Sovereign CDS Spread Determinants and Spill-Over Effects During Financial Crisis: A Panel VAR Approach

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Abstract

This paper examines the determinants of CDS spreads and potential spillover effects for Eurozone countries during the recent financial crisis in the EU. We employ a Panel Vector Autoregressive (PVAR) model which combines the advantages of traditional VAR modelling with the advantages of a panel-data approach. In addition to variables that proxy for global and financial market spread determinants we also employ variables that proxy for behavioral determinants. We find that the determinants of CDS variance are neither uniform nor stable during different periods and different countries. For instance, as we move from 2008 to 2014 the impact of the slope of the term structure on CDS spread variance is increasing for Spain, Portugal, Italy, Greece, Ireland, and decreasing for Germany, France, Netherlands, Belgium and Austria. Other findings indicate that investor sentiment may be an important CDS spread determinant during the period between 2008 and 2010, along with other factors, while spillover effects may run from Spain and Italy to core countries while spillover effects from Portugal, Greece, and Ireland are of minor importance.

Keywords: Financial Crisis, CDS, Spreads, Panel VAR, Sentiment
JEL Classifications: G12, G14, G15

1. Introduction

During the past two decades the Credit Default Swap (CDS) market has undergone a significant expansion. For instance, in early 1998 the value of this market was estimated at a few hundred billion US dollars; however, as of June 2007 the notional amount outstanding for OTC CDS was $45,179 billion, and by June 2014 at $19,462 billion (source: Bank for International Settlements). Peltonen et al. (2014) find that the CDS market is clustered around fourteen major dealers and exhibits a "small world" structure, where most CDS investors are net buyers. CDS spreads reflect the perception of market participants about the financial health of creditors and signal warnings about financial stability (Annaert et al., 2013).

Following this market growth, the emergence of CDS as an asset class, and motivated by the role of the CDS market in the global financial crisis, academic research on CDS instruments and spreads flourished. Also, as Ang and Longstaff (2013) argue, there is an important advantage in using CDS spreads compared to debt spreads when studying credit risk: debt spreads are determined by many other factors apart from credit risk, such as changes in the interest rates, the supply of the underlying bond, liquidity, etc. The literature on sovereign CDS, however, developed less rapidly compared to the literature on corporate CDS (Doshi et al., 2014). For instance many recent studies focus on bank or corporate CDS spreads (e.g. Chiaramonte and Casu, 2013; Galil et al., 2014; Annaert et al., 2013; among others) or emerging market CDS spreads (see Hilscher and Nosbusch, 2010; Ammer and Cai, 2011; Fender et al., 2012; among others). Furthermore, the early literature on credit spreads mainly concentrates on bond yield spread determinants and documents the role of common global and financial market factors (Edwards, 1984; Berg and Sachs, 1988; Boehmer and Megginson, 1990; Eichengreen and Mody, 2000; Remolona, et al. 2008; among others). In terms of empirical approaches employed to study the CDS market, Doshi et al. (2014) point out that there are two different strands in the recent literature. Many studies employ reduced-form latent models to model credit risk (e.g. Pan and Singleton, 2008; Longstaff, et al., 2011), while other studies regress CDS spreads on variables that capture fundamental macroeconomic spread determinants (e.g. Dieckmann and Plank, 2012). For example, spillover effects are often examined with global vector autoregression (GVARs) models of sovereign debt across countries; usually a VAR model for each sample country is estimated that includes global variables (Caporale and Girardi, 2011; Eickmeier and Ng, 2011).

This paper examines the determinants of CDS spreads and potential spillover effects for Eurozone countries during the recent financial crisis in the EU. It contributes to the relevant literature in a number of ways. More specifically, we employ a research methodology that is based on a Panel Vector Autoregressive (PVAR) model which combines the advantages of traditional VAR modelling with the advantages of a panel-data approach. According to Love and Zicchino (2006) the PVAR is a combination of the traditional VAR "….which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity" (p. 193). Also a main difference between PVAR and Global VAR models is that the coefficients on the foreign variables are restricted to zero, and only one set of coefficients are estimated (not one set for each country, as in the GVAR). In other words, we are able to examine the extent to which CDS spreads in Eurozone countries are due to changes in global or country-specific factors while allowing for a country-specific unobserved heterogeneity in the levels of the variables (fixed effects). We also examine spillover effects, orthogonalized impulse-response functions, and variance decompositions through which we are able to separate the response of CDS spreads to shocks coming from each variable used to proxy for spread determinants.

Furthermore, in addition to variables that proxy for global and financial market spread determinants we also employ variables that proxy for behavioral determinants. Note that the vast majority of previous studies focuses on macroeconomic and fundamental information in order to study the determinants of spreads and neglect behavioral variables that may capture investor and economic sentiment. The variables we employ are the Economic Sentiment Indicator (ESI) that is published monthly by the European Commission (DG ECFIN) and aims to assess the business and consumer confidence, and the ZEW Economic Sentiment indicator which is an amalgamation of the sentiment of approximately 350 economists and analysts regarding the economic climate in Europe for the next six months. Experts are asked for a qualitative assessment of the direction of inflation, interest rates, exchange rates and the stock market and as a result the indicator provides a medium-term forecast for the Eurozone economy. The ESI combines assessments and expectations stemming from business and consumer surveys for different sectors: industry, consumers, construction, and retail. Rua (2002) argues that the ESI has information content for the GDP growth rate; in this sense, the domestic ESI may have significant information content for spreads. Note that we also employ a variable that has not been used in previous studies, the number of CDS contracts traded, which may serve as a twin proxy: on one hand it may proxy for liquidity (for which we also use the bid-ask spread) but on the other hand a measure of trading volume, such as the number of contracts traded, may capture optimism or pessimism and, thus, it may serve as a market-based proxy for sentiment (see Baker and Stein, 2004; Baker and Wurgler, 2006).

Several interesting results emerge from the analysis. We find that the determinants of CDS variance are neither uniform nor stable during different periods and different countries. For instance, as we move from 2008 to 2014 the impact of the slope of the term structure on CDS spread variance is increasing for peripheral countries (Spain, Portugal, Italy, Greece and Ireland) and decreasing for the core countries (Germany, France, Netherlands, Belgium and Austria); the effect of VIX, a proxy for global market risk, is not very important for the core countries, however, it is very important for peripheral countries between 2008 and 2012 (it contributes to CDS variance by approximately 31%). We also report evidence that investor sentiment may be an important CDS spread determinant during the period between 2008 and 2010, along with other factors, a result consistent with the results of Spyrou (2013) who reports that similar findings for both the level and changes in bond yields (see also, Heinz and Sun, 2014).

Other findings indicate that spillover effects may run from Spain and Italy to core countries while spillover effects from Portugal, Greece, and Ireland are of minor importance. Italy and Spain, being much larger economies, could potentially destabilize the euro area, even though their likelihood of running into financial difficulties was perceived by the markets as comparatively smaller, based on their SCDS spreads. Moreover, following the first Greek debt restructuring in mid-2011, Greek CDS spread was persistently well above 1000 bps and probably carried little information for investors. Our finding is consistent with the results of Kalbaska and Gatwoski (2012) who study contagion among several European sovereigns using CDS data and conclude that the potential spillovers from Spain and Italy, especially until July 2012, were of a great importance. The rest of this paper is organized as follows. Section 2, reviews the relevant literature, section 3 discusses the data and the methodology, section 4 presents the results, while section 5 concludes the paper.

