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THE SOVEREIGN CREDIT DEFAULT SWAP MARKET: PRICE DISCOVERY, VOLUMES AND LINKS WITH BANKS' RISK PREMIA

by Alessandro Carboni*

Abstract

This paper looks into the sovereign credit default swap (CDS) market from two perspectives. First, it analyses the relation between CDS and bond spreads. The results on a single-entity basis suggest that the CDS market leads the bond market in price discovery, especially during 2010, while both markets contribute during the pre-Lehman period and in 2009. Moreover, the inclusion of the EURIBOR-EUREPO 3-month spread helps to restore the long-run relation after the Lehman bailout. An event-study, which compares the reaction of sovereign CDS and bond markets to policy announcements in Europe, suggests that both markets react in the same way, especially after the release of bad news. As for the relation between prices and volumes of sovereign CDSs, estimates do not point to any stable relation. The second perspective is the relation between CDS spreads for sovereign and corporate entities. Our estimates on an aggregate and sector-wide basis point to a leading property of the former sector, even in 2009, while the banking sector increases its leading power during 2010.

JEL Classification: G00, G01, G14.
Keywords: announcements, corporate sector, credit spread, CDS, government bond, limits to arbitrage, volumes.

Contents

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1 Introduction[1]

Credit risk indicators have received much attention during the financial crisis that began in the summer of 2007. The bail-out of Lehman Brothers (15° September 2008) has shown the importance of financial market liquidity and has demonstrated that risk management is dangerous if inappropriately used. During the crisis OTC credit derivatives came under attack because they were identified as the main contributors to the widespread turmoil, creating a new kind of dimension, namely counterparty credit risk. Hence, the need to provide more information through the creation of trade reporting for regulatory authorities, as suggested for example by Banque de France (2010) and IFSL (2009), as well as to understand what is the "best" credit risk indicator, especially during a crisis. During 2010, the country risk crisis evidenced the need to identify whether sovereign CDS spreads are linked to corporate sector CDS spreads and whether CDS market volumes could affect sovereign CDS spreads. In the latter case, speculative behaviour could occur in order to increase spreads, affecting market perception of country risk assessment. However, Duffie (2010a, 2010b) and Citigroup (2010) suggest that CDS traders are not able to push corporate and sovereign entities to default given the small size of the CDS market relative to bond markets. Moreover, Carmassi and Micossi (2010) demonstrate that sovereign bond spreads react to significant bad news about the Eurozone.

The empirical literature on the econometric properties of credit risk indicators concentrates on detecting the leading market for credit risk. To do this, authors study the dynamic relation between CDS and bond markets. For the sovereign sector, studies by Aktung et al. (2009), Ammer and Cai (2007) and more recently by Coudert and Gex (2010), among others, analyse the relation between CDS and bond spreads in the short run, through the Granger casuality test, and in the long run, through cointegration analysis and measures such as Gonzalo and Granger (1995) and Hasbrouck (1995) derived from a vector error correction model (VECM). Results from all the papers indicate that the CDS market seems to lead the bond market in terms of price discovery, even if the liquidity of every market is essential for the leading property, especially before 2007. Moreover, the first paper shows that results change according to different information criteria, while the second points to the *cheapest-to-deliver* option as an important determinant of the basis. The third paper uses a panel analysis to demonstrate that in both emerging markets and the riskiest countries (such as PIIGS) the CDS market is the leader, while for the safest countries (for example France and the Netherlands) the bond market leads in terms of price discovery.

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For the corporate sector, Blanco et al. (2004) and Zhu (2004), among others, use the same econometric techniques for both the short- and long-run relations. They show that the CDS market is the main forum for credit risk, even if Zhu notes that the leading property of one market against the other could depend on geographical location and different market liquidity. More recently, Baba and Inada (2007) confirm the dominant role of the CDS market for Japanese mega-banks.

Another strand of the literature deals with the relation between CDS and asset swap spreads. The analysis of Crouch and Marsh (2005) and De Wit (2006) on corporate and sovereign entities is based on Granger casuality test and cointegration techniques to verify the validity of the no-arbitrage relation and the price discovery. The first paper shows that the CDS market is the leader in terms of price discovery for the corporate sector, while the second paper finds that most of the series analysed are cointegrated.

Other works try to go a step further by extending the analysis and introducing different factors in the relation between two credit risk markets for both sovereign and corporate entities. Chan-Lau and Kim (2004), Longstaff et al. (2003) and Norden and Weber (2004), among others, study the dynamic analysis among CDS spreads, bond spreads and equity market returns. By using the same econometric techniques they highlight the importance of CDS market information flows for price discovery of credit risk for the majority of the entities. On the other hand, Forte and Peña (2007) show that the stock market leads credit risk markets expressed by CDS and bond spreads. Fontana (2009) shows that the introduction of the TED spread in the VECM drives the basis dynamics when it is negative, maintaining the leading role of the CDS market during financial turmoil. Finally, Byström (2005), Ehlers et al. (2010) and Fung et al. (2008) measure the extent to which iTraxx and equity markets are related. In the short run one market contributes to the other with a bivariate direction, as evidenced by the Granger casuality test. For the cointegration analysis, Fung et al. (2008) use VECM to demonstrate that the credit market is the leader in terms of price discovery.

To the best of our knowledge, the relation between the sovereign and the corporate sector is only offered, on a sector-wide basis, in a technical document provided by Credit Suisse (2010), in which they analyse the relation between an index of sovereign CDS spreads (SovX Western Europe) and a corporate index (iTraxx Europe or the iTraxx Senior Financials). Moreover, they go a step further and try to price sovereign default risk into corporate credit spreads.

In this paper we focus our attention on two features of credit risk indicators. Firstly, we study their dynamic properties using both short- and long-run analysis of sovereign CDS and bond spreads. We also add a proxy for funding costs to try to restore the long-run dynamic relation between CDS and bond spreads during financial turmoil. Moreover, we analyse how CDS and bond spreads react to particular negative news regarding country risk and the interaction between spreads and market data. Secondly, we turn to the relation between the sovereign and the corporate sector using CDS indices, on the one hand, and CDS spreads for both the sovereign and the banking sector, on the other.

Our study adds to the existing literature in three ways. We extend the dynamic analysis to local CDS and bond markets during 2010. Moreover, we take into account the funding issues and counterparty risk in the interbank market after the Lehman Brothers bailout. Secondly, we perform the analysis of the sovereign and the corporate sector on both an aggregate, through the use of CDS indices, and a sector-wide basis. Finally, we try to detect the relation between spreads and volumes in the sovereign CDS market.

The paper is structured as follows: Section 2 describes the credit risk indicators used in our analysis and shows the no-arbitrage relationship. Section 3 deals with econometric methodologies and treats data selection. Section 4 provides the results, while Section 5 concludes. Figures and tables are contained in an Appendix.

2 Credit Default Swap and Bond Spreads: Definition and No-Arbitrage Relation

2.1 Definition

Credit default swaps (CDS) are the most common type of credit derivatives. A CDS is a bilateral contract that provides protection on the par value of a specified reference asset, with the protection buyer paying a periodic fee (spread) or a one-off premium (set as a percentage amount of the protection bought) to a protection seller, while the protection seller makes the payment when a credit event occurs during the life of the contract.[2] According to ISDA (2003) and Credit Suisse (2007 and 2010), credit events for governmental authorities can be classified as: 1) failure to pay, 2) repudiation / moratorium and/or 3) restructuring. Hence, a CDS can be viewed as an insurance contract against a risky event on a reference entity. In this case, the settlement payment is made by the seller according to the contract settlement option.

Credit derivatives specify physical or cash settlement.[3] In the physical settlement, when a credit event occurs, the buyer delivers the reference asset to the seller, in return for which the seller pays the face value of the delivered asset to the buyer (Choudhry 2006). The contract may specify a number of alternative assets (called *deliverable obligations*) that the buyer can deliver.[4] When more than one deliverable obligation is specified, the buyer will invariably deliver the cheapest asset on the list of eligible assets: this provides the concept of *cheapest-to-deliver* option, which is an embedded option afforded by the protection buyer.[5]

On the other hand, in the cash settlement option the contract specifies a predetermined payout value when a credit event occurs. Generally, the protection seller pays the buyer

[2]There are two pricing types in the CDS market. The first is the running spread, while the second is the up-front basis. See O'Kane and Sen (2003) for the differences between the two.

[3]There is a third type of settlement, called digital, where the seller pays a fixed percentage (decided at the issue of the contract) on the notional.

[4]See ISDA (2003) and Credit Suisse (2010) for specific contractual issues.

