding balance sheet data, the so-called deposit and loan gaps are incorporated in the analysis. These are the cyclical component of the total deposits (loans, respectively), estimated by the usage of the Hodrick – Prescott filter. Finally, the bank profitability is depicted by the interest rate margin of banks (that is, the difference between loans interest from the deposit one). Turning now to the equities market, the authors choose to use the stock market general index, decreasing prices of which indicate potential market stress. Also, the general stock index realized volatility is taken into account, in the same fashion as the banking index volatility. The final variable in use is the one for the money market. Specifically, the authors include the well known TED spread (the difference between the three month Euribor from the similar German treasury bill, an important measure for the representation of the liquidity and counterparty risk). Of course, it is questionable how useful the inclusion of such a variable is, since the intention of the authors is the creation of a systemic stress index for Greece. In our view, it seems more appropriate to create such a spread, using the Greek treasury bill rate.

Turning to the authors' construction methodology for their index, they first use principal components analysis to construct sub-indices for the aforementioned groups of variables. They do this, using the first principal component in each case, which they rescale to range from zero to one, through a logistic transformation. Then, as it was mentioned above, the framework by Hollow et al. (2012) is followed. The authors consider portfolio based approach to aggregate the sub-indices into a common FSI. The rationale is that, whenever correlation among the different market increases, financial upheaval increases as well. Thus, their stress index is of the following form

$$FSSI_t = \sqrt{s_t' C_t s_t} \tag{3}$$

where $s_t = w \otimes y_t$ is the vector of the weighted stress variables, with w being the weights and y the five sectoral stress indicators, while C_t is the time-varying correlation matrix. Hence, according to this empirical approach, there are two things that need to be estimated: the weighting vector (w) and the correlation matrix, in order to get the FSI. The former is estimated, according to each sub-index relative importance on the industrial production growth rate. In this way, an effort is made to link the evolution in the financial conditions with the real economy. According to the authors' calculations, the biggest effect comes from the fundamentals sector, while the smallest weight is ascribed to the banks balance sheet data. Then, regarding the correlation matrix, two approaches were followed. First, the correlation structure of the stress sub-indices is derived from an exponential weighted moving average model, an approach with limitations[4]. Then, the well established BEKK model was used, especially a diagonal representation of it, so that to avoid any dimensionality issues. The model's representation is

$$\Sigma_t = CC' + \sum_{i=1}^{p}\sum_{k=1}^{q} A_{ki}' \overline{s}_{t-i} \overline{s}_{t-i}' A_{ki} + \sum_{j=1}^{q}\sum_{k=1}^{K} B_{kj}' \Sigma_{t-j} B_{kj} \tag{4}$$

where C is a lower triangular matrix, A and B are n*n parameter matrices, k specifies the generality of the process and p and q are the number of lags in the specification used.

In order to evaluate the usefulness of their FSI, the authors graphically inspect its behavior. There is evidence that the index can accurately capture periods of financial turmoil, while the sub-indices inspection reveals the relevant importance of the different market segments. According to this decomposition, the money market seems to be the most important contributor to the present crisis, while economic fundamentals are also quite important. It is interesting that the banks balance sheet index minimally affect the level of financial risk, probably because of the limited

[4] In this approach, the decay parameter choice is arbitrary, while a random shock in the model can be proved quite persistent.

exposure of Greek banks to "toxic assets" effects. A final evaluation of the index is provided from a survey that was conducted among financial experts of the Greek financial market. In this way, a number of international financial crises episodes were evaluated, for their importance to the conditions prevailing in Greek markets. From this survey, a binary variable was constructed, which represents periods of financial turmoil and tranquility. Thus, this variable is used in a probit model, in order to assess the FSI usefulness as a leading indicator of such events:

$$\Pr(Crisis_t) = \Phi\left(c + \alpha x_t + \sum_{k=0}^{1} b_k \Delta x_{t-k} + e_t \right) \tag{5}$$

In (5), the dependent variable is the aforementioned binary one, x_t is the FSSI and, respectively, the lagged growth rate of the FSSI[5]. According to these estimations, all versions of the FSI provide some evidence of predictability, with the time-varying correlation modelling one to be the most accurate.