2. Previous Studies

Longstaff, et al. (2010) examine monthly 5-year CDS for 26 countries between 2000 and 2010 and find that sovereign CDS spreads can be explained to a large extent by U.S. equity, volatility, and bond market risk premia, while global risk is a good predictor of risk premia. In addition, Longstaff et al. (2011) find that important determinants are global financial market variables or a global risk premium, while the contribution of local macroeconomic variables is of minor importance; this implies that systemic sovereign risk is more related to financial markets than to country-specific variables. Heinz and Sun (2014) use a panel GLS error correction framework and find that European sovereign CDS spreads are largely driven by factors such as global investor sentiment, macroeconomic fundamentals and liquidity conditions in the CDS market, with their relative importance changing over time (see also Beirne and Fratzscher, 2012; Ejsing and Lemke, 2011).

Caporin et al. (2012) find that contagion in Europe remained subdued during their sample period and suggest that the common shift observed in CDS spreads is the outcome of the usual interdependence. Broto and Perez-Quiros (2013) employ a multivariate model with time-varying correlations and volatilities, and decompose the sovereign CDS spreads of ten OECD economies into three single components: a common factor, a second factor driven by European peripheral countries and an idiosyncratic component. They argue that since the onset of the sovereign debt crisis contagion has played a role of major importance in the European peripheral countries. Anderson (2010) studies the source of the increase in the correlation CDS spread changes during the crisis and finds evidence suggesting that fluctuations in fundamental credit risk account for only a small fraction of the increase in correlation, and no evidence of increased correlations due to liquidity or counterparty risk. Focusing on contagion between sovereigns and banks, Gross and Kok (2013) document a number of salient facts: firstly that spill-over potential in the CDS market was particularly intense in 2008 and more recently in 2011-12; secondly, while in 2008 contagion primarily moved from banks to sovereigns, the direction reversed in 2011-12 during the sovereign debt crisis; thirdly, spill-over indices indicate that the system of banks and sovereigns has become more densely connected over time (see also Alter and Schüler, 2011). Diebold and Yilmaz (2009, 2011, and 2012) find that equity markets had an important contribution in transmitting spillovers to international markets and other asset classes, while Claeys and Vašíček (2012) using a similar econometric framework find that spillovers among sovereign yields increased considerably since 2007 and that they dominate the domestic fundamental factors for EMU countries.

Many studies also focus on price discovery. For instance, Fontana and Scheicher (2010) study the relationship between the relative pricing of euro area sovereign CDS and the underlying government bonds and find that since September 2008, market integration for bonds and CDS varies across countries: in half of the sample countries, price discovery takes place in the CDS market, while in the other half, price discovery takes place in the bond market. Ammer and Cai (2011) find evidence that CDS premia and bond yield spreads are linked by a stable linear long-run relationship and underline the role of the "cheapest to deliver" option in affecting CDS premia, while Palladini and Portes (2011) find that the CDS market moves ahead of the bond market in terms of price discovery.

Canova, Cicarrelli and Ortega (2012) use a PVAR model of the type developed in Canova and Ciccarelli (2009), and apply their approach to data of ten European countries in order to examine changes in European business cycles and the transmission of shocks. Ciccarelli, Ortega and Valderama (2012), using a Bayesian VAR model, examine heterogeneity and spillovers in macro-financial linkages across developed economies with a particular emphasis in the most recent debt crisis. Diebold and Yilmaz (2010) use a Generalized VAR framework and report that although significant volatility fluctuations exist in all their sample markets, cross-market volatility spillovers were quite bordered until the global financial crisis outburst in 2007. Bouvet, Brady and King (2013), employ a PVAR model for EMU countries to investigate the effect of yield spreads in fiscal variables.

3. Data and Methodology

For the empirical analysis we employ monthly observations on 5-year Credit Default Swap (CDS) spreads are employed for ten Eurozone markets: Germany, Austria, Belgium, France, Greece, Ireland, Italy, Netherlands, Portugal, and Spain, which we group to two sub-samples denoted for simplicity as the "core" countries (Germany, France, Netherlands, Belgium and Austria) and the "peripheral" countries (Spain, Portugal, Italy, Greece and Ireland). In order to investigate what drives European sovereign CDS spreads, especially over the recent turbulent period, we employ a set of explanatory variables that proxy for credit risk, global risk aversion, European wide market risk, banking stress, investor market expectations about future conditions in financial market, country specific economic sentiment, and liquidity in the CDS market. The explanatory variables are described in more detail below.

The Chicago Board Options Exchange Volatility Index (denoted as *VIX*). Since credit spreads are assumed to also compensate investors for pure expected losses (Hull et al., 2005), they may be sensitive to changes to investor risk aversion. The VIX is often considered as a measure of market expectations of near-term volatility conveyed by S&P 500 stock index option prices. It is based on the weighted average of the implied volatilities for a wide range of strikes and is considered as a market estimate of future volatility. Implied volatility has the potential to reflect information that a model-based forecast could not; for instance the VIX index reflects information related to both past jumps and future jump activity (Becker, et al. 2009).

The 3-month Euribor–Eonia Spread (denoted as *Eur-Eon*). This measure captures both credit risk/banking stress and market liquidity, and may be considered as an alternative to the Libor spread. The Euro Inter Bank Offered Rate (Euribor) is the rate at which major European banks borrow funds from each other for maturities ranging from one week to twelve months. The Euro OverNight Index (Eonia) is the 1-day interbank interest rate for the Euro zone, in other words it may be thought of as the 1-day Euribor rate. We employ the difference between the 3-month Euribor and the 3-month Eonia rate. Pelizzon et.al. (2014) use the Euribor-Eonia in order to examine the dynamic relationship between credit risk and liquidity, while Caporin et al. (2012) employ this measure to analyse sovereign risk contagion.

Corporate CDS Premium (denoted as *iTraxx*). In order to capture market-wide credit risk we use iTraxx Europe (non-financial firms). The iTraxx Europe is composed of the 125 most liquid investment-grade default swaps. The European index is further split up into several sector indexes, namely, a corporate index comprised of the largest non-financial names (from the 125 names), a crossover index comprising the 25 most liquid sub-investment grade non-financial names and a HiVol index that consists of the 30 names with the widest CDS spreads. The iTraxx indices typically trade with 5 as well as 10-year maturities and new series are issued every 6 months. Berndt and Obreja (2010) find that a main spread determinants is the iTraxx Europe index, referred to as "the economic catastrophe risk".

The slope of the term structure (denoted as *termspread*). We define the slope of the term structure as the difference between the 10-year government bond yield for each country and the 3-month Euribor rate (see, among others, De Bruyckere, 2012; Estrella and Hardouvellis, 1991). A rising slope of the term structure may lower credit spreads (Longstaff and Schwarz, 1995) while inversions of the yield curve are often related to expected recessions (Estrella, 2005; Dombrosky, 1996). To the extent that an increase in the slope of the term structure can be thought of as an indicator of an expected improvement in the level of future economic activity, it should result in a reduction in credit spreads.

Economic Sentiment Indicator (denoted as *ESI*). The ESI is published monthly by the European Commission (DG ECFIN), in order to assess business and consumer confidence. This indicator combines assessments and expectations stemming from business and consumer surveys. Such surveys include different sectors of the economy: industry, consumers, construction, and retail trade.

CDS trading volume (denoted as *NOC*). We use trading volume (number of CDS contracts traded on a weekly basis) as a liquidity proxy for the market of sovereign CDS. The Number Of Contracts (NOC) is the total number of CDS contracts bought (or equivalently sold) for all Warehouse contracts in aggregate, by sector or for single reference entities displayed. Fontana and Scheicher (2014), use the NOC measure in order to investigate whether basis deviations from the parity predict CDS and bond trading activity. Note that it can also be thought of as a measure of investor sentiment: Baker and Stein (2004) note that if short-selling is costlier than opening and closing long positions, irrational investors are more likely to trade, while Baker and Wurgler (2006) use NYSE share turnover as investor sentiment proxy.