[5]See Bomfin (2005), Choudhry (2006), Duffie and Singleton (2003) and Jankowitsch et al. (2007) for a more specific reference.

the difference between the nominal amount of the default swap and the final (market) value of the reference asset, determined by means of a poll of dealer banks. This last value can be viewed as the recovery value of the asset.[6]
The CDS spread is the spread that determines the cash flow paid by the buyer of the contract. In this sense, the spread is the compensation for taking the risk of incurring the loss given default when a credit event occurs. The contract specifies two legs: the premium leg, which contains the periodic payments until maturity or until the credit event occurs, and the protection leg, which contains the payment made by the protection seller in the case of a credit event.
In mathematical terms, the spread is the sum that makes the expected present value of the two legs the same at the origination of the contract, satisfying the following condition:[7]

$$\sum_{i=1}^{N} e^{-rt_i} Q(t_i)\rho = \int_0^{t_N} e^{-rt}(100 - M_t)q(t)dt, \tag{1}$$

where r is the constant risk free rate, $Q(t)$ is the risk neutral survival probability at time t, with $Q(t_i) = 1 - \int_0^{t_i} q(t)dt$, M_t is the market value and ρ is the CDS premium.[8] The left-hand side corresponds to the premium leg, while the right-hand side is the protection leg.

2.2 No-Arbitrage Relation

An investor can buy credit risk by selling a CDS or by buying a risky bond, otherwise he can sell credit risk by buying a CDS protection or by selling a bond. By buying a CDS on a certain sovereign entity and a bond issued by the same entity, one can replicate a riskless bond. Therefore, the credit spread (defaultable minus the riskless bond) must equal the credit default swap spread. This simple no-arbitrage relationship is the baseline building block for every study of the lead-lag definitions between the two markets.

Following Zhu (2004), we can state formally the no-arbitrage relationship between the CDS spread and the bond spread. The current price of the defaultable par fixed coupon bond is:

$$P = 100 = \sum_{i=1}^{N} e^{-rt_i} Q(t_i)c + e^{-rt_N} 100 Q(t_N) + \int_0^{t_N} e^{-rt} M_t q(t)dt, \tag{2}$$

where $q(t)$ is the risk neutral default probability. The price of a par fixed coupon bond can be decomposed in three terms. The first is the value of discounted coupons in the

[6]Intuitively, for a notional value of 1 the seller pays the loss given default $LGD = (1 - RR)$, where RR is the recovery rate of the reference asset.

[7]This pricing relation is different in the case of up-front pricing. See O'Kane and Sen (2003) for details.

[8]This kind of specification uses the risk neutral valuation principle under complete markets hypothesis and the absence of arbitrage opportunities. These conditions allow us to use the class of equivalent martingale measures for both survival and default probabilities.

event that there is no default, the second is the value of the principal at maturity, while the third relates to the market value of the bond if it defaults.
Assume that an investor shorts the defaultable bond and purchases a par fixed rate risk free note: since the risk-free rate is constant, the risk-free note can always be sold at par whenever the risky bond defaults. Given that the initial net investment is zero, the no-arbitrage relation requires that:

$$0 = -\sum_{i=1}^{N} e^{-rt_i} Q(t_i)c - e^{-rt_N} 100 Q(t_N) - \int_0^{t_N} e^{-rt} M_t q(t)dt + \sum_{i=1}^{N} e^{-rt_i} r Q(t_i) +$$
$$+ \int_0^{t_N} e^{-rt} 100 q(t)dt + e^{-rt_N} 100 Q(t_N) \Rightarrow \sum_{i=1}^{N} e^{-rt_i} Q(t_i)(c-r) = \int_0^{t_N} e^{-rt}(100 - M_t)q(t)dt \tag{3}$$

Comparing this with the CDS pricing equation it is straightforward to obtain that $\rho = (c-r)$, with the no-arbitrage relation between the two markets. According to Choudhry (2006) this difference is called cash-CDS basis.
In this case, if c is the yield-to-maturity (YTM) on the bond and r the YTM on risk-free bond, we have:

$$c - \rho = r \tag{4}$$

Obviously, if $c-\rho$ is significantly greater than r, it is profitable to buy the T-year par yield bond issued by the reference entity, buy the default swap and short the T-year Treasury par yield. This is the negative basis strategy suggested by Choudhry (2006): an investor aims to earn a risk free return by buying and selling identical credit risk across different markets. On the other hand, if $c-\rho$ is significantly less than r, it is profitable to short the T-year par yield bond, sell the credit default swap and buy the T-year Treasury par yield.

As suggested by Choudhry (2006), De Wit (2006) and O'Kane and McAdie (2001), this relation does not hold in practice, for particular times and market conditions, owing to several factors. Positive basis could be determined, among other things, by the presence of an appreciable delivery option, as well as by the difficulties in shorting cash bonds. Negative basis, instead, could depend also on counterparty default risk and funding issues.

In particular, funding and liquidity issues may affect the validity of the no-arbitrage relation, especially during a financial crisis, when the basis could become negative. Normally, one could buy a par risky bond funded at EURIBOR, buy a credit default swap on the same reference entity, and enter into an interest rate swap (IRS) to swap fixed coupons from the par bond against a stream of floating rates (EURIBOR) plus a spread, the asset swap spread.

To take care of funding issues during the financial crisis, one can buy a par risky bond, funded at a REPO rate, using the purchased bond as collateral, buy a credit default swap and enter into an IRS to swap fixed coupons from bond against a stream of floating rates (EURIBOR) plus the asset swap spread.[9]

Finally, when the CDS and bond are traded in two different currencies, the basis is also affected by the correlation between the exchange rates and the spreads, by their volatilities, and by FX depreciation on default.[10]

3 Methodology and Data

3.1 Econometric Analysis

Since one of the main purposes of the paper is to examine the econometric properties of credit risk indicators (in our case credit default swap and bond spreads), modern time series techniques, like cointegration tests, Granger causality test and vector error correction models, are appropriate.

To test whether the no-arbitrage theoretical relations hold empirically, it is possible to use the cointegration test proposed by Engle and Granger (1987): two series are cointegrated if there are one or more common trends that allow them to move in the same fashion in the long-run. In simple terms, two series are cointegrated if their linear combination originates a stationary series. Let us assume, for example, that X_t and Y_t are the two (integrated) series of interest. If the two series are cointegrated, with cointegrating coefficient θ, then the difference $Y_t - \theta X_t$ is stationary, otherwise it has a unit root.

The Engle and Granger test follows two steps: testing for stationarity and estimation of the order of cointegration of the variables. For the first step, the most common two tests are the Dickey-Fuller unit root test and the Phillips and Perron test.[11] Moreover, given that the econometric literature has suggested that stationarity tests may have a lower power, it is possible to perform the two together with the DF-GLS test of Elliott et al. (1996). As suggested by Engle and Granger (1987), when the cointegrating coefficient θ is unknown, it could be estimated using for example an OLS estimation. Therefore, we have:

$$Y_t = \alpha + \theta X_t + z_t, \tag{5}$$

and then perform the Engle-Granger-ADF on residuals $\hat{z}_t$ of this regression, with an intercept but without time trend. There are two different useful methodologies that allow us to estimate cointegrating vectors. The first is the Johansen Maximum Likelihood analysis of cointegration (Johansen 1988, and 1991), while the second is the Dynamic OLS (DOLS) proposed by Stock and Watson (1993). The Johansen methodology helps us in two different ways: it provides the number of cointegrating vectors through the lambda-trace and lambda-max test, and it allows us to estimate the value of the cointegrating

[9]During a financial crisis the possibility of offering the purchased bond as collateral could reduce the cost of funding at EUREPO, which is the funding rate available against a high quality collateral.

[10]See J.P. Morgan (2010) for further details.

[11]See Hamilton (1994) for a comprehensive treatment of cointegration and unit root analysis.

coefficients. On the other hand, Stock and Watson show that the estimator of θ in (5) is consistent, but with a non-normal distribution. To overcome this problem, they have developed a modified version of (5), where Y_t is also explained by past and future values in the variation of X_t:

$$Y_t = \beta_0 + \theta X_t + \sum_{j=-p}^{p} \delta_j \Delta X_{t-j} + u_t. \tag{6}$$

The DOLS estimator of θ is the OLS estimator of θ in (6). On the opposite side, when the cointegrating coefficient is known, the stationarity hypothesis could be tested on $z_t = Y_t - \theta X_t$ with Dickey-Fuller, Phillips-Perron, as well as with the DF-GLS test.

All empirical literature on the lead-lag relationships among credit risk indicators (Blanco et al. 2004 and Zhu 2004, among others) have verified that two prices should be equal in the long run, with a cointegrating vector of [1, -1, c]: for example, if CDS spreads and bond spreads are I(1) and the basis is I(0), there are no-arbitrage opportunities in the long run, as predicted by the theory, with a zero constant in the cointegrating space. The same could be applied to the CDS-bond basis. If the two prices do not cointegrate with the [1, -1, c] restriction, it is possible that either the two markets price credit risk differently, that the prices of one credit risk market reflect something other than credit risk (i.e. liquidity risk), or that one market price contains measurement errors. Blanco et al. (2004), De Wit (2006) and O'Kane and McAdie (2001) suggest that the failure of the cointegrating test depends on the presence of the *cheapest-to-deliver* option embedded in the CDS spreads. To deal with this problem we build the Johansen methodology for both credit risk indicators with and without a constant in the cointegraing space, testing for the presence of [1, -1, c] and [1, -1] cointegrating vectors. Moreover, when the evidence of cointegration is confirmed, we estimate the cointegrating coefficient by DOLS, ignoring the constant, and we test for the [1, -1] cointegrating vector. In addition, we estimate a cointegrating vector by adding the spread between three-month EURIBOR and EUREPO, similar to Fontana (2009), and by considering that Collin-Dufresne et al. (2001), Cossin and Hricko (2001) as well as others, and more recently Di Cesare and Guazzarotti (2010) and Tang and Yan (2007) treat liquidity as an important component for credit risk. In addition, Coudert and Gex (2010) emphasize the effect of liquidity in both bond and derivative markets. From our point of view, the rationale is simple. If the basis is negative, as evidenced by Figure (1), it is profitable to buy the bond and the CDS on the same entity. Given the fact that during periods of financial distress, the interbank market dries up and an increase in counterparty risk arises, we have decided to include this spread in the cointegrating vector to help restore the long-run relationship between derivative and bond markets. With this extension we are able to deal with the funding issues related to the crisis period.[12]

The study of the dynamic relationships between two variables can be conducted with two different approaches, which allow us to focus on both short- and long-run properties. For the first case, the Granger causality test is a suitable measure. By using a Vector

[12]During financial crises, posting a collateral could reduce funding costs to EUREPO level.