A similar effort to the previous one is made by Angelopoulou et. al (2012). Again, the authors try to construct financial conditions indexes for the Euro area as a whole, together with indices for some Eurozone countries (Germany, Greece, Ireland, Portugal, Spain). In their case, three different types of indices are formulated, one including monetary variables (so that the monetary policy effect can be evaluated), one without the aforementioned variables and, finally, one which is the difference between the previous one and an index computed through a principal components analysis, where the monetary policy loading are set to zero by the authors. It should be emphasized here that this family of indices, the so called financial conditions indices are similar, but not exactly the same, with the financial stress indices we study in this piece of research. It is argued that financial stress indices are more useful acting as early warning indicators of forthcoming stress, while the financial conditions indexes are better in the analysis of the macro-financial linkages in an economy. In any case, this distinction is still blurred and many researchers use these terms interchangeably[6]. Proceeding to their data selection, the authors choose twenty four variables, for the Eurozone aggregate index, while twenty are those included in the

[5] Here, all three versions of the FSI are used, namely the weighted-average one, the multivariate GARCH one and the exponentially weighted moving average modelled one.
[6] An interesting methodological discussion on this issue is provided by Carlson et. al (2012).

country specific ones. The choice is driven from, both, data availability, as well as based on the previous literature on this research topic. In this line of thought, the researchers incorporate several types of interest rate spreads (such as spreads between different types of loans and deposits), together with spreads from the interbank market (for instance, the three-month Euribor from the EONIA rate). Moreover, a number of quantity indicators are also included, like the value of debt securities issued by non-financial corporations and monetary institutions. Finally, a number of survey series (related to banks' liquidity position and consumer creditworthiness), along with series representing the volatility risk of stock and bond prices are also included in their stress indices. In order to create their aggregate indexes, these authors proceed to their analysis based on principal components methodology. According to this empirical approach, the variables under consideration are linearly combined, in such an order that the newly produced variables capture as much as possible of the variability of the initial set of variables. As it is emphasized by the writers, it is a way to compress the data, without losing much information. The process of acquiring the principal components of a dataset is by calculating the eigenvalues and eigenvectors of the variance – covariance matrix of the variables. Beginning from the highest eigenvalue, the eigenvectors are set in an ascending order, with the elements of each one of these eigenvectors representing the so called loading of each variable for the specific vector. Based on this kind of analysis, it is assured that each component is orthogonal to the rest. In their work, Angelopoulou et. al (2012) use the first three principal components for the Euro Area, while for the country specific indices the first four. The decision criterion is that the components included in the analysis to explain, about, 70% of the total variance. Then, the contribution of each one of the series in the final index is calculating, based on the loading of them in each component, weighted according to the level of variance explained by each one of these principal components. The final step is to weight the computed indices by the exact share of variance that the components which are included in the analysis explain.

Based on the loading weights, the authors suggest that each principal component represent different kind of influence in the financial conditions. For instance, it is evident that the most important variables in the first principal component are the survey variables, while interbank market spreads and bond volatility are also important. On the other hand, bank credit variables and securities issuance ones seem to be more important in the second component, while the third

component emphasizes the role of the spreads between loans and deposits. In the weighted loading case, the magnitude of the variables is, in general terms, as it is expected to be. By inspecting the FCIs graphs, useful comments can be made. Beginning with the Euro-wide index, there seems to be a tendency to loosen financial conditions, since the beginning of the sample (2003, with end of 2011 to be the end of the sample here)[7]. This situation prevailed until early 2007, when the financial conditions began to worsen. Several incidents rendered the conditions gloomier, like the liquidity shock induced by Bear Stearns failure in March 2008, as well as the Lehman Brothers default in September 2008. Since lat 2009 and until 2011, financial conditions are improved, whereas the situation worsens in the second half of this year, given the increasing uncertainty, due to the outbreak of the debt crisis in Greece and Portugal. In the case of the countries FCIs, it is evident the existence of asymmetric responses of the different economies to the varying financial conditions. The situation in Germany diverges from the other countries under investigation (which are the ones most seriously hit by the debt crisis), both in the pre-crisis period (where the financial conditions were tighter to the other countries but Germany) and in the post-crisis period. In the last two years of the sample (since 2010), situation worsens in Greece and Portugal mainly, while in Germany are improved. Generally, it is shown that monetary policy effects are not unanimous in the whole Eurozone, something that indicates the need for particular attention on the kind of policies prescriptions proposed by ECB.

3. Data and Empirical Methodology

Having completed the brief account of the literature on financial stress indices and the relevant research conducted for Eurozone and European countries, we now proceed to a discussion of the dataset used in this piece of research, along with a description of the methodological approach adopted for the indexes calculation and their incorporation to econometric analysis. Our aim is the construction of financial stress indices, able to accurately capture periods of increasing abnormality in the

[7] in the case of Financial Conditions Index, loosening conditions are captured by increasing level of the index, while tighter conditions by decreasing level of it.

markets, as well as indices that can act as indicators of heightening systemic risk. In this way, an evaluation of the systemic financial stability can be conducted, while the relevant sub-indices can perform in the same fashion, for each one of the market sector examined.