Changes are defined as the first differences of the logarithmic levels; all data are monthly and obtained from DataStream International, Bloomberg, and the Depository Trust & Clearing Corporation, DTCC. The sample covers the period between November 2008 and January 2014 (the start date is dictated by the availability of number of CDS contracts data). Table 1 presents descriptive statistics for the variables. In order to examine the stability of the results overtime we also split the sample into three sub-periods. The first is between November 2008 and April 2010, the second is between May 2010 and July 2012, and the third is between August 2012 and April 2014). The first period roughly coincides with the outbreak of the subprime crisis in the USA, the second with the outbreak of EU financial crisis (see Hermosillo and Johnson, 2014), while the third period may be considered as a more tranquil period, comparatively. Note that Greek CDS trading data are not available during the second and the third period since in 2010 trading was halted. Thus, the reported results exclude Greek CDS data; however, we re-estimated all results for the second and third period with the unavailable Greek CDS spread date being replaced by the sovereign Greek bond yield spread (vs Germany) and the results are qualitatively the same to the reported results (available upon request). Also, Ireland is excluded from the third period due to lack of ESI data.

Table 1
Descriptive Statistics

Variables	Mean	Min	Max	Std. Deviation	No Obs
Vix	0.0066	-0.4242	0.4242	0.1844	660
iTraxxEu	-0.0118	-0.2464	0.3018	0.1286	660
Termspread	-0.0186	-0.6480	0.9030	0.2880	660
Eur-Eon	0.0418	-11.850	10.047	0.9396	660
Esi	0.0016	-0.1315	0.0896	0.0286	648
Noc	0.0277	-0.4187	0.3938	0.0768	634
Sov CDS	0.0021	-0.7054	0.7531	0.2053	629

Notes to Table 1
The Table presents descriptive statistics for the following variables: The Chicago Board Options Exchange Volatility Index (denoted as VIX), the Corporate CDS Premium (denoted as iTraxx), the slope of the term structure (denoted as termspread), the 3-month Euribor–Eonia Spread (denoted as Eur- Eon), the Economic Sentiment Indicator (denoted as ESI), the CDS trading volume (denoted as NOC), the Sovereign CDS spread (denoted as Sov CDS). Changes are defined as the first differences of the logarithmic levels. All data are monthly and obtained from DataStream International, Bloomberg, and the Depository Trust & Clearing Corporation, DTCC. The sample covers the period between November 2008 and January 2014 (the start date is dictated by the availability of number of CDS contracts data).

For the empirical analysis, we use Panel Data Vector Autoregression (PVAR) methodology; all variables in the system are treated as endogenous (VAR), while unobserved individual heterogeneity is allowed. Using a PVAR approach we are able to combine the traditional VAR model with a panel-data approach based on the PVAR routine written by I. Love (Love & Zicchino, 2006). We consider this to be a major advantage of this approach, as it allows for intertemporal interactions between the variables and it estimates the impulse responses by calculating the reaction of one variable from a shock to another. We specify a first-order seven-variable VAR model:

$$Z_{i,t} = \gamma_o + \gamma_1 Z_{i,t-1} + f_i + \epsilon_d \qquad (1)$$

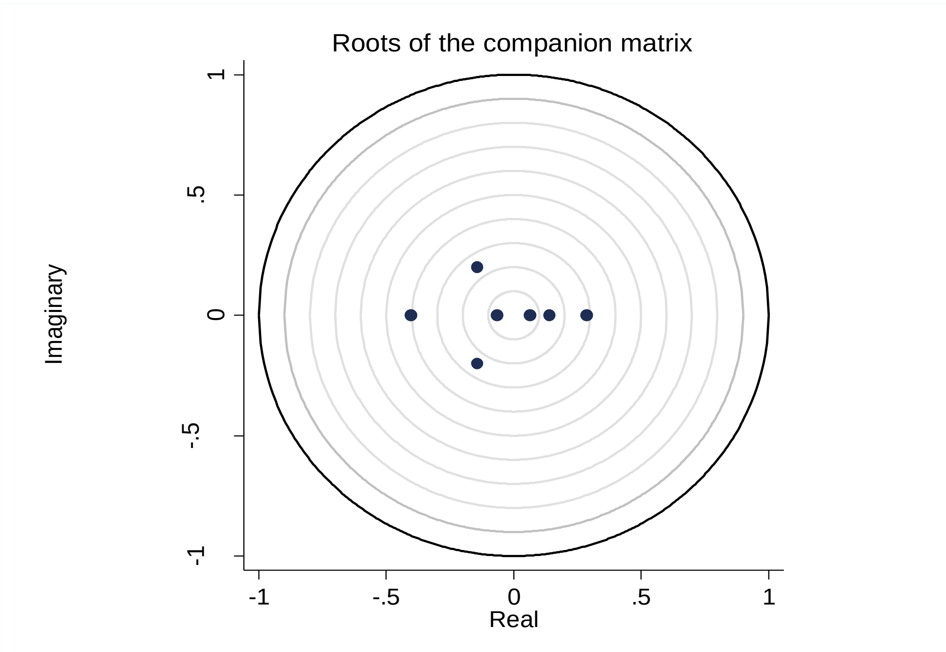
In (1), $Z_{i,t}$ is a seven-variable vector, γ are the coefficients, f_i are the fixed effects, and ε_d the residuals of the model. We use the Love and Zicchino (2006) code for panel VAR estimation in STATA, and all of the results are estimated using a PVAR with one lag. The evidence from this analysis is mostly based on the results from the impulse-response functions and the variance decompositions. Furthermore, we use a Choleski decomposition of the variance-covariance matrix of residuals, since the actual variance-covariance matrix of the errors is highly unlikely to be diagonal. In this case, it becomes difficult to isolate shocks to one of the VAR errors, i.e. we have to decompose the residuals in a way that they become orthogonal. With the Cholesky ordering we assume that the most exogenous variable is the VIX Index and the least exogenous is the sovereign CDS. An important restriction is that the underlying structure is the same for each cross-sectional unit, which however, may not hold. Thus, we allow for "individual heterogeneity" in levels by introducing fixed effects. Simple-mean differencing would give us biased estimators, as fixed effects are correlated with the repressors due to lags of the dependent variables. In order to avoid that we follow Love and Zicchino (2006); that is, we introduce the forward mean-differencing procedure also known as Helmert transformation. According to Arellano and Bover (1995), the Helmert transformation removes only the forward mean. Since, dependent and lagged variables remain orthogonal we can estimate the coefficients by using system GMM.

To analyze the impulse- response functions we need an estimate of their confidence intervals. Since the matrix of impulse-response functions is constructed from the estimated VAR coefficients, their standard errors need to be taken into account. We calculate standard errors of the impulse-response functions and generate confidence intervals with Monte Carlo simulations.

4. Results

Table 2 presents results for the panel unit root test of Im-Pesaran-Shin (2003; IPS test). As can be seen in the Table we cannot reject the null hypothesis of a unit root, for all sample variables. The next step is the lag selection for the PVAR model. In order to decide on the lag structure we use the overall coefficient of determination (CD) and the Moment and Model Selection Criteria (MMSC) developed by Andrews and Lu (2001) and the MMSC-Akaike's information criterion (MMSC-AIC). Andrews and Lu's MMSC are based on Hansen's *J* statistic, which requires the number of moment conditions to be greater than the number of endogenous variables; the authors argue that the MMSC-AIC criterion works best, in comparison to other competitors, in small samples as the case is in this paper. The results are presented in Table 3 (Panel A) and indicate that the optimal lag structure is one lag. In Panel B of Table 3 we report evidence on the stability properties of the estimated PVAR model. The stability of the PVAR requires the moduli of the eigenvalues of the dynamic matrix to lie within the unit circle which is the case in our estimated model (see Figure 1).

Figure 1
Roots of the Companion matrix



Notes to Figure 1
The stability of the Panel VAR requires the moduli of the eigenvalues of the dynamic matrix to lie within the unit circle. Panel VAR satisfies stability condition as all eigenvalues lie inside the unit circle.