Autoregression (VAR) methodology it is possible to detect whether past values of a credit risk indicator (for example CDS spreads) can predict future values of the other indicator (for example bond spreads). The number of lags in the VAR can be selected according to the most commonly used information criteria, such as Akaike Information Criteria (AIC) or Schwartz Information Criteria (SIC). After VAR estimation, the Granger causality test can be performed by an F-test with null hypothesis that all coefficients of past values are zero against by hypothesis that at least one is different from zero. More specifically, if we want to verify the relationship from X_t to Y_t, we can write:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + \epsilon_t \tag{7}$$

and perform the F-test with H_0: γ_1=γ_2=…=γ_p=0, and H_1= $\gamma_i \neq 0$, with at least one γ_i different from zero. We can say that this test could be considered a first approximation of the relationships between different credit risk indicators. However, the empirical literature shows that the Granger causality test does not give a direct answer regarding the causality relations, as suggested for example by Zhu (2004).
In the second case, when two or more variables are cointegrated, one can use the vector error correction model (VECM) to investigate further the dynamic relationships between credit risk indicators, as well as to compute the contributions of price discovery. The VECM becomes:

$$\begin{aligned} \Delta p_{CDS,t} &= \lambda_1 \left(p_{CDS,t} - \alpha_0 - \alpha_1 p_{BS,t-1}\right) + \sum_{j=1}^{p} \beta_{1,j} \Delta p_{CDS,t-j} + \sum_{j=1}^{p} \delta_{1,j} \Delta p_{BS,t-j} + \varepsilon_{1t} \\ \Delta p_{BS,t} &= \lambda_2 \left(p_{CDS,t} - \alpha_0 - \alpha_1 p_{BS,t-1}\right) + \sum_{j=1}^{p} \beta_{2,j} \Delta p_{CDS,t-j} + \sum_{j=1}^{p} \delta_{2,j} \Delta p_{BS,t-j} + \varepsilon_{2t} \end{aligned} \tag{8}$$

with p_{CDS} the CDS spread, p_{BS} the bond spread and ε_{it} i.i.d. residuals. The lagged basis spread is the error correction term and it is used as an added explanatory variable.
The meaning of the coefficients of the error correction term (λ_1 and λ_2) is straightforward: they measure the degree to which prices in a particular market adjust to correct price discrepancies from their long-term trend. For example, if λ_1 is negative and significantly different from zero, the bond market is contributing to the discovery of credit risk and the CDS market adjusts to remove pricing errors, while if λ_2 is positive and significantly different from zero, the CDS market contributes to the discovery of credit risk and the bond market adjusts to remove pricing errors. If both coefficients are significant, then both markets contribute to price discovery. In our analysis, when the traditional basis is I(0), we assume that $\alpha_0 = 0$ and $\alpha_1 = 1$, while we relax these restrictions on the error correction term by using the cointegrating vectors according to both the DOLS and Johansen's methodology.

Moreover, when the cointegrating vector is augmented with the liquidity proxy, the new system of equations for the VECM becomes:

$$\begin{aligned}
\Delta p_{CDS,t} &= \lambda_1 \left(p_{CDS,t} - \alpha_0 - \alpha_1 p_{BS,t-1} - \alpha_2 Spr_{t-1}\right) + \\
\sum_{j=1}^{p} \beta_{1,j} \Delta p_{CDS,t-j} &+ \sum_{j=1}^{p} \gamma_{1,j} \Delta p_{BS,t-j} + \sum_{j=1}^{p} \delta_{1,j} \Delta Spr_{t-j} + \varepsilon_{1t} \\
\Delta p_{BS,t} &= \lambda_2 \left(p_{CDS,t} - \alpha_0 - \alpha_1 p_{BS,t-1} - \alpha_2 Spr_{t-1}\right) + \\
\sum_{j=1}^{p} \beta_{2,j} \Delta p_{CDS,t-j} &+ \sum_{j=1}^{p} \gamma_{2,j} \Delta p_{BS,t-j} \sum_{j=1}^{p} \delta_{2,j} \Delta Spr_{t-j} + \varepsilon_{2t} \\
\Delta Spr_{t} &= \lambda_3 \left(p_{CDS,t} - \alpha_0 - \alpha_1 p_{BS,t-1} - \alpha_2 Spr_{t-1}\right) + \\
\sum_{j=1}^{p} \beta_{3,j} \Delta p_{CDS,t-j} &+ \sum_{j=1}^{p} \gamma_{3,j} \Delta p_{BS,t-j} \sum_{j=1}^{p} \delta_{3,j} \Delta Spr_{t-j} + \varepsilon_{3t},
\end{aligned} \tag{9}$$

with Spr_t the three-month EURIBOR-EUREPO spread.

Once the VECM is constructed, we can compute the measures to understand price discovery. As suggested by Ballie et al. (2002) and Lehman (2002), when the same asset (i.e. credit risk in our case) is traded in different markets, its price is discovered by news presented in one or more of these markets. Together with Blanco et al. (2004), they argue that the appropriate method to investigate price discovery is not clear, but there are two popular common factor models that can be used: the first one is the method developed by Hasbrouck (1995), while the second is that of Gonzalo and Granger (1995). Both models are related on VECM specifications, but they differ regarding at least two points. For the first, Hasboruck decomposes the implicit price variance, with the assumption that price volatility reflects the flows of information. For the other, Gonzalo and Granger ignore the correlation among markets and consider that the market that adjusts least to price movements in the other markets is the leading one. Concerning the second point, the two indicators offer similar results when the markets are affected by the same information flows. When residuals are correlated, Hasbrouck's model can produce an efficient estimate of the contribution to price discovery only when the average of its bounds is considered, while the Gonzalo and Granger measure is efficient. However, Baillie et al. (2002) conclude that one measure does not provide a better price discovery with respect to the other because this depends on its definition, according either to the error correction phenomenon or to the correlations among markets innovations. They suggest using the Hasbrouck measure because it has a more general economic appeal and interpretation. Blanco et al. (2004) report both measures, while Zhu (2004) computes only the Gonzalo Granger measure because of residual autocorrelation.

According to the Gonzalo and Granger (1995) study, we calculate the contribution of each market to price discovery by measuring the ratio of the speed of adjustment in the two markets. More specifically, the contributions of market one (the CDS market) to price discovery is:

$$GG = \frac{\lambda_2}{\lambda_2 - \lambda_1}, \tag{10}$$

with a lower bound of zero and an upper bound of 1: when the value is negative, the indicator is zero, while if the value is above 1, GG is worth 1. If this measure tends to 1, the CDS market leads in price discovery and the bond market moves afterwards to correct for pricing errors; if this measure tends to 0, the bond market leads the derivative market, while if the measure is close to 0.5 both markets contribute to price discovery and we can say nothing about the leading market. Even in this case, the analysis can be extended to the CDS-bond basis or to other variables.
On the other hand, Hasboruck's measure is constructed using the variance-covariance matrix of residuals. We can define the bounds as:

$$HAS_1 = \frac{\lambda_2^2\left(\sigma_1^2 - \frac{\sigma_{12}^2}{\sigma_2^2}\right)}{\lambda_2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2} \qquad HAS_2 = \frac{\left(\lambda_2\sigma_1 - \lambda_1\frac{\sigma_{12}}{\sigma_1}\right)^2}{\lambda_2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2}, \tag{11}$$

where volatilities relate to the variance-covariance matrix between ε_{1t} and ε_{2t}. The Hasbrouck measure is rarely used in the literature because of the dependence of the bounds on the residual correlation. In the case of the augmented VECM system, we calculate the two price discovery measures in the same way as the initial VECM. We have decided to repeat the same analysis on different CDS indices and on CDS spreads for the banking sector. Our purpose is to investigate the extent to which CDS spreads for sovereign entities, expressed as an index or a single-basis, are affected or affects movements in corporate CDS spreads.[13]

To measure the extent to which i) sovereign credit risk markets are affected by news and announcements and ii) credit risk indicators are related to market dynamics, we conduct two different types of analysis. For the first we investigate the reaction of the CDS market after the release of information regarding Greek default risk and Eurozone financial stability. To do this we construct a dummy variable with an event window of $(t-2 \leq t \leq t+2)$, where t is the day of the announcement. Then we use several equations, including lagged levels of CDS spreads either with the dummy variable or with both the dummy variable and an interaction term obtained by multiplying the dummy for lagged values of CDS, and estimate the weights by OLS. An alternative way to analyse the same problem is to construct an event study following the same lines as Panetta et al. (2009). We conduct this exercise and estimate the differences in the reaction from both CDS and bond markets.
The second type of analysis is related to market dynamics. Recently, Duffie (2010a and 2010b) and others have argued that speculation in CDS markets does not drive up borrowing costs for Eurozone countries. For every country, we try to assess the relationship between CDS and bond spreads, together with three credit risk market proxies, namely,

[13] I would like to thank Aviram Levy and Antonio Di Cesare for suggesting this point.

gross and net positions and the number of contracts. We compute different regressions: the level, the first difference and the growth rate of CDS and bond spreads are regressed on both their lagged values together with the lagged values of the growth rates of these proxies; moreover, we try to put ourselves on the opposite side by estimating whether CDS premia are useful determinants of these market proxies.