3.1 Dataset Description

In order to depict the effects of a financial turmoil in a systemic wide level, we employ data from four markets, for each one of the initial Eurozone members[8]: the banking sector, money market, equity market and bond market. In all cases, we use monthly data, ranging from January 2004 until August 2011. The selection of variables is based, partly, on previous work done on systemic risk issues, as well as on variables that are important on the formulation of the state of the financial systems. In the following table, we provide an overview of the series used. As it is evident, a plethora of variables has been employed, in order to represent as accurately as possible the prevailing conditions in the financial markets of Eurozone countries. An important innovation here, compared to the previous literature in this area is the inclusion of an extensive number of balance sheet data, for a wide number of European banks. The multifaceted nature of the current crisis that hit hard many major banks around Europe, in many cases without obvious underlying reasons, stated the examination of balance sheet indicators very crucial. Depending on data availability, the number of banks by each country that has been incorporated to the construction of the bank and the aggregate index varies (from one bank to Belgium and Netherlands to eight for Greece).

In any case, our sample consists of 41 banks, covering major banks from all countries and banks with big market capitalization, size and market power. The limitation on the number of the financial institutions is dictated by the fact that many of them are not listed to a stock exchange and, as a consequence, there is a lack of data on their market performance. There are five groups of variables for each one of the bank, while the last one, called "overall market conditions", represent the general conditions prevailing in the banking sector of each country (here, the series are market wide, not bank specific ones). So, the number of the indicators included for the

[8] These are: Austria, Belgium, Finland, France, Germany, Greece (since 2001), Ireland, Italy, Netherlands, Portugal and Spain.

banking stress index of each country varies from 27 variables (in cases where only one bank for a country is used) to 181 variables (in the case of Greek banks). The data are retrieved from various sources, but most of the balance sheet ones are from Bureau Van Dijk Bankscope database. Since most of these series are provided in yearly or quarterly basis, they are interpolated into monthly frequency.

Table 1: Indicators of Financial Stress

Variables Used in Financial Stress Indices		
Banking Sector		
Operational/ Profitability	***Liquidity***	***Assets Quality***
ROA	Interbank Ratio	NPL/Gross Loans
ROE	Net Loans/Total Assets	Loan Loss Reserves/Total Loans
EPS	Loans/Deposits	Loan Loss Reserves/Impaired Loans
P/E	Total Liabilities/Liquid Assets	Size
Inefficiency	Interbank Funds/Liquid Assets	Market Power
Net Interest Margin		
Capital Adequacy	***Volatility Risk***	***Overall Market Conditions***
Tier 1 Capital Ratio	Stock Returns	Deposit Gap
Total Capital Ratio	Dividend Yield	Loan Gap
	Market Value	Bank Equities Realized Volatility
	Turnover by Volume	Banking Sector Beta
		Bank Equities Returns
Money Market		
TED Spread		M2 Growth
Inverted Term Spread		M2/Foreign Exchange Reserves
Treasury Bill Realized Volatility		Intermediation Rate
Main Refinancing Rate - 2yr		Main Refinancing Rate - 5yr Government Bond Yield
Government Bond Yield		
Equity Market		**Bond Market**
Stock Returns		Sovereign Spread
EPS		Government Bond Realized Volatility
Dividend Yield		Corporate Spread
P/E		Government Bond Duration
Stocks Realized Volatility		Stock Returns/German Bund Realized Correlation

In the first category, there are series representing the operational characteristics and banks' profitability determinants. Here, returns on assets (ROA), as well as returns on equity (ROE) are crucial ratios for the evaluation of the smooth performance of a bank. As indicated by Morales and Estrada (2010), these two variables depict the efficiency of the banks on employing their available funds, while on the same time are accurate representations of the level of profits they produce. Thus, it is evident the importance of their inclusion in this fragility index, since banks with low level of profitability are more susceptible to default. Additionally, regarding

ROE, Louzis et. al (2012) emphasize its importance as a measure of the cost efficiency and of the efficacy with which banks use their internal and external financing. On the other hand, earning per share (EPS) ratio and P/E ratio are also indicative of the financial health of these institutions. The former is a well known metric of profitability, the behavior of which is indicative of the banks ability to cope with strenuous financial conditions[9]. Price-to-earnings ration works in the same fashion. Since a decline of the P/E ratio would represent decreasing profitability for a financial institution, it is reasonable to include this variable with a negative sign in the following empirical work. Inefficiency, which is the ratio of operating expenses with operating income, is a very efficient proxy for how prudent a bank is. In their work for the determinants of non performing loans, Louzis et. al (2012) propose the use of inefficiency as a measure of banks management quality, in terms of their ability to monitor and avoid excessive funding to default – like investments. Thus, it is natural to include this indicator to our dataset. Finally, net interest margin, defined as the bank's income from its intermediation activities, is also included in the set of indicators as an important contributor to the banks financial robustness.