Following the Cholesky Ordering the variables are ordered as follows: VIX, Euribor-Eonia spread, iTraxx index, Termspread, Economic Sentiment Indicator, number of CDS contracts and sovereign CDS spreads. The recursive order dictates that the other countries' CDS spread responds to changes in the other variables in time *t*. In contrast, the VIX index only responds to itself in time *t*, and only with a lag to the other variables. However, one could argue the other way if automatic stabilizers immediately change the ratio. We considered this alternative ordering, but the change in ordering does not greatly affect our analysis and conclusions. Note that Lutkepohl (1991) argues that the ordering of the variables makes little difference when the residuals' correlation is small. There have been two exceptions, this being the peripheral countries in the first and the second period. Testing for alternative orderings we detected that between VIX and iTraxx index the ordering was not clear. Financial instabilities through this turbulent period lead to such problems, and as a result in order to address this problem in these periods for the peripheral countries, we take iTraxx and VIX as a single indicator, namely a factor counting for global wide market risk.

As far as the estimated parameters of the Panel Var are concerned, we suggest that the estimates do not convey much information. Instead, one should pay attention to the underlying moving average (MA) representation of the VAR model, namely the impulse response functions (IRs) and the associated variance decompositions (VDs). These two combined, convey information on how each variable responds to a surprise change (a shock) to another variable in the system. Nevertheless, for indicative purposes, we present the results of the estimated parameters in Table 4, only for the case when the Sovereign CDS are treated as endogenous variable in the system (the rest of the results are available upon request).

Table 2
Panel data unit-root tests

	Critical Values			Test Statistics (*p*-values)						
	1%	5%	10%	**VIX**	**iTraxx**	**Eur-Eonia**	**termspread**	**ESI**	**NOC**	**SOV CDS**
Core	-2.40	-2.15	-2.02	-5.837 (0.00)	-5.772 (0.00)	-6.918 (0.00)	-5.031 (0.00)	-4.703 (0.00)	-5.243 (0.00)	-5.337 (0.00)
Core 1st	-2.50	-2.19	-2.04	-2.922 (0.00)	-2.886 (0.00)	-3.468 (0.00)	-2.072 (0.00)	-2.331 (0.00)	-2.486 (0.00)	-2.581 (0.00)
Core 2nd	-2.44	-2.16	-2.02	-3.738 (0.00)	-3.686 (0.00)	-4.346 (0.00)	-3.658 (0.00)	-2.831 (0.00)	-3.785 (0.00)	-3.432 (0.00)
Core 3rd	-2.46	-2.18	-2.04	-3.495 (0.00)	-3.713 (0.00)	-3.632 (0.00)	-3.274 (0.00)	-3.141 (0.00)	-3.281 (0.00)	-3.026 (0.00)
South	-2.50	-2.19	-2.04	-2.922 (0.00)	-2.886 (0.00)	-3.468 (0.00)	-2.105 (0.00)	-2.549 (0.00)	-2.978 (0.00)	-2.491 (0.00)
South 1st	-2.50	-2.19	-2.04	-2.922 (0.00)	-2.886 (0.00)	-3.468 (0.00)	-2.105 (0.00)	-2.549 (0.00)	-2.978 (0.00)	-2.491 (0.00)
South 2nd	-2.44	-2.16	-2.02	-3.738 (0.00)	-3.686 (0.00)	-4.34 (0.00)	-3.603 (0.00)	-3.718 (0.00)	-3.531 (0.00)	-3.882 (0.00)
South 3rd	-2.46	-2.18	-2.04	-3.427 (0.00)	-3.713 (0.00)	-3.632 (0.00)	-3.348 (0.00)	-3.487 (0.00)	-3.117 (0.00)	-2.871 (0.00)

Notes to Table 2

The Table presents results for the Im. Pesaran and Shin (2009) test (IPS test). The null hypothesis is that of a unit root. VIX is the Chicago Board Options Exchange Volatility Index; Eur-Eon is the 3-month Euribor–Eonia Spread; iTraxx is the corporate CDS Premium (iTraxx Europe non-financial firms); Termslope is the slope of the term structure, i.e. the difference between the 10-year government bond yield for each country and the 3-month Euribor rate; ESI is the Economic Sentiment Indicator; NOC is the number of CDS contracts traded on a weekly basis; SOV CDS is the Sovereign CDS spread. Changes are defined as the first differences of the logarithmic levels. All data are monthly and obtained from DataStream International, Bloomberg, and the Depository Trust & Clearing Corporation, DTCC. The sample covers the period between November 2008 and January 2014.

Table 3
Lag Selection and Eigen Value Stability Condition

Panel A: Lag order selection statistics estimated using GMM				
Lag	**CD**	**MBIC**	**MAIC**	**MQIC**
1	0.5900	2.04E-30	2.04E-30	2.04E-30
2	0.8125	1.39E-29	1.39E-29	1.39E-29
3	0.8839	2.74E-29	2.74E-29	2.74E-29
4	0.9230	3.86E-29	3.86E-29	3.86E-29

Panel B: Eigen Value Stability Condition of Panel VAR estimates		
Eigenvalue		
Real	**Imaginery**	**Modulus**
-0.4023	0	0.4023
0.2865	0	0.2865
-0.1413	0.2011	0.2458
-0.1413	-0.2011	0.2458
0.1402	0	0.1402
-0.0664	0	0.0664
0.0632	0	0.0639

Notes to Table 3
The Table presents test reults for the optimal lag structure. We employ the overall coefficient of determination (CD) and from the Moment and Model Selection Criteria (MMSC) developed by Andrews and Lu (2001) and the MMSC-Akaike's information criterion (MMSC-AIC). Andrews and Lu's MMSC are based on Hansen's *J* statistic, which requires the number of moment conditions to be greater than the number of endogenous variables; the authors argue that the MMSC-AIC criterion works best, in comparison to other competitors, in small samples as the case is in this paper.

Table 4
Coefficients of the Panel VAR with sovereign CDS as endogenous variable

	Core Countries			**Peripheral Countries**		
	1st Period	**2nd Period**	**3rd Period**	**1st Period**	**2nd Period**	**3rd Period**
VARIABLES	Sov_Cds	Sov_Cds	Sov_Cds	Sov_Cds	Sov_Cds	Sov_Cds
L.vix	-0.1180	-0.0289	-0.0633	-0.6630***	0.2560	-0.0217
L.itraxxEu	0.4140	0.0640	-0.0139	-0.4260	0.1250	-0.2060
L.Eur-Eon	0.2211**	0.0794	0.4881***	0.1990**	0.0888	0.5970***
L.termslopefd	0.2260*	-0.0119	-0.0483	-0.0056	-0.0265	0.1270***
L.esi	-2.3920**	-1.8810**	1.3101**	-2.5650***	-0.3650	1.5701
L.noc	-1.894***	0.8740***	-0.0506	-2.3861**	0.7000***	0.4841***
L.cds	0.1181	-0.1194	0.0468	0.2092	-0.1111	0.0187

Notes to Table 4
The Table reports coefficients of regressing the dependent variables on lags of the independent variables. ***, **, *, denote significance at the 1%, 5%, and 10% respectively. See also Notes to Table 1.