3.2 Data Selection

We perform the empirical analysis on a sample of 18 European sovereign entities.[14] Our period spanned from 3 January 2005 to 29 July 2010, splitting in three subperiods: pre-Lehman Brothers bailout (3 January 2005 - 12 September 2008), post-Lehman Brothers (15 September 2008 - 31 December 2009) and (1 January 2010 - 29 July 2010) to deal with country risk turmoil.

European sovereign entities data are selected in two different ways.[15] Bond spread measures are obtained from the aggregate ten-year Treasury index from Bloomberg for every country by removing the same index for Germany. Hence, the bond spread measure is a difference over the 10-year German Bund index. However, for three countries (Sweden, Hungary and Latvia) the ten-year benchmark bond is taken from Datastream.
Given that the market does not evaluate Germany as a pure risk-free country, every country's CDS measure was corrected by removing the same measure for Germany. To match CDS with bond spreads, we have chosen five-year CDS spreads measure as a compromise between maturity and liquidity homogeneity for bonds.[16] Data for CDS spreads are obtained from Datastream. We use daily data for the analysis of price discovery.

To deal with sovereign credit risk market dynamics we use both gross and net positions on CDSs, as well as the number of contracts for our selected countries from DTCC. However, data are available only from November 2008 and with weekly frequency. We perform our regression analysis from 7 November 2008 to 23 July 2010.[17] Therefore, we construct our sample by selecting weekly (Friday) values of credit risk and market indicators for the available time period, adjusting for missing days.[18] The dummy variable for announcements derives from the timeline of significant bad news in Carmassi and Micossi (2010), which spans from 4 December 2009 to 21 June 2010. Daily data are used for this analysis.

For CDS indices we have used the iTraxx Europe (ITRXEBE), the iTraxx Senior Financials (ITRXESE) and the iTraxx Crossover (ITRXEXE) gathered from Bloomberg for corporate firms, and the SovX Western Europe index for sovereign entities. Unfortunately,

[14]The 18 sovereigns are Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Netherlands, Poland, Portugal, Slovakia, Spain and Sweden.

[15]There could be different currencies involved in the construction of the basis. However, Quanto CDS could reduce the impact of this issue.

[16]I am grateful to Antonio Di Cesare for this caveat. We have decided to concentrate on the most liquid segments for both bond and credit derivative markets.

[17]I would like to thank Maria Pia Mingarini for providing DTCC data.

[18]Volumes data are not available for 25 December 2009 and 1 January 2010.

this index was only available from September 2009. The time series before September 2009 was constructed using a simple average of the CDS premia for the constituent countries. Data for these spreads are gathered from Datastream.[19]

For banks' CDS spreads we have proceeded with a filtering process. Firstly, we have gathered the name of banks for every country from the list of local banks provided by Datastream. Secondly, we have ordered the banks in the list according to the market value. We have chosen those banks representing 80 per cent of market value of total market value of the list. Therefore, we have gathered five-year CDS spreads for every selected bank and we have computed the average of spreads. After this process, we remain with eleven sovereign entities for which bank spreads are available.[20]

4 Results

For ease of exposition we have decided to divide empirical results in two parts. In the first we present results from the analysis of sovereign CDS and bond spreads, dividing between dynamic relations and market reactions. In the second we describe the relation between sovereign CDS spreads and corporate CDS spreads on a sector-wide basis.

4.1 Sovereign CDS vs Bond Spreads: Descriptive Statistics and Cointegration Analysis

Results for descriptive statistics suggest that the average value of our bond spread and the average value of five-year CDS spread measures are divided by few basis points.[21] However, data show heterogeneous composition, reflecting both different perceptions of country credit risk, as well as different developments in derivative and bond markets.
While the average basis turns out to be negative for all the three periods considered, there are cases, like Bulgaria, Latvia and Sweden, where the values are all positive over time. This could indicate the presence of different liquidity levels for both credit risk markets, which can be relevant especially during periods of distress, or different market developments with respect to the benchmark market.[22]

Unit root analysis was performed by running the Augmented Dickey Fuller (ADF) and Phillips-Perron test for the all series considered. We found that most of the series for bond spread measures considered are I(1), while the CDS spread of one country over the same spread for German CDS is I(1) for 61 per cent of the countries considered.

[19]We have used all the countries on the Markit list, except Luxembourg. From 28 September 2009 to 19 March 2010 we have used the S2 series; from 22 to 30 March the average between S2 and S3 series, while from 31 March to 29 July we have used the S3 series.

[20]The eleven sovereign entities are: Austria, Belgium, Denmark, France, Greece, Ireland, Italy, Netherlands, Portugal, Spain and Sweden. The list of banks for every country is available from the author upon request.

[21]For brevity we have decided not to show descriptive statistics and cointegration results. Tables are available from the author upon request.

[22]See Boone et al. (2010).

However, after Lehman Brothers bailout only one country out of eighteen has stationary CDS spreads. When we focus on the traditional basis, we find that for two thirds of all countries, stationarity holds during the pre-Lehman period, but drops significantly for the other two subperiods. This can suggest that the no-arbitrage relation may no longer be valid during periods of financial distress.

We check for this by investigating the presence of cointegration through the λ_{trace} test. We provide the analysis for both the classical and the augmented cointegrating vector, performing the test both with and without constant restricted to the cointegrating vector. Akaike information criterion was chosen to determine the lag length of the VAR. When there is cointegration between the series, in Tables (1) and (2), we have indicated for every country the estimated cointegrating vector from the Johansen methodology without constant, with constant and from the DOLS methodology. We have also indicated the restrictions on the estimated cointegrating vectors.

Our findings suggest that during the pre-Lehman period, CDS and bond spreads seem to price credit risk equally in the long run only for eight out of eighteen countries. When we impose restrictions on the estimated cointegrating vectors, we show that there are only two cases where the traditional basis [1,-1] is respected and the same is true for [1,-1,c]. This could suggest that both credit risk measures are not equal in the long run, as theoretically indicated, but the linear combinations could be different, also bearing in mind the significance level of the constant in the cointegrating vector. Following the same lines as Fontana (2009), we control for the presence of cointegration between CDS and bond spreads by allowing the cointegrating vector to deal with funding cost issues. Surprisingly, for the pre-Lehman period, twelve out of eighteen sovereign entities have both credit risk indicators with a common trend. From the estimated cointegrating vector we can see that the spread coefficient is usually statistically different from zero, while the number of cases where the constant is different from zero decreases.

For the post-Lehman period we find that the number of cointegrating relations decreases to six countries, while when we allow for the presence of the spread, credit risk has the same price for derivative and bond markets in twelve countries. This finding suggests that the introduction of the spread EURIBOR-EUREPO allows us to restore cointegration, especially for those countries with negative basis during the financial turmoil. Even for this subperiod, restrictions are rejected, suggesting a different linear combination between credit risk indicators. Moreover, the significance level of the constant in the cointegrating vector is often high: this result could be interpreted in light of the analysis of Blanco et al. (2004), who suggest that CDS and bond spreads could theoretically reflect elements other than credit risk, especially during periods of distress.

Finally, turning to the 2010 period, where country risk arises, we can see that cointegration among derivative and bond markets holds for five countries, for both traditional and augmented cointegrating vectors.

4.2 Sovereign CDS vs Bond Spreads: Short- and Long-Term Dynamic Interactions

As in Chan-Lau and Kim (2005) and Coudert and Gex (2010), among others, for sovereign entities, results from the Granger causality test in Table (3) do not give a direct answer for the short-term relationships between credit risk indicators. As a matter of fact, there is a two-way causality relationship for most of the entities considered, indicating the presence of a close connection between different markets, especially after the Lehman bailout, but a no clear sign of the direction.[23]

However, it could be interesting to investigate the lead-lag properties in the short run.[24] To deal with this issue, we show the details of the VAR analysis, indicating the lag, the sign and the significance level for both the CDS and bond spreads. Lagged values of bond and CDS spreads seem generally significant at one, four, five, nine and ten days, with different signs. However, it is difficult to try to extract a cyclical behaviour from these market data. On the other hand, when we focus on the post-Lehman period, the data suggest that lags from one to three days are usually significant. Finally, results show that both CDS and bond spreads with one, two and in some cases, seven days of delays are useful determinants.