The second group of variables consists of liquidity indicators. The interbank ratio represents the value of funds a bank lent to other banks over the money it has borrowed by others. In this way, interbank ratio is a good proxy for financial instability transmission, since it represents the exposure of each bank to funds from other banks. The ratio of net loans to total assets is a ratio of dual nature, in the sense that it, concurrently, depicts the degree of liquidity of an economy (since the higher the financial leverage of a banking system, the higher should be this ratio), but on the same time it is a variable mirrored the banks portfolio quality and sustainability. Thus, it is a metric with ambiguous sign, regarding its contribution to excessive systemic risk or not. On the other hand, loans to deposits ratio is another important variate. A higher value of this testifies lower liquidity available for banks, while the exposure to default risk is, also, greater. It can be considered as a good funding proxy, as well, if its usefulness as a measure is viewed from the economy's aspect. This set of indicators concludes with two liquidity risk ratios, namely the total liabilities to liquid

[9] Grimaldi (2010) and Louzis and Vouldis (2012) pinpoint the negative relation of EPS ratio with cases of increasing financial stress. Thus, we incorporate it with negative sign in the stress indexes construction.

assets and the interbank funds – liquid assets one[10]. The reason behind the inclusion of these two indicators has, mostly, to do with their importance for the capability of a bank to cope with situations of increasing default rates and deepening recession of the economy. In this sense, the higher these ratios are, the more vulnerable the banks become.

Moreover, the quality of the assets a bank has to its portfolio is of utmost importance for its survival in an uncertain financial environment. As it is well known, credit risk is the main type or risk that banks must manage and be cautious towards it. Thus, the reserves of such a financial institution, which are capital provisions for cases of bad loans writing offs, compared to its loans portfolio (both total and the impaired ones) is crucial. As Puddu (2008) indicates, these measures are proxies of the quality deterioration in banks' balance sheets[11]. Thus, a positive contribution on the crisis index should be expected. On the same time, the credit risk they face is negatively related their size and market power[12]. Finally, the analogy of non performing loans to total loans is, clearly, evident of the quality of loans in a bank's portfolio and a positive sign is expected for its contribution to the financial stress index.

The capital adequacy indicators are those dictated by the Basel Accord, related to the minimum capital needed for the default risk coverage by the banks. In the group of volatility risk variables, we include those series which abnormal behavior renders the bank vulnerable to market risks and instabilities. For instance, higher stock returns indicate heightened uncertainty among investors, something that can have serious effects on the bank's operation and viability. Moreover, dividend yield can, potentially, give negative signal for a bank, since it is negatively related to the robustness of a financial institution's fundamentals. Market value and turnover by volume are, also, closely related to market sentiment, with a feedback loop existing between their level and market uncertainty (and, of course, with the level of financial stress). Turnover by volume is defined as the number of a bank's equities traded on

[10] Morales, M. and Estrada D. (2010), "A Financial Stability Index for Colombia", *Annals of Finance*, 6:555-581

[11] The tendency to increase loan loss reserves is indication of worsening balance sheets, since banks in this way admit their concern on losses on their loans portfolio. On the same time, it can be considered as a sign of prudence from their side. In any case, in the literature, the first case is considered as more important and effective on the role of this indicator.

[12] Size is the value of each bank's assets, compared to market's total, while market power is related to loans given, to total value of them. For details, consult Louzis et. al (2012).

any particular date, usually given in thousands of stocks. Thus, increasing turnover for a bank's equity provides signals against this institution's viability and vigor.

General conditions of the banking sector of each Euro Area economy are sketched out by the last bunch of variables used for this market. In the same fashion as Louzis and Vouldis (2012), we employ the so called deposit and loan gaps. These are produced, using the Hodrick – Prescott filter, proposed by the aforementioned economists in 1997, in order to extract the cyclical component of the deposits and loans of each bank from the trend element of them. This is a useful approach, indicating the cumulative dynamics of these two important elements of banks balance sheets. Increasing deposit gap is indication of deposit shortage, while a loan gap can be interpreted as higher market uncertainty and, thus, reluctance from the banks to provide loans. The level of investors' uncertainty is depicted by the realized volatility of the bank equities index for each country. Increasing values of this volatility measure represent increasing financial upheaval. A very common component for stress indices is the beta coefficient of the banking sector index[13]. High beta values are an indication of banking sector equities to be considered as riskier and, thus, investors' sentiment is against them. Finally, we also include the bank sector index returns, in the same logic as the stock price returns of the individual banks.