In order to assess the contribution of each determinant in the behavior of sovereign CDS spreads, we estimate their variance decomposition. The results for the three sub-periods are presented in Table 5 (for the period between November 2008 and April 2010), Table 6 (for the period between May 2010 and July 2012), and Table 7 (for the period between August 2012 and April 2014). The focus is on the last line of each panel matrix as it represents the sovereign CDS variance decomposition. As can be seen in Table 5 (Panel A) the main contributor in the first sub-period for the core countries' sovereign CDS variance decomposition (except for the own effect, 23.9%), is the iTraxx European index, with a 26.3% of the total sovereign CDS variance. The termspread and the number of CDS contracts traded are also important contributors each contributing to 13% of the total variance, while Euribor-Eonia spread contributes another 10% approximately. VIX and ESI indices appear to be less important. For the peripheral countries (Panel B), however, it is the VIX and the iTraxx that together contribute approximately 32% to the variance of peripheral countries CDS while second more important contributor is the number of CDS contracts traded with a further 16.61%. The Euribor-Eonia spread and the ESI contribute less than 10% to the total variance. The termspread contributes approximately 10%. The sovereign CDS own effect is approximately 23%. Note that the two variables that may proxy for sentiment (ESI & NOC) have a combined effect of around 20% for core countries and around 25% for peripheral countries.

During the second sub-period, for the core countries (Table 6, Panel A) the iTraxx contributes approximately 33% and together with the CDS own effect (41%) account for approximately 72% of variance. The number of CDS contracts contributes 8% to the total variance while the other variable contribution is of minor importance. For the peripheral countries (Panel B) the major contributors are the VIX (approximately 30%), the CDS own effect (37.45%), and the termspread with 18.77%, while the contribution of the other variables is minor. During the third sub-period (Table 7) the results indicate that for the core countries (Panel A) the most important contributors are the CDS own effect (61.84%), the Euribor-Eonia spread with 16.7% and the iTraxx with 11.39%. For the peripheral countries (Panel B) the determinant contributing the most to the variance of CDS is the Euribor-Eonia spread (32.8%), the termspread (21.35%), the CDS own effect (19.39%) and the iTraxx (14.78%). Note that the effect of the two sentiment variables is significantly reduced during the second and third sub-periods.

Several interesting results emerge from the analysis. More specifically, the results indicate that the determinants of CDS variance are neither uniform nor stable during sample periods and sample countries. For instance, the CDS own effect is increasing with time for the core countries and increases only during the second sub-period for peripheral countries; the iTraxx (a proxy for market-wide credit risk) is important for the core countries during the first and second period but less important during the third; for the peripheral countries its impact is reduced during the second period. Note also that the impact of the slope of the term structure on CDS spread variance is increasing as we move from 2008 to 2014 for the peripheral countries, and decreasing for the core countries for the respective period. The VIX, a proxy for global market risk, is not very important for the core countries, however, it is very important for peripheral countries during first and second sub-periods: for instance its effect for the peripheral countries is reduced between the second and third period from 30.49% to 5.13%. Also, the CDS trading volume (NOC) is important during the first sub-period for all countries (around 23%), but not important in the second and third sub-periods. Investor sentiment may be an important CDS spread determinant during the period between 2008 and 2010.

The Euro-Eonia spread (that proxies for banking stress in Europe) is not very important for all countries during the first and second sub-period (in the aftermath of the subprime crisis in the US) but it becomes very important during the third: for example, for the peripheral countries it increases from 4.43% during the second sub-period to 32.8% during the third sub-period; for the core countries it increases from 1% to 16.07%, respectively. Note that following the failure of Lehman Brothers, the Euro-Eonia spread rose sharply, since the largest euro-area banks are highly global in their orientation (McGuire and von Peter, 2009; Shin, 2012); however, the ECB reduced interest rates and increased its own balance sheet and volume of loans to the banking sector. As a result the initial liquidity crush on euro-area banks did calm down, and rates in interbank markets returned to more normal levels by late 2009.

Table 5
Forecast Error Variance Decomposition
November 2008- April 2010

Panel A Core countries							
	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	82.25	1.14	2.16	0.41	1.1	12.5	0.41
Eur-Eon	1.88	54.79	9.07	1.2	3.31	23.9	5.8
iTraxx	17.97	4.38	55.42	5.05	3.1	9.42	4.63
Termslope	12.96	1.54	8.33	52.93	14.16	8.54	1.5
Esi	2.41	1.83	11.81	24.14	48	8.33	3.44
Noc	1.53	5.24	5.57	11.71	5.09	69.81	1.01
CDS	**7.76**	**9.76**	**26.3**	**13.79**	**6.09**	**13.07**	**23.19**
Panel B Peripheral countries							
	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	68.07	4.12	0.21	0.28	2.66	23.26	1.37
Eur-Eon	7.36	67	2.03	2.88	6.16	9.73	4.81
iTraxx	39.39	2.66	27.4	2.16	4.06	17.29	7.01
Termslope	15.48	1.96	14.75	50.7	7.85	8.3	0.94
Esi	8.2	6.77	10.99	13.21	50.69	7.25	2.84
Noc	8.65	19.97	3.28	7.47	4.93	55.29	0.38
CDS	**19.23**	**8.39**	**12.97**	**10.61**	**9.29**	**16.61**	**22.86**

Notes to Table 5
The Table reports the fraction (in percentage points) of the 10 months ahead forecast error variance of each variable that is attributable to VIX, Euribor –Eonia, iTraxx, termspread, Esi, Noc, Sovereign CDS. Our main interest is on the bottom line of each matrix as it represents the sovereign CDS variance decomposition. See also Notes to Table 1. The sample period is November 2008- April 2010.

Table 6
Forecast Error Variance Decomposition
May 2010- July 2012

Panel A Core countries							
	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	96.53	0.5	0.06	0.69	1.42	0.72	0.04
Eur-Eon	0.62	81.39	1.16	1.01	0.81	12.74	2.24
iTraxx	19.38	11.23	52.86	0.56	5.63	8.94	1.37
Termslope	6.04	1	10.21	80.2	2.09	0.17	0.26
Esi	6.46	4.63	9.16	4.66	74.6	0.31	0.15
Noc	2.48	7.84	10.18	2.75	2.56	74.14	0.01
CDS	**10.07**	**1**	**32.89**	**3.1**	**3.88**	**8.02**	**41.01**
Panel B Peripheral countries							
	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	89.18	1.03	1.43	6.39	0.6	1.02	0.32
Eur-Eon	2.89	69.41	8.72	4.6	4.3	4.51	5.47
iTraxx	58.69	10.72	20.35	5.04	0.69	1.39	3.08
Termslope	6.66	2.5	1	87.66	1.29	0.82	0.03
Esi	15.34	3.2	3.95	0.89	73.88	0.35	2.36
Noc	14.88	3.74	5.59	3.09	4.96	66.45	1.26
CDS	**30.49**	**4.43**	**2.19**	**18.77**	**0.53**	**6.1**	**37.45**

Notes to Table 6
The Table reports the fraction (in percentage points) of the 10 months ahead forecast error variance of each variable that is attributable to VIX, Euribor –Eonia, iTraxx, termspread, Esi, Noc, Sovereign CDS. Our main interest is on the bottom line of each matrix as it represents the sovereign CDS variance decomposition. See also Notes to Table 1. The sample period is May 2010- July 2012.
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Table 7
Forecast Error Variance Decomposition
August 2012- April 2014

Panel A
Core countries

	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	40.1	42.61	8.68	1.76	3.94	1.03	1.85
Eur-Eon	6.93	76.33	7.89	1.35	3.53	1.45	2.47
iTraxx	4.6	21.16	49.2	17.44	2.48	4.16	0.93
Termslope	1.87	8.42	11.36	70.74	2.76	4.65	0.17
Esi	4.48	32.6	11.47	6.14	39.65	4.22	1.42
Noc	3.4	32.92	6.21	4.83	6.44	45.41	0.74
CDS	**1.9**	**16.07**	**11.39**	**0.8**	**6.88**	**1.09**	**61.84**

Panel B
Peripheral countries

	Impulse Variables						
Response variable	Vix	Eur-Eon	iTraxx	Termspread	Esi	Noc	CDS
Vix	27.74	48.32	11.77	3.22	2.71	1.5	4.7
Eur-Eon	11.38	62.95	10.42	5.01	1.76	1.38	7.06
iTraxx	9.19	30.35	40.02	10.91	1.09	4.55	3.85
Termslope	7.56	30.94	15.2	37.81	4.01	1.14	3.3
Esi	4.19	32.77	5.42	14.96	38.23	2.28	2.12
Noc	9.98	36.75	6.58	5.84	3.88	33.21	3.72
CDS	**5.13**	**32.8**	**14.78**	**21.35**	**1.82**	**4.7**	**19.39**

Notes to Table 6
The Table reports the fraction (in percentage points) of the 10 months ahead forecast error variance of each variable that is attributable to VIX, Euribor –Eonia, iTraxx, termspread, Esi, Noc, Sovereign CDS. Our main interest is on the bottom line of each matrix as it represents the sovereign CDS variance decomposition. See also Notes to Table 1. The sample period is August 2012- April 2014.