Further investigations for understanding the dynamic properties of different credit risk indicators can be implemented by the use of the VECM (Eqs. 8 and 9), from which it is possible to compute the two price discovery measures. Results for the pre-Lehman period suggest that lambda coefficients are with the correct suspected sign in half of the cases considered. When we turn to the price discovery measures, both Gonzalo and Granger (1995) and Hasbrouck (1995) values suggest that the bond market leads the CDS market in terms of price discovery. However, France is the only entity for which the weight of one market against the other changes according to different cointegrating vector estimations. The importance of the bond market before the Lehman bailout is confirmed by the same analysis conducted with the augmented cointegrating vector, even if one has to take into account the small number of significant lambdas.

The post-Lehman period seems to shift the magnitude and the significance of the lambas, while there is an increase in the volatility of credit risk indicators, reflecting erratic residuals from the VECM. On the one hand, we find that the Gonzalo and Granger (1995) measure suggests a doubtful interpretation of which market leads the other. However, estimations conducted with DOLS indicate the derivative market as the main forum for credit risk. The Hasbrouck measure seems to confirm the leading properties of the CDS market.

On the other hand, when we perform the analysis with the augmented cointegrating vector, both the Gonzalo and Granger (1995) and the Hasbrouck (1995) measures attribute to the bond market the role of leading venue for credit risk information. From an econometric

[23] We select lag length by using Akaike information criterion.

[24] Once again, I am grateful to Antonio Di Cesare and Aviram Levy who suggested this exercise. For brevity, we have decided not to show these tables, which are available from the author upon request.

point of view, these different results could reflect the high values of volatility during the second subperiod.[25]

Finally, during 2010 the credit risk information content within the CDS market is greater than that within the bond market. Both price discovery measures are in line with this finding, even if there are opposite results when the cointegrating vector is constructed by the Johansen methodology without a constant.

Our results are in line with Aktung et al. (2009) and Kavussanos and Palamidi (2008), who find an increasing role for the CDS market. However, Coudert and Gex (2010) interpret their results splitting their sample according to the risk category. High spread countries, such as PIIGS should have a leading role for the CDS market, while low spread countries should reflect a leading role for the bond market. Our results are in line only for those countries with high CDS spreads, while for the others the interpretation is cumbersome.[26]

4.3 Market Reactions: Implicit Behaviour Within the CDS and Bond Markets

After the analysis of price discovery we consider credit risk market behaviour. On the one hand we check whether the CDS and bond markets react to news about the Eurozone crisis, according to the contribution of Carmassi and Micossi (2010). On the other, we analyse the impact of the market structure proxy, such as CDS gross and net volumes, together with the number of contracts on CDS and bond spreads.

For the reaction to especially bad news we use two methodologies. First, we estimate AR(1), AR(2) and AR(5), plus a dummy variable as defined in Section (3.1), for either the difference between sovereign CDS spreads and German CDS spread, or the sovereign CDS spread alone. Second, we conduct an event-study analysis in order to examine the impact of bad news on cumulative changes in both CDS and bond spreads, with a ten-day window. For ease of exposition, we will show only the second one in the Appendix. Results suggest that the dummy variable has an impact from 3 to 14 basis points, for six countries out of eighteen when we use net CDS spreads, while the impact goes from 3 to 18 basis points, for five out of eighteen when we use gross CDS spread.[27] However, with gross CDS spreads, the dummy variable becomes significant only when combined with an interaction term. Moreover, Italy and Spain are the only countries for which the dummy is always significant, irrespective of the lag length of the process describing the CDS spreads.
For the event-study analysis, even if the news is reabsorbed five days after release, Figures (4) and (5) seem to suggest that the reaction in the derivative market is smoother than in the bond market. However, Table (10) indicates that the reaction is only significant in

[25] The average value of standard deviations more than doubled from the pre- to the post-Lehman period.

[26] Nonetheless, the Hansen parameter stability test implies caution because of the presence of instability among lambdas. Results are available upon request from the author.

[27] The impact of this dummy variable is 6 basis points only for the SovX index, exclusively in the case of one and two lags for the model. Results are available from the author upon request.

the case of one and two days after the event for Greece and Ireland. Moreover, Table (11) shows that both derivative and bond markets react in the same way.

For the impact of proxies of market structure on the CDS and bond spreads, we estimate a battery of regressions, where the dependent variable is either the level, the first differences or the growth rate of credit risk indicators (CDS or bond spreads), while the regressors are lagged values of both the dependent and either net or gross positions, or the number of contracts in the CDS markets, expressed in terms of growth rates. Moreover, we use one to four lags to capture the interrelations within one month.
Results (not shown) are difficult to interpret from an economic point of view. For the relation between CDS spreads and net positions, the four- and the two-week growth rate is significantly different from zero, with a negative sign, especially for countries like PIIGS. Moreover, countries like Poland and Sweden show that the first lag of the change in net positions is significantly different from zero. On the bond side, the same considerations could be extended to Ireland, while for the other cases it is difficult to find a regularity.
When we focus on the relation between CDS spreads and the growth rate of gross positions we find two results: for Ireland, Portugal and Spain, this market proxy becomes significant, especially from the second to the fourth lagged value, while the significant impact holds for one week for Sweden. Moreover, the number of countries for which the lagged values of gross positions become significantly different from zero increases to fourteen. Turning to the bond side, it is not easy to guess a particular regularity: results seem to confirm that the first two lags could be significant determinants of bond spreads.
Finally, when the growth rate of the number of CDS contracts is considered, we can say that for most of the entities (fifteen out of eighteen), the first two lagged values are significantly different from zero and with a positive sign. One or two lagged values of the growth rate of the number of contracts are significant CDS spread determinants. On the bond side, the number of contracts are significantly different from zero especially for one and two lags.
Table (12) shows that for nine countries out of eighteen, either the level or the first difference of the CDS spread helps to predict future values of growth rates in market proxies. Our results seem in line with the studies of Duffie (2010a and 2010b), who find that there is no empirical relationship between CDS spreads and market volumes. Our statistical analysis may suffer from the problem of simultaneous relation among spreads and volumes, so we are sceptical about a clear conclusion.

4.4 Sovereign CDS vs Corporate CDS: Descriptive Statistics and Cointegration Analysis

Data for CDS indices evidence that the iTraxx Europe has lower average premia than the iTraxx Senior Financials for both the pre- and the post-Lehman period. However, during the 2010 sample period, the iTraxx Senior Financials become riskier, on average. When we turn to the relation between sovereign CDS spreads and banks' CDS spreads, the story is the same. There is an increase in the spreads of both categories during the three periods considered, with the average CDS spreads of the banking sector always greater than the sovereign ones. Moreover, the difference between the two average spreads becomes wider during the post-Lehman period, suggesting an increase in the risk of banks.

Results from cointegration analysis for CDS indices show that cointegration is confirmed during the pre-Lehman period, while for both the post-Lehman and 2010 periods the long-term relationship between the variables weakens. However, when we perform the analysis for the augmented cointegrating vector, cointegration comes back during the post-Lehman period and 2010, but only for iTraxx Europe. Lastly, cointegration analysis for the relation between sovereign CDS and banks' CDS spreads confirms what we have found before.[28] Once again, the inclusion of the spread three-month EURIBOR versus EUREPO seems to help restore the relationship between the two credit spreads during the post-Lehman period. However, during the 2010 period cointegration holds in only one case and in two cases with a traditional or augmented cointegrating vector. Estimates of the cointegrating vector suggest that the coefficient for banks' CDS spreads is negative and significant, while the constant is usually negative and significant.

4.5 Sovereign CDS vs Corporate CDS: Short- and Long-Term Dynamic Interactions

When we repeat the short-term exercise with the Granger causality test for CDS indices, we find in Table (15) that every iTraxx index is a useful determinant for the SovX index during all periods.[29] The CDS index on sovereign entities helps to predict the future values of the iTraxx crossover after the Lehman bailout, while it increases its predicting power during 2010. Generally, one day of delay in the data is shown to be significant for every regression in the VAR.

To complete the lead-lag analysis for the short run we have decided to calculate cross-correlations between both the SovX index and every single iTraxx index, using ten days for leads and lags.[30] Our findings (not shown) suggest that: i) all sovereign and corporate indices are highly positively correlated, ii) all series are coincident as a result of the significance level in every one-day lagged variable, iii) the only exception is the leading power of the SovX index (highest value of correlation at ten days) with respect to the iTraxx Senior Financials, going against our previous findings from the VAR analysis. However, this point deserves caution in the light of the recent debate on the exposure of European banks to PIIGS' debt.[31] Moreover, Table (16) shows the Granger causality test conducted on the relation between sovereign CDS spreads and banks' CDS spreads. Our results suggest that the passage from the post-Lehman to the 2010 period seems to confirm the

[28]Results are available from the author upon request.

[29]In this case we do not consider different weights in the index, as suggested by Credit Suisse (2010).