Proceeding with the discussion of the variables included in the other three markets investigated here, we begin with the money market. Here, eight variables are included in the dataset. One of the most frequently used series for financial stress indices construction is the so called TED spread. It is the difference of the uncovered interbank short term lending towards a short term treasury bill (usually the 90-days treasury bill). For the case of Eurozone, the former is the well known 3-month Euribor, which is the benchmark and basic rate based on what European banks offer funds in the interbank market. The use of this indicator is popular, since it represents both, counterparty risk and liquidity risk in the markets. In times of increasing uncertainty and financial instability, problems of adverse selection can rise, since lending banks would be unable to identify the most financially reliable banks while the need for funds can be excessively high. Thus, increasing TED spread is expected for times of heightening financial fragility. Additionally, the slope of the yield curve is used, sometimes called inverted term spread. It is nothing more than the difference of the

[13] It is used in most cases of FSI construction. For instance in Louzis and Vouldis (2012), Slingenberg and de Haan (2011), Melvin and Taylor (2009) and many others.

yield of short –term governmental securities from the long term ones (here, the 3 month treasury bill from the 10 year government bond yield is used). The reason for including this variable has to do with the well justified, from the literature, ability of the yield curve to work as leading indicator of the real economic activity[14]. Hence, a forthcoming recession greatly affects the financial position of many debt ridden firms and the default risk is highly exacerbated. Additionally, it is a good indicator of the investors' expectations on future short term interest rates. Since, during period of financial turmoil, the need for liquidity is higher and more intensive, investors turn to more easily liquidated securities, like the treasury bills. In turn, this affects their returns, expanding the spread between the aforementioned securities. The next two indicators, namely the spread of the main European refinancing rate from the two and three – year government bond yields are also strong indicators of monetary liquidity. As it is emphasized by Grimaldi (2010), the decrease of these spreads represents liquidity worsening situation. For this reason, we incorporate these two indicators with negative signs in the analysis, so that their deterioration can indicate increasing level of financial suffocation. Growth of money supply and the ratio of money stock to the economy's foreign exchange reserves are two series, coming from the prior literature on early warning indicators of currency and banking crises. As it is evident from Kaminsky et. al (1998) and Demirguc-Kunt and Detragiache (1998), the previously mentioned variables are among the successful leading indicators for forthcoming currency and banking crises. Since both can produce signals, long before the actual outbreak of a crisis event, and since they both represent values of utmost importance for the economy's growth rate and the total credit available, their inclusion to this dataset is advantageous. The realized volatility of the treasury bill rate is incorporated here, representing the uncertainty and excessive abnormality of the money market, since treasury bills are those securities with the highest value of transactions in short term borrowing markets. Finally, the intermediation spread is the difference between lending rate and deposit rate. Even though, it is a variable that is, partly, reflects the level of profitability of financial intermediaries, it is contained in this group of variables, since it is also a strong indication of the available sources of credit and its supply level into the economy.

[14] Mishkin, F. S. and Estrella, A. (1998), "Predicting U.S. Recessions: Financial Variables as Leading Indicators", *The Review of Economics and Statistics*, vol. 80(1): pp. 45-61

In the equity market group, we include five variables. Firstly, the stock returns are incorporated, with negative signs since the large negative returns are those that create the greatest uncertainty for investors. Then, the earnings to price ratio (with a negative signs in the formation of the stress indices, because of the reasons stated in the banking sector analysis) and the P/E ratio are chosen, as major variables representing the profitability and health of the market participants. Moreover, dividend yield is another series, reflecting the robustness of the stock market. Thus, its inclusion is important, since its behavior is a sign of listed companies' ability to cope with financial strain. This set of indexes is concluded with the realized volatility of the stock markets' general indexes. As in all previous cases, the realized volatility is computed, using daily data, as the sum of squared logarithmic returns, adjusted by the trading days of each year in the sample.

The last set of series has to do with the bond markets of Euro Area countries. An important contributor in this group is the sovereign bond spread, calculated as the difference between each country's long term government bond yields from the German long term bond yield. It is reasonable to follow this convention, since the German economy is considered as the strongest, most prudent economy of the union[15]. This indicator represents the sovereign risk each country faces. Then, the realized volatility of each country's long term bond is used, again using daily data on their yields. Increasing uncertainty and flight-to-quality phenomena, sprung by excessive systemic stress level, would lead to higher volatility. The corporate bond spread, defined as the spread between the corporate bond yield from the governmental one. In this way, the default risk and inability of firms in times of financial strain to acquire the necessary capital for their operation, is depicted. An innovative feature of the dataset is the use of government bond duration. It is an interesting variable, since it represents the sensitivity of bonds prices to changes in interest rates. In general, it is expected to have a negative relation between bond duration and interest rates. Based on the volatile behavior of interest rates in periods of financial uncertainty, there not seems to be a consensus on the kind of effects a financially instable period have on bonds duration. On the other hand, recent research by Lee et. al (2012) and Lee et. al (2011), indicates the strong effect that excessive sovereign risk has on governmental bonds. According to these authors, the duration decreases, especially for bond with

[15] For the case of the Germany itself, we just include the yield of its 10 year governmental bond.

lower ratings. As a result, the heightening investors' concerns on possible default of debt strangled countries with low rated bonds, should lead to lower duration for the bonds of these troubled countries. The last indicator here is the so called realized correlation of each country's stock returns with the German Bund. With this variate, we aim to include the effects of the financial instability on the investors' decision to withdraw their invested funds from a troubled economy to one that is perceived as safe (in Eurozone's case, Germany). Again, this indicator is computed using daily data on our sample's general stock indices and the German long term government bond yield.