4.1. Robustness tests

The results in the previous section indicate that the ESI index (a proxy for economic sentiment) is not important in any sub-period in all countries. In order to test whether this is due to the choice of the proxy variable for sentiment or due the non-importance of sentiment as a CDS determinant, in this section we recalculate the model and replace ESI with the ZEW Sentiment Indicator. The ZEW Economic Sentiment is an amalgamation of the sentiment of approximately 350 economists and analysts regarding the economic future of Europe for the next six months. The results are summarized in Table 8 and indicate that, when the ZEW Index is used as a sentiment proxy, the impact of sentiment on CDS variance is more significant for the core countries during the second and third sub-periods (around 10%) and more significant for the peripheral countries during the second period (4.68% from 0.55%). Thus, sentiment may play a role in CDS spread determination, albeit limited.

Table 8
Forecast Error Variance Decomposition - Zew Sentiment

	Impulse Variables						
Periods	Vix	Eur-Eon	iTraxx	ZEW	Termslope	Noc	Cds
1st Period/Core	5.5	4.45	21.9	2.29	30.97	4	30.86
2nd Period/Core	9.86	0.83	32.24	**10.2**	3.71	3.71	39.6
3rd Period/Core	2.75	20.92	18.21	**10.52**	2.37	2	43.2
1st Period/Peripheral	13.38	0.54	15.49	7.05	30.79	10.52	22.2
2nd Period/Peripheral	26.93	3.29	3.04	**4.68**	19.21	8.07	34.75
3rd Period/Peripheral	2.67	27.11	13.51	0.43	22.91	2.78	30.56

Notes to Table 8
The ZEW Economic Sentiment is an amalgamation of the sentiment of approximately 350 economists and analysts regarding the economic future of Europe for the next six months. The survey shows the balance between those analysts who are optimistic about Europe's economic future and those who are not.

In order to test the robustness of the results (the rest of the results discussed in this sub-section are available upon requests) with respect to the proxy variable for global market risk, we replace the VIX index with the VSTOXX implied volatility index. The VSTOXX Indexes are based on EURO STOXX 50 real time options prices and are designed to reflect the market expectations of near-term up to long-term volatility by measuring the square root of the implied variance across all options of a given time to expiration (see also Collin-Dufresne et al., 2001; Frigyes, Heinz and Sun, 2014). In order to test the robustness of the results with respect to our proxy variable for the market liquidity, we replace the NOC variable (number of CDS contracts traded) with the bid-ask spread, i.e. the difference between the ask price and the bid price of a CDS contract. We obtain similar results with one exception: for the first period the bid-ask variable seems to have no effect on CDS variance, in contrast to the results reported in Table 5 where it contributed between 13.07% (core countries) and 16.61% (peripheral countries).

4.2. Impulse response functions

Figures 2, 3, and 4, present Orthogonalized Impulse Response Functions (IRFs) and the 5% error bands (in red) generated by Monte Carlo simulation (200 repetitions) for the three sub-periods for the core countries while Figures 5, 6, and 7, present the same IRFs for the peripheral countries. More specifically, we do not present all IRFs but only these with the response variable being the sovereign CDS spread (i.e. its response to a shock of the other variables). Note that for the first period, the pattern is quite similar across both the core and the peripheral countries, although the impact of the lagged determinants on the level of sovereign credit risk is much larger in the peripheral countries than it is in the core countries (Figures 2 and 5). Furthermore the responses are the expected ones. For instance, there is a positive response to a shock in iTraxx and the Euribor-Eonia spread, i.e. as wide market risks increases and banking stress intensifies, spreads also increase. Also there is a negative response to a shock in the ESI and the NOC, implying that as increases in economic sentiment and liquidity lead to reduced spreads. During the second period, for all countries, credit spreads increase in response to an iTraxx shock and also exhibits a negative response to a shock in VIX. For the core countries, there is a negative response to NOC as well while the other variables have no significant effect on CDS spreads. For the peripheral countries, spreads also show a positive reaction to a termspread shock, while other variables have no significant effect on sovereign CDS. In the third period, for both groups, credit spreads respond positively to iTraxx shocks, showing the that financial turbulence still exists, while the response to Euribor-Eonia spread shock is negative and then turns to positive. Note also that the positive response of CDS spreads to termspread shocks only in peripheral countries.

Figure 2
Orthogonalized Impulse Response Functions: Core countries
(November 2008- April 2010)

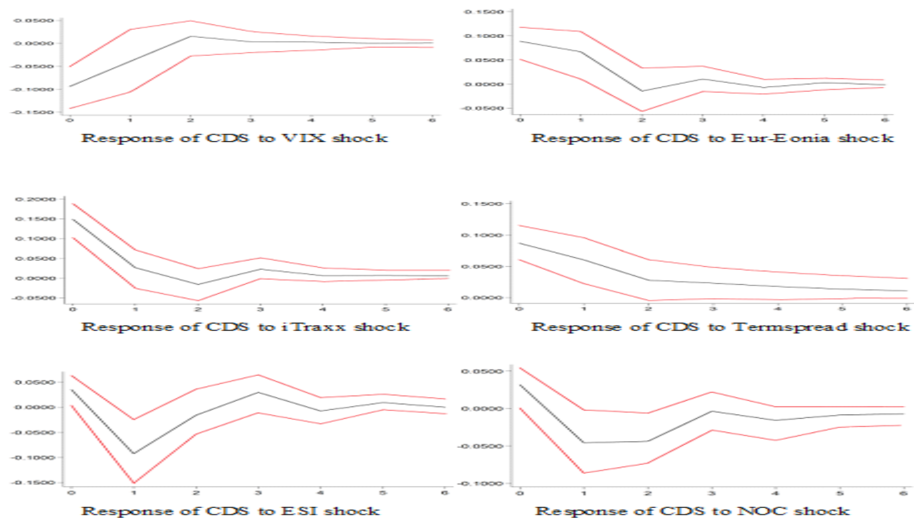


Figure 3
Orthogonalized Impulse Response Functions: Core countries
(May 2010- July 2012)

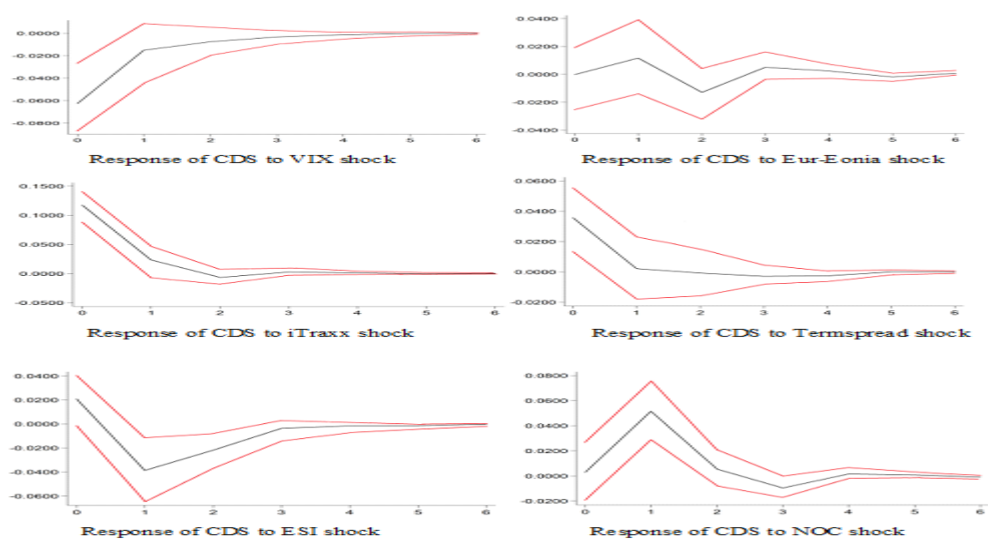


Figure 4
Orthogonalized Impulse Response Functions: Core countries
(August 2012- April 2014)