[30]We have used a well-known methodology in the literature on stylized facts for business cycle. See Stock, J.H. and M.W. Watson, (1999) for more on the methodology. However, we have decided not to use cyclical component.

[31]See Money Supply blog on Ft.com, 13 August 2010.

power of sovereign CDS spreads in predicting future changes in banks' CDS spreads. This result could emphasize the leading role of the sovereign CDS market, especially during country crisis periods. However, results from the Granger causality test show a two-way relationship during 2010, when even banks' CDS spreads are useful determinants of future changes in sovereign CDS spreads. This could depend on both a higher correlation due to contagion and greater positions of banks on sovereign CDS contracts.

Tables (17) and (18) show the results from the VECM analysis on cointegrated series. When we use the simple bivariate cointegrating vector, we find that the Gonzalo-Granger (1995) and the Hasbrouck (1995) measures are difficult to interpret. However, when we include the spread, price discovery measures seem to go in the same direction.[32] Results from Table (18) suggest that the iTraxx market, for both European corporate and financials, beats the SovX market in terms of price discovery. However, after the Lehman Brothers bailout and during 2010, the relation is opposite: the SovX market reacts more rapidly to credit risk information and the iTraxx market adjusts to movements in the sovereign market. Even in this case, estimation results should be interpreted with caution because of the presence of parameter instability for both lambdas. Finally, results for the relation between sovereign CDS spreads and banks' CDS spreads are illustrated from Table (19) to Table (22). When cointegration holds, our estimates show the leading power of the sovereign CDS especially during post-Lehman period. However, the absence of a long-run relation between the two series does not allow us to perform the model for the 2010 period.

[32]During the pre-Lehman period, the VECM estimated with DOLS for iTraxx Senior Financials and all results for iTraxx Crossover are troubling. Even if the estimated λ_1 coefficients are significant and with the correct sign, λ_2 coefficients have a higher weight, leading to an inappropriate meaning.

5 Conclusions

This paper has examined two types of analysis for the sovereign credit risk market. In the first, we consider the relation between CDS and bond spreads for sovereign entities using short- and long-run exercises. Moreover, we also consider credit risk market behaviour. In the second, we study the relation between CDS spreads for sovereign and corporate entities by running the same short- and long-run analysis on both an aggregate and sector-wide basis.

The relation between sovereign CDS and bond spreads offers three useful indications. Cointegration results suggest that credit risk indicators do not move in the same way in the long run when we the shift from the pre- to the post-Lehman subperiod. The three-month EURIBOR-EUREPO spread helps to restore this relationship, especially for countries with a negative basis. Second, when we shift to short-term causality, the results imply a predictive power from one market to the other, with a two-way relationship. Third, the CDS sovereign market becomes the leading forum for credit risk during 2010, especially for higher spread countries, even if for the previous two subperiods both markets contribute in price discovery.

Moreover, market behaviour results, especially for Ireland, Italy and Spain, suggest that the CDS market may react to announcements about the Eurozone crisis. The same evidence is confirmed by the event-study analysis only for the case of Ireland. Secondly, market proxies seem to be significant determinants for both CDS and bond spreads in some cases, even if the impact and the meaning of the sign and the time lag is difficult to interpret. Thirdly, when we put on the opposite direction, we find significant evidence of the role of the sovereign CDS market on net and gross positions, as well as on the number of contracts. It seems difficult to detect a possible relationship between prices and volumes.

For the comparison between sovereign and corporate CDS spreads, short-term causality imply a bivariate relation between the two markets when we consider CDS indices. However, when we turn to the analysis between the sovereign and the banking sector, the bivariate relationship holds only for 2010 and for countries with high CDS spreads. The banking sector increases its leading power over the sovereign sector during 2010. On the other hand, long-run analysis suggests that the iTraxx leads the SovX during the pre-Lehman, while the sovereign CDS index leads in terms of price discovery thereafter. The leading property of sovereign CDS spreads is also confirmed through the relation with the banking sector.

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Appendix

1. Figures

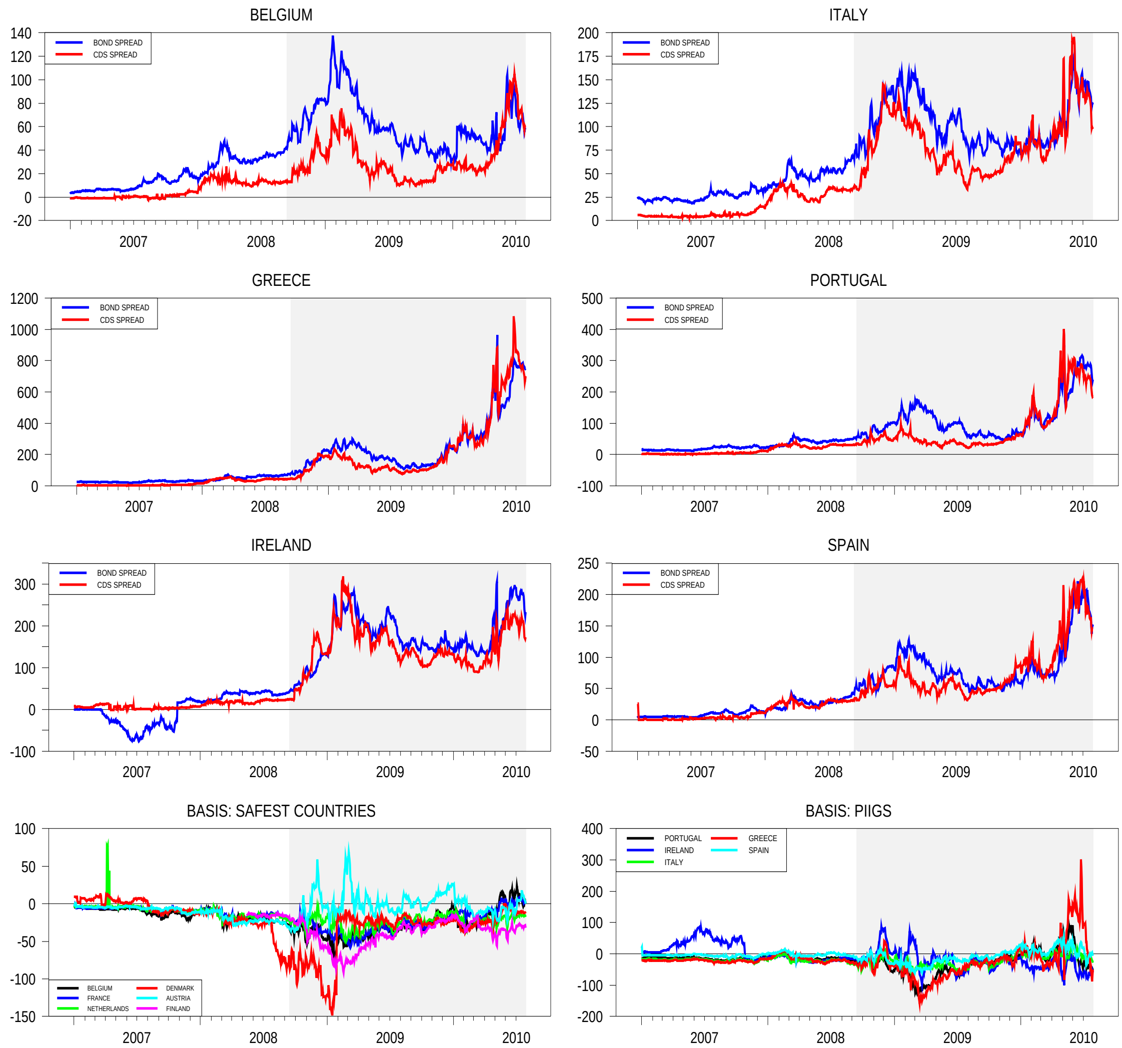

Figure 1: PIIGS and Belgium. CDS spreads vs bond spreads. 2007 - 2010. Shaded area refers to the post-Lehman period and 2010. Basis for PIIGS and safest countries. See Coudert and Gex (2010).