3.2 Methodological Approach

Our decision, regarding the construction methodology of our financial stress indices, follows the literature. We intend to calculate the FSIs based on the equally – weighted approach. According to this approach, an equal weight is attributed to all variables in each of the markets. In this way, the sectoral indices are computed, while the same approach is followed for the country – wide one. It should be emphasized here the fact that each series is demeaned and divided by its standard deviation. This is useful for two reasons: it helps avoiding problems of mis-measurement in the series, while it is also a necessary transformation, in order to evaluate the size of the financial instability in each time period, in terms of deviation from the mean value of the series. On top of that, in the case of the banking sector, since there is a cross-sectional dimension in our dataset (each variable in this sector, excluding the common ones, is extracted for more than one bank), we used an extra weight level, based on the size of each bank (so that, the employed banking balance sheet dataset to be more balanced and according to the systemic importance of each financial institution).

In the second stage of our analysis, we intend to explore potential existence of interactions and interrelations of the stress indices, both in country level as well as between the different markets. In order to do this, we are going to employ VAR models, one of the most popular empirical approaches for analysing causal relationships between macroeconomic and financial variables. Since these models were propagated by Sims (1980), they became something like a workhorse for macroeconomic and macro-financial empirical investigation. Especially, in cases where prior economic theorizing or established causal relations between some

economic or financial measures do not exist, the use of such a data driven econometric approach sounds natural.

In general, a VAR model consists of a number of equations, where all variables are considered as endogenous. Each equation incorporates lagged values of the dependent variable, in addition to lagged values of the rest of the variables. In the case of *k* variables and *k* error terms, the VAR(*p*) model is of the following form:

$$FSI_t = \gamma_1 FSI_{t-1} + \gamma_2 FSI_{t-2} + \ldots + \gamma_t FSI_{t-\rho} + \varepsilon_t$$

where $FSI_t = \left[FSI_{1,t} \; FSI_{2,t} \; \ldots \; FSI_{k,t} \right]'$ is a vector of all the endogenous variables of our model and

$\varepsilon_t = \left[\varepsilon_{1,t} \; \varepsilon_{2,t} \; \ldots \; \varepsilon_{k,t} \right]'$ is the vector of the error terms of the model, which are usually considered to be white errors, with a zero mean and constant variance. Finally, $\gamma_i \; (i = 1, \; \ldots \; , t)$ are the *kxk* matrices of the coefficients that need to be estimated by the model. For this chapter's case, we first employ a VAR model with eleven equations[16], while the examination of the country confined models consists of four equations (one for each market a stress index has been compiled for).

In the case of an unrestricted VAR model, the estimation can be done, using the usual OLS estimator. Of course, in order to have stable and robust results, it is necessary to test our series for their order of integration. Thus, before proceeding to our models' specification, we proceed with performing stationarity testing of the original series. The main test used is the augmented Dickey – Fuller (1979) test, while in case where the results were dubious, Phillips – Perron (1988) and KPSS (1992) test were also performed to verify whether or not a specified variable is stationary or not. The next step has to do with the models' specification. Thus, in order to choose the optimum number of lags for the equations, we use a number of lag selection criteria. These are the Akaike information criterion, the Schwarz criterion and the Hannan – Quinn one. As it is reasonable, not all of these criteria should indicate the same number of lags for a model. As it is discussed by Luetkepohl (2011), Akaike criterion is usually the most tolerant (provides evidence for higher lag order), while Schwarz

[16] This is the case of country wide models, where we estimate models for financial stress index in national level and, then, for the European bank, money, equity and bond markets.

criterion chooses the shorter order. The general idea is to begin modelling with a moderate lag structure, which is what we do, given the time span covered and the number of equations involved in the estimations. Models' adequacy is examined through the inspection of the residuals behaviour[17], even though, as commented by Luetkepohl (2011), residuals non-normality is not a problematic situation for the validity of the inference conducted with these models.

In any case, the importance of this empirical investigation lies on the detection of channels of financial stress propagation from country to country and from one market to another European market. Canova (2007) mentions that inference through the estimated VAR coefficients is not an efficient approach to use these models. Instead, he suggests the use of impulse responses, as an efficient way to study the interrelations and causal relationships of the endogenous variables included in such a model. Impulse response analysis is the trace of a one – unit innovation to one of the system's variable to itself and to the rest of the variables under investigation. This approach is really useful on pointing and analysing the effect of a structural change to any of the included financial stress indicators to the level of financial stress in the Euro Area countries. Here, we employ both the well-known Cholesky decomposition approach, where the variables ordering (in terms of the sequence of the unexpected shocks involved) is important, while the generalized impulse responses, as proposed by Pesaran and Shin (1998), are employed as robustness checks in the aforementioned methodology. Here, the derived orthogonal set of innovations renders variables ordering obsolete.