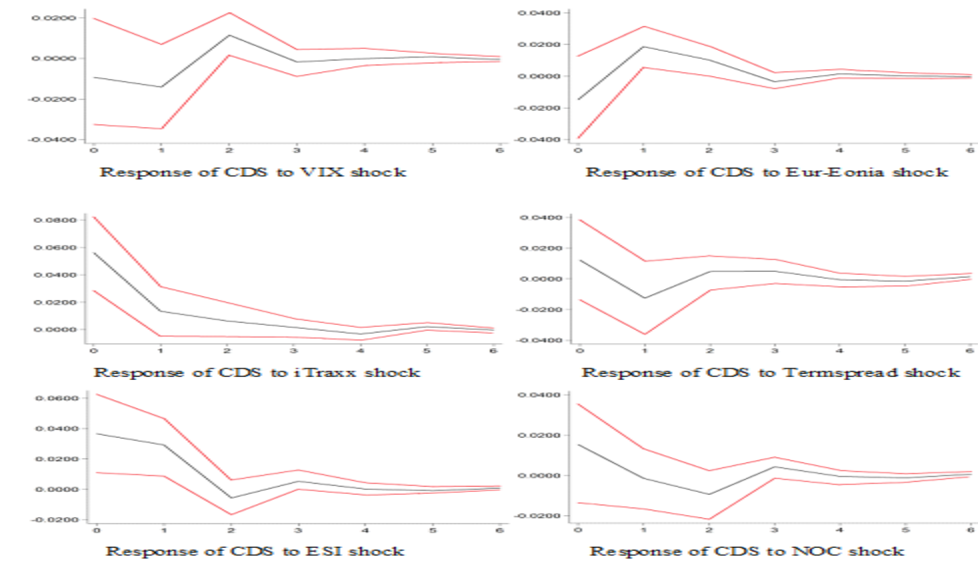


Figure 5
Orthogonalized Impulse Response Functions: Peripheral countries
(November 2008- April 2010)

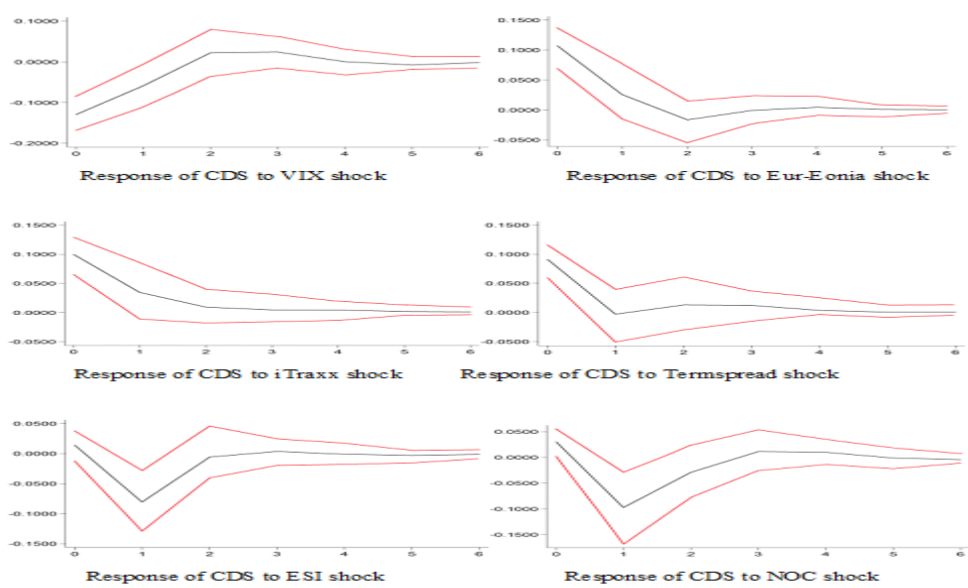


Figure 6
Orthogonalized Impulse Response Functions: Peripheral countries
(May 2010- July 2012)

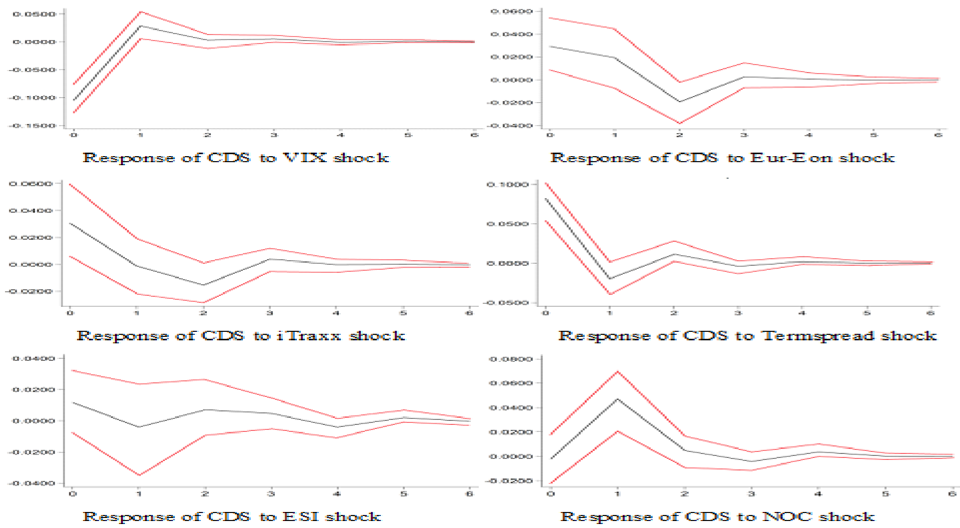


Figure 7
Orthogonalized Impulse Response Functions: Peripheral countries
(August 2012- April 2014)