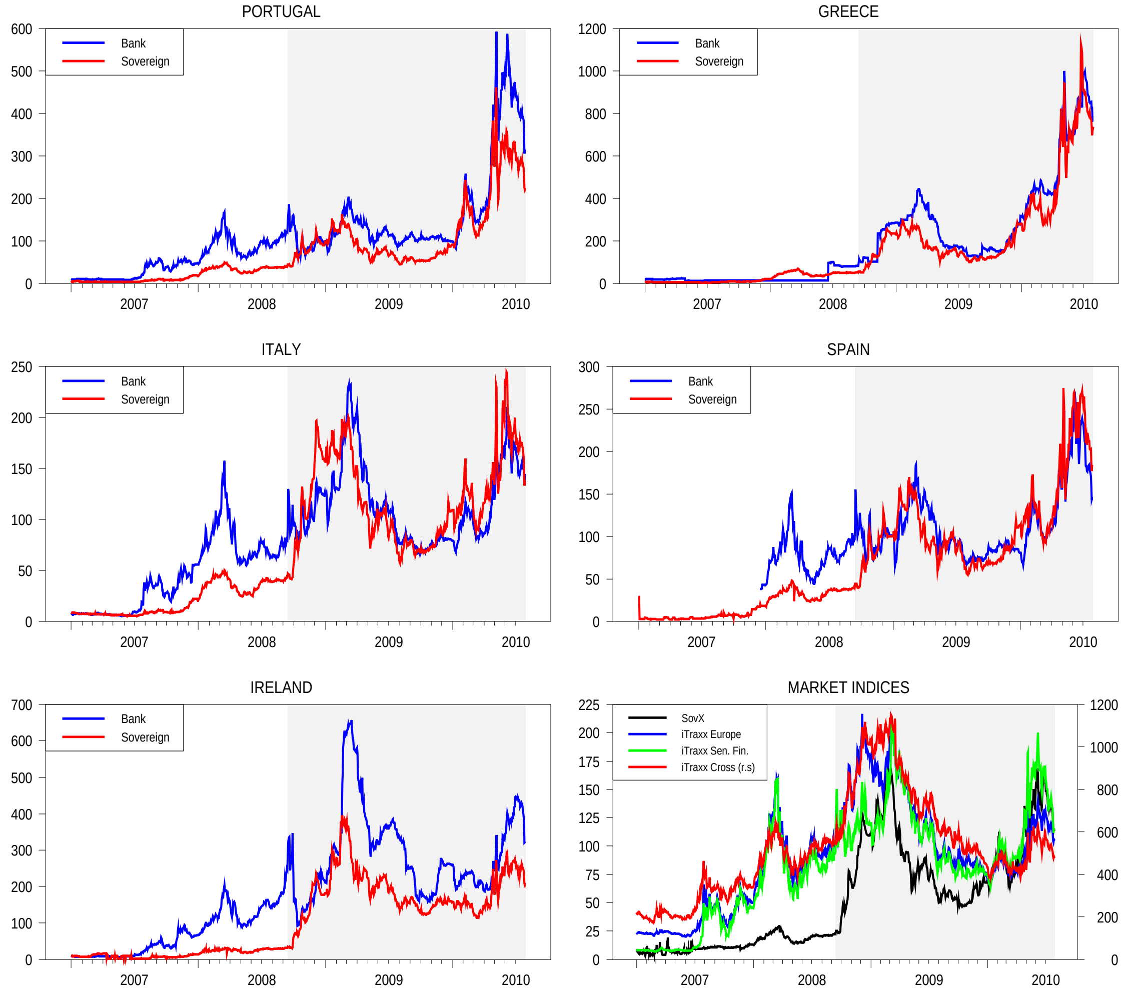

Figure 2: CDS spreads for bank and sovereign entities (PIIGS) and CDS indices. 2007 - 2010 period. Shaded area refers to the post-Lehman and 2010.

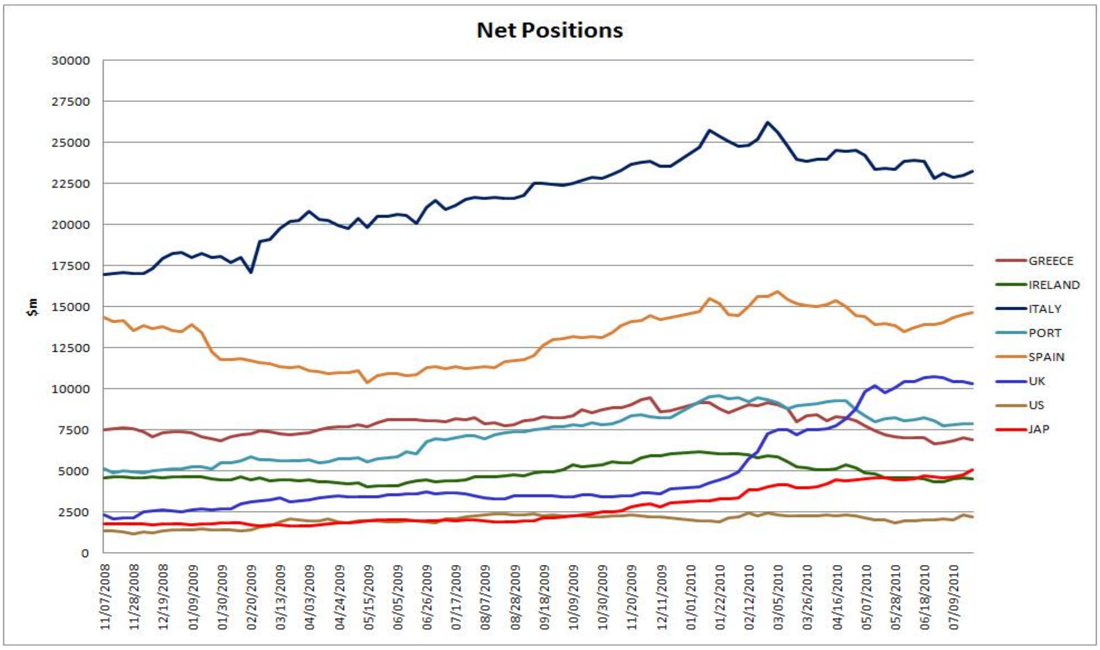

Figure 3: Net positions for selected countries.

Timeline of significant bad news. December 2009 - June 2010

* **December 8**: Fitch cuts rating on Greek debt to BBB plus with negative outlook - first time in ten years a leading rating agency has rated Greece sovereign paper below A grade
* **January 12**: Greece is condemned by the European Commission for falsifying data on its public finances. Angela Merkel says that Greece's mounting deficit could harm the euro, which faces a very difficult phase in the coming years (comment posted on a government website and later removed).
* **January 28**: Bungled attempt by Greece to sell government debt to China becomes public.
* **March 25**: Eurozone agrees on emergency plan for Greece, but immediately after divergent interpretations of agreement surface between member states and unsettle markets.
* **April 23**: Greece asks for activation of Eurozone/IMF loan. EU says terms of aid may be agreed in a matter of days, but Merkel says Greek government must satisfy very stringent conditions.
* **May 3**: 110 billion euro Eurozone-IMF support package for Greece adopted. ECB relaxes collateral policy for Greek sovereign debt.
* **June 14**: Moody's downgrades Greek sovereign debt to junk.

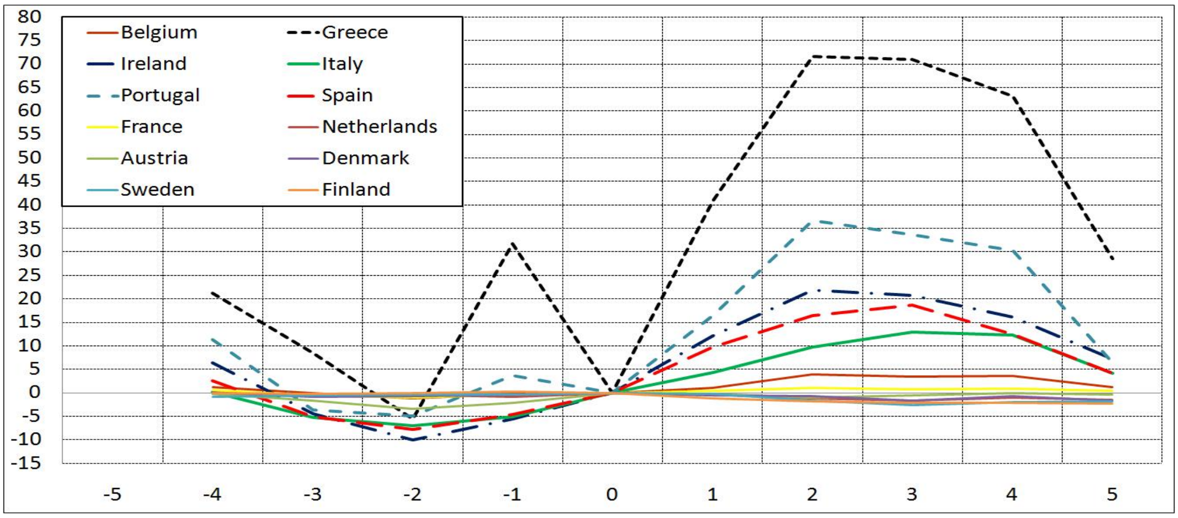

Figure 4: Event-study analysis. Average reaction to bad news. Cumulative change in CDS spreads.