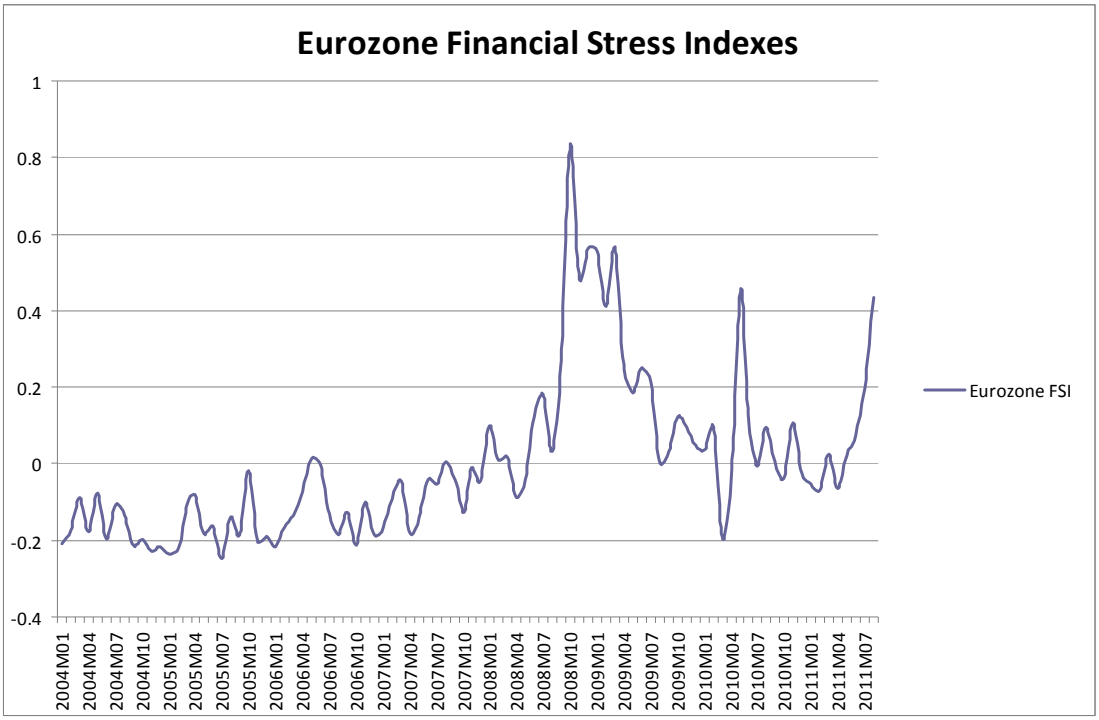
4. Eurozone's Financial Stress Narrative

The following graph depicts the aggregate Euro Area- wide Financial Stress Index. As it is previously noted, the period covered is from January 2004 to August 2011. In this sense, there is a wide coverage of, both, the initiation of the global financial crisis, its evolution and transformation to the current situation faced by the most indebted members of the monetary union. In general, the index indicates some minor fluctuations to its value, prior to 2007, without any of those presenting a serious

[17] That is, whether they are normally distributed, heteroskedastic or autocorrelated.

threat for the stability of the markets. On the other hand, it is evident a slow but steady gradual increase in the level of financial stress, which reached its climax in the third quarter of 2008. The reason cannot be other than the Lehman Brothers collapse that took place in September 2008, with a number of major repercussions to the world

Graph 1: Level of Financial Stress for Euro Area



financial system. In this case, the index reached it maximum value of 0.84 on October 2008, while it remained in high level until the end of the first quarter of 2009. In the meantime, the European Central Bank, through a number of unconventional monetary policies initiatives, tried to stabilize the increased systemic risk and uncertainty in the markets. For instance, right after the Lehman Brothers collapse and the, consecutive drying up of the interbank money market, the Eurozone's monetary authority proceeded to the acceptance of more financial assets, as collateral for the emergency funding, while on 2009 the covered bonds program was populated. Together with the decrease of the main refinancing rate by ECB, it was expected and apparent from the graph above an abatement of the financial stress level. But this would not last for long, since the evolving crisis in Greece led to another outbreak of financial stress, on April and May 2010. The agreement on a rescue program seemed to tranquil the Eurozone

economy, for a while, until another spike in the index came out as a consequence of the need for financial assistance and fiscal austerity measures, this time for Ireland (towards the end of 2010) and Portugal in early 2011. The financial stress remained excessively high, until the end of our sample, which includes the decision for the haircut on the Greek public debt.