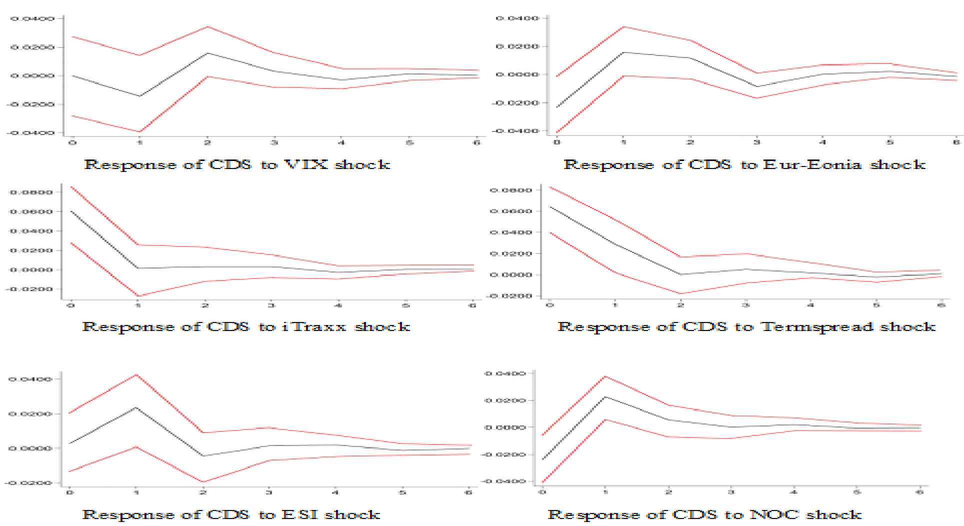
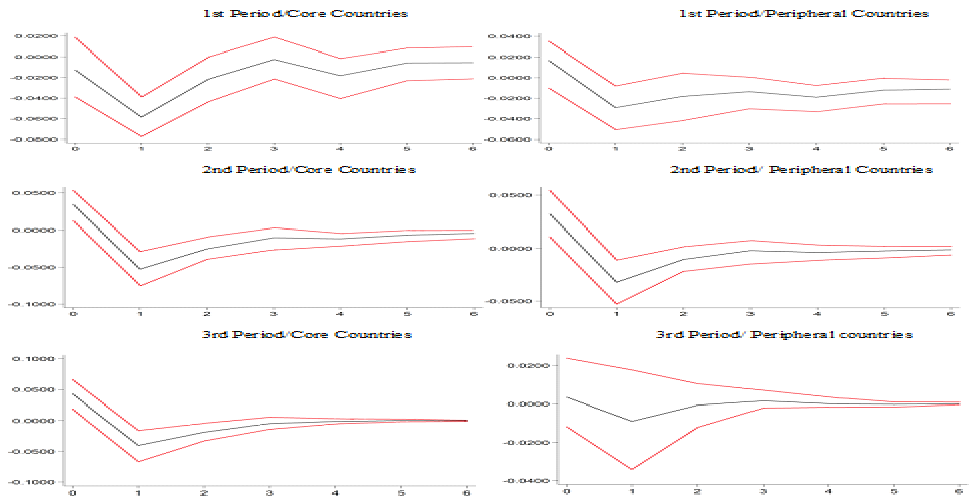


Figure 8
Orthogonalized Impulse Response Functions:
Sovereign CDS response to ZEW shock



4.3. Spillover Effects

In December 2011 Greece admitted a much larger than expected fiscal deficit, which lead to a series of downgrades by rating agencies, capital market turmoil, and fears that other Southern European countries will soon be affected. Greece negotiated a bailout package with the European Commission (EC), the European Central Bank (ECB), and the International Monetary Fund. Within the following months, Ireland and Portugal negotiated their own bailout packages. As a result, sovereign yield spreads and CDS spreads for many European countries were affected. This section investigates potential spillover effects; more specifically we examine he forecast error variance of sovereign CDS in core and peripheral countries that is attributable to the variables that proxy for spread determinants. We also include in the analysis sovereign CDS spreads for Spain, Portugal, Italy, and Ireland and Greece (due to data availability for Greece we include sovereign bond yield spreads vs Germany). In other words we also test for the impact of shocks to core economies steaming from countries that experienced financial difficulties. We also include the ZEW index as a proxy for sentiment (although results with the ESI index are similar). Note that when the CDS spread of a country is included in the PVAR as a potential determinant it is deleted from the sample group. For example, when Greek spreads are included in the PVAR as explanatory variables they are excluded from the "peripheral countries" sample in order to isolate its effect on the other countries' spreads. The results (Table 9, sample period between 2010 and 2012) indicate that for core countries potential spillover effects may steam from Spain and Italy, as they appear the main sources of cross-country spillovers. More specifically, Spanish spreads contribute 14.42% to core CDS variance while Italian CDS contribute 15.8%. The Portuguese, Greek, and Irish spreads are of minor importance. As far as peripheral countries are concerned, it is Spanish and Portuguese spreads that contribute the most (17.69% and 14.91%, respectively). It is interesting to note that Greek spreads contribute the least to variance decomposition (7.63%). This may reflect the fact that investor concerns about debt sustainability in Spain and Italy were linked much more to concerns about the future of the euro area as a whole given the size of the two economies and their stronger ties to the core euro area countries compared to Greece. Italy and Spain, being much larger economies, could potentially destabilize the euro area, even though their likelihood of running into financial difficulties was perceived by the markets as comparatively smaller, based on their SCDS spreads. Moreover, following the first Greek debt restructuring in mid-2011, Greek CDS spread was persistently well above 1000 bps and probably carried little information for investors.

Table 9
Spillover effects to core and peripheral CDS spreads through sovereign debt crisis

Response variable	Impulse Variables							
	Vix	**Eur-Eon**	**iTraxx**	**ZEW**	**Spanish_CDS**	**Termspread**	**Noc**	**CDS**
Core	9.06	0.74	31.71	11.18	14.92	1.54	4.85	26.47
Peripheral	29.11	3.89	1.1	3.12	17.69	8.68	6.82	29.56
	Vix	**Eur-Eon**	**iTraxx**	**ZEW**	**Portuguese_CDS**	**Termspread**	**Noc**	**CDS**
Core	9.05	1.15	32.27	10.41	1.65	3.91	2.66	38.83
Peripheral	26.13	3.53	4.39	3.89	14.91	10.8	4.71	31.6
	Vix	**Eur-Eon**	**iTraxx**	**ZEW**	**Italian_CDS**	**Termspread**	**Noc**	**CDS**
Core	7.75	0.40	29.71	13.54	15.8	5.28	3.93	23.55
Peripheral	24.23	3.28	1.7	2.41	11.36	23.64	10.84	22.5
	Vix	**Eur-Eon**	**iTraxx**	**ZEW**	**Greek_Bonds**	**Termspread**	**Noc**	**CDS**
Core	4.23	1.14	27.32	13.48	4.54	3.57	3	42.68
Peripheral	22.46	3.12	4.56	4.60	7.63	18.07	5.57	33.96
	Vix	**Eur-Eon**	**iTraxx**	**ZEW**	**Irish_CDS**	**Termspread**	**Noc**	**CDS**
Core	9.80	0.89	32.82	10.95	1.39	3.89	3.71	36.5
Peripheral	26.04	4.40	4.72	7.60	13.73	13.44	9.71	20.31

Notes to Table 9

The Table reports the fraction (in percentage points) of the forecast error variance of sovereign CDS in core and peripheral countries that is attributable to the variables that proxy for spread determinants. We also include in the analysis sovereign CDS spreads for Spain, Portugal, Italy, and Ireland. Due to data availability for Greece we include sovereign bond yield spreads (vs Germany). See also Notes to Table 5. Sample period: May 2010 to July 2012.

5. Conclusion

This paper examines the determinants of CDS spreads and potential spillover effects for Eurozone countries during the recent financial crisis in the EU. We employ a Panel Vector Autoregressive (PVAR) methodology that combines the advantages of traditional VAR modelling with the advantages of a panel-data approach. In addition to variables that proxy for global and financial market spread determinants we also employ variables that proxy for behavioral determinants. Note that the vast majority of previous studies focuses on macroeconomic and fundamental information in order to study the determinants of spreads and neglect behavioral variables that may capture investor and economic sentiment. We find that the determinants of CDS variance are neither uniform nor stable during different periods and different countries. For instance, as we move from 2008 to 2014 the impact of the slope of the term structure on CDS spread variance is increasing for peripheral countries (Spain, Portugal, Italy, Greece and Ireland) and decreasing for the core countries (Germany, France, Netherlands, Belgium and Austria); the effect of VIX, a proxy for global market risk, is not very important for the core countries, however, it is very important for peripheral countries between 2008 and 2012 (it contributes to CDS variance by approximately 31%). We also report evidence that sentiment may play a role in CDS spread determination, along with other factors. Other findings indicate that spillover effects may run from Spain and Italy to core countries, while spillover effects from Portugal, Greece, and Ireland are of minor importance.

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