5. Empirical Analysis

In this section, we proceed to a more systematic analysis of the interconnections and the level of transmission of systemic stress from one country of the Eurozone to the others. In order to do this, a Vector Autoregressive (VAR) model is employed, which includes the financial stress indexes of the eleven Euro Area countries under examination. As a result, a model with eleven equations is used, the lags of which were chosen according to the usual well-known criteria[18]. Based on the different specifications, the residuals normality and autocorrelation tests, the model chosen to be presented is a VAR(1) model. The following graphs represent the impulse responses of this model, where the effects of a financial shock in each one of the countries we examine are depicted.

The results offer some quite interesting and intriguing illustrations for the Eurozone crisis. First of all, it seems that, in all cases, countries are mostly responsive to their own financial shocks. With the exceptions of Finland, Belgium, Italy and Greece, the excessive financial stress soon returns to its prior levels. In case of Greece, the effect lasts for almost a year after the initial shock, while Finland's one is even more persistent. Additionally, some degree of regionalism is apparent in the results. According to the impulse responses, the peripheral debt-ridden countries are more responsive to the increasing financial stress of the same countries, while the similar effect is sketched for the major Euro Area countries, notably Germany, France, Netherlands and Finland. This implies the existence of disparities in the way that financial shocks reflect on the union's member countries, while it can be also an indication to ECB for adoption of different policies in countries that face divergent

[18] AIC, SIC, HQ criteria.


Response of Financial Stress Indices Level to Financial Stress Shocks
Response of AUFSI to AUFSI
Response of AUFSI to BEFSI
Response of AUFSI to FIFSI
Response of AUFSI to FRFSI
Response of AUFSI to GEFSI
Response of AUFSI to GRFSI
Response of AUFSI to IRFSI
Response of AUFSI to ITFSI
Response of AUFSI to NEFSI
Response of AUFSI to POFSI
Response of AUFSI to SPFSI
Response of BEFSI to AUFSI
Response of BEFSI to BEFSI
Response of BEFSI to FIFSI
Response of BEFSI to FRFSI
Response of BEFSI to GEFSI
Response of BEFSI to GRFSI
Response of BEFSI to IRFSI
Response of BEFSI to ITFSI
Response of BEFSI to NEFSI
Response of BEFSI to POFSI
Response of BEFSI to SPFSI
Response of FIFSI to AUFSI
Response of FIFSI to BEFSI
Response of FIFSI to FIFSI
Response of FIFSI to FRFSI
Response of FIFSI to GEFSI
Response of FIFSI to GRFSI
Response of FIFSI to IRFSI
Response of FIFSI to ITFSI
Response of FIFSI to NEFSI
Response of FIFSI to POFSI
Response of FIFSI to SPFSI
Response of FRFSI to AUFSI
Response of FRFSI to BEFSI
Response of FRFSI to FIFSI
Response of FRFSI to FRFSI
Response of FRFSI to GEFSI
Response of FRFSI to GRFSI
Response of FRFSI to IRFSI
Response of FRFSI to ITFSI
Response of FRFSI to NEFSI
Response of FRFSI to POFSI
Response of FRFSI to SPFSI
Response of GEFSI to AUFSI
Response of GEFSI to BEFSI
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Response of SPFSI to SPFSI

financial and economic obstactles. Another important finding, which appears to contradict the mainstream view on the current crisis, is the minor effects that increasing financial stress in Greece and Portugal seem to have to the rest of the Eurozone countries. According to the impulse response graphs above, there is no evidence of transmission of heightening financial risk from these troubled countries to the rest. On the other hand, the Italian financial upheaval has some effect on most countries, although not always in the expected way (negative effect on the level of financial stress). In any case, the previously mentioned finding, for the minor role of Greece and Portugal in the crisis transmission is concurrent by a recent piece of research by Gonzalez-Hermosillo and Johnson (forthcoming). In this work, the authors emphasize the fact that, according to their stochastic volatility model, most of the risk associated with the current Eurozone countries is country specific, while they could not provide any hard evidence to blame Greece or Portugal as major channels of crisis contagion to the rest of the Euro Area. These are very interesting results, with further empirical investigation needed, in order to become even more conclusive. Last but not least, we should also mention that our results remain consistent, using generalized impulse responses. Finally,

6. Concluding Remarks

Aim of this work is the study of financial stress level of the countries that constitute the Euro Area. In this way, an early warning indicator of forthcoming financial turmoils can be constructed, which is able to provide timely indications of potential financial crashes. Additionally, a VAR model is employed, so that indications on the existence or not of financial stress transmission within the Eurozone countries can be provided. According to our results, countries are mostly responsive to their own financial shocks, while a degree of regionalism is evident, in the sense that peripheral countries are more susceptible to their financial stress, while the same holds for the core Eurozone countries. Finally, in contrast to common wisdom, financial conditions in Greece and Portugal do not seem to affect the rest of the Euro Area, at least in the degree that Italy and Ireland do.

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