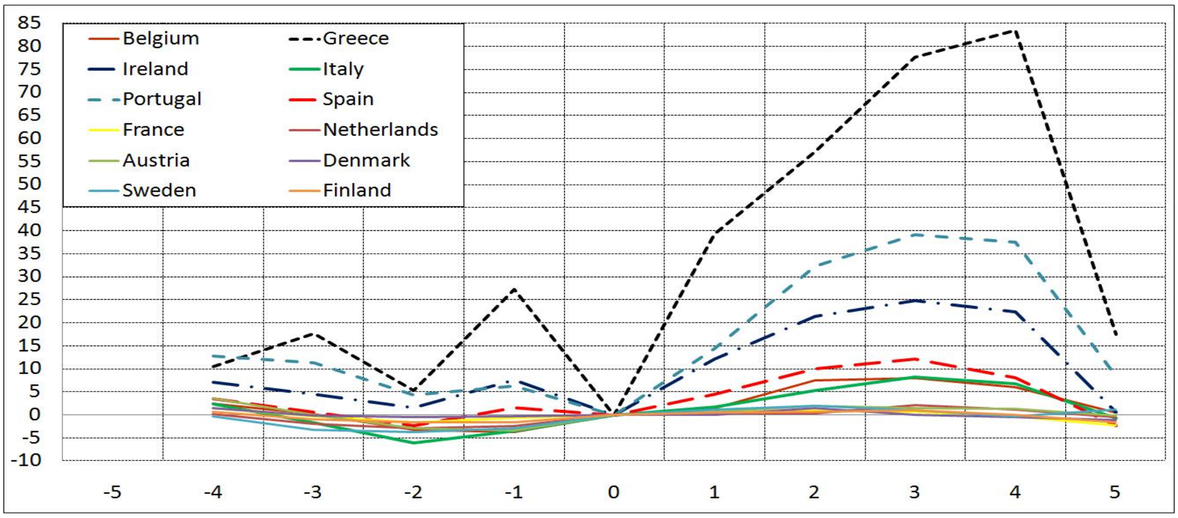

Figure 5: Event-study analysis. Average reaction to bad news. Cumulative change in bond spreads.

2. Results

2.1 Sovereign CDS vs Bond Spreads

Table 1: Long-run relationship between credit risk indicators. Estimated cointegrating vectors. Pre-Lehman period. A, B and C stand for 1%, 5% and 10% significance level only for the constant and for the augmented cointegrating vector. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to DOLS estimation.

Country	**CDS**	**BS**	**constant**	**CDS**	**BS**	**spread**	**constant**
BELGIUM				1	2.388^{A}	-1.450^{A}	0
				1	-2.852^{A}	1.212^{A}	5.868
				1	-0.535^{A}	0.047^{B}	
GREECE				1	-0.141	-0.435^{A}	0
				1	-0.848^{A}	0.010	
IRELAND				1	-0.095^{C}	-0.232^{A}	0
	1	-0.252	-6.347^{A}	1	-0.118^{A}	-0.176^{A}	-2.160
	1	-0.188		1	-0.108^{A}	-0.159^{A}	
ITALY	1	-0.372	0	1	-0.230^{A}	-0.240^{A}	0
	1	-0.670		1	-0.702^{A}	0.010	
SPAIN	1	-0.749	0	1	-1.465^{A}	0.261^{A}	0
				1	-1.517^{A}	0.299^{A}	-1.004
	1	-0.851		1	-0.993^{A}	0.060	
FRANCE	1	-0.150	0	1	7.813^{A}	-2.182^{A}	0
	1	-0.207	0.875^{A}	1	-0.987^{A}	0.212^{A}	0.873
	1	-0.190		1	-0.248^{A}	0.014	
NETHERLANDS	1	-0.146	0	1	-0.041	-0.029	0
	1	0.021	-2.599^{C}	1	-0.131	0.045	-2.910^{B}
	1	0.029		1	-0.052	0.024	
DENMARK	1	0.168	0				
	1	0.447	-9.758^{B}				
	1	0.323					
AUSTRIA	1	-0.095	0	1	-0.101^{A}	0.003	0
	1	-0.100	0.160	1	-0.090^{A}	-0.005	0.216
	1	-0.075		1	-0.047^{A}	-0.019	
BULGARIA				1	7.984	-5.423^{A}	0
				1	-2.247	-0.766	
CZECH REP.				1	0.979^{A}	-1.157^{A}	0
				1	-0.161	-0.161	
FINLAND				1	-0.190^{A}	0.018^{C}	0
				1	0.119	0.082^{A}	-9.375^{A}
				1	-0.164^{B}	0.019	
SWEDEN	1	1.393	0	1	1.020^{A}	-0.209^{C}	0
	1	-0.281	-16.742^{A}	1	0.451	-0.101	-7.799
	1	0.168		1	0.267	-0.034	

Table 2: Long-run relationship between credit risk indicators. Estimated cointegrating vectors. Post-Lehman and 2010 periods. A, B and C stand for 1%, 5% and 10% significance level only for the constant and for the augmented cointegrating vector. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to DOLS estimation.

Country	CDS	BS	constant	CDS	BS	spread	constant
POST-LEHMAN PERIOD							
IRELAND	1	-0.893	0	1	-0.800^{A}	-0.177^{C}	0
	1	-1.093	36.097	1	-0.509^{A}	-0.023	-59.446^{C}
	1	-0.854		1	-0.919^{A}	-0.304^{C}	
ITALY				1	-0.643^{A}	-0.089	0
	1	-1.291	60.452^{A}	1	-0.210	-0.219^{B}	-35.871^{B}
	1	-0.887		1	-0.752^{A}	-0.127	
PORTUGAL							
	1	0.049	-49.649^{A}				
	1	-0.131					
FRANCE				1	1146.250^{A}	-73.682^{A}	0
				1	11.965^{A}	-0.794^{A}	-36.003^{A}
				1	0.004	-0.062^{A}	
NETHERLANDS				1	-0.380^{A}	-0.027	0
				1	-0.582^{A}	-0.009	7.993^{A}
				1	-0.640^{A}	-0.023	
DENMARK				1	-0.209^{A}	-0.169^{B}	0
				1	-0.198^{A}	-0.192^{B}	1.053
				1	-0.317^{A}	-0.063	
AUSTRIA				1	-1.094^{A}	0.093	0
				1	-1.167^{A}	0.079	
BULGARIA	1	-7.164	0	1	-2.569^{A}	-2.906^{A}	0
				1	-2.032^{A}	-2.318^{A}	-75.513^{B}
	1	-5.114		1	-3.727^{A}	-1.454^{A}	
CZECH REP.							
	1	2.470	-435.409^{A}				
	1	-0.282					
POLAND							
				1	3.827^{A}	0.304	-1211.205^{A}
				1	-0.668	-0.886^{A}	
FINLAND				1	0.251^{A}	-0.180^{A}	0
				1	-0.018	-0.066^{A}	
SWEDEN				1	0.030	-0.436^{A}	0
				1	1.093^{A}	0.233^{A}	-39.494^{A}
				1	0.567	0.018	
HUNGARY				1	-0.406^{A}	-1.151^{A}	0
				1	-0.562^{A}	-1.116^{A}	85.152
				1	-0.670^{A}	-1.034^{A}	
LATVIA	1	-30.431		1	-25.161^{A}	-4.093^{A}	0
	1	-11.566	-421.633^{A}	1	19.284^{A}	1.007	-1020.530^{A}
	1	-2.781		1	-3.288^{A}	-2.068^{A}	
2010 PERIOD							
IRELAND	1	-0.770	0				
	1	-0.800					
SPAIN	1	-1.070	0	1	-0.968^{A}	-0.558^{A}	0
	1	-0.968	-14.442^{C}	1	-1.036^{A}	2.791^{C}	-77.924^{A}
	1	-0.925		1	0.985^{A}	2.230	
AUSTRIA				1	-4.741^{A}	6.490^{A}	0
	1	-3.079	95.568^{A}	1	-3.674^{A}	2.169	65.376
	1	-0.874		1	-0.749	-0.976	
CZECH REP.	1	-0.424	0	1	-0.312^{A}	-0.526^{C}	0
	1	-0.307	-14.322^{B}	1	-1.167^{A}	13.352^{A}	-256.476^{A}
	1	-0.244		1	-0.141	-1.940	
POLAND				1	2.739^{A}	-34.584^{A}	0
				1	-0.235^{A}	-4.891^{A}	103.540^{A}
				1	-0.474^{A}	-1.882	
SWEDEN	1	-0.258	0	1	-0.673^{A}	-0.213	0
	1	-0.623	-4.477	1	-0.423	-5.427^{A}	138.069^{A}
	1	-0.725		1	-0.815^{A}	-0.789	

Table 3: Granger causality test. F-statistic values. CDS and bond spreads. Pre-Lehman. A, B and C stand for 1%, 5% and 10% significance level.

	Granger causality. F-test value					
	PRE		POST		2010	
COUNTRY	CDS spreads do not Granger cause BS	BS do not Granger cause CDS spreads	CDS spreads do not Granger cause BS	BS do not Granger cause CDS spreads	CDS spreads do not Granger cause BS	BS do not Granger cause CDS spreads
BELGIUM	4.827^{A}	3.322^{A}	6.018^{B}	2.818^{B}	0.041	1.328
GREECE	1.960^{A}	4.922^{A}	9.618^{A}	0.991	3.857^{A}	2.434^{C}
IRELAND	0.126	0.918	9.770^{A}	7.776^{A}	6.957^{A}	2.153^{B}
ITALY	3.405^{A}	3.598^{A}	1.777	3.350^{C}	2.994^{C}	0.354
PORTUGAL	2.087^{B}	2.870^{A}	3.389^{B}	1.201	9.340^{A}	9.110^{A}
SPAIN	3.011^{A}	2.708^{A}	8.274^{A}	6.505^{B}	3.834^{A}	1.039
FRANCE	3.088^{A}	3.679^{A}	2.433^{C}	0.423	10.610^{A}	2.154
NETHERLANDS	0.496	0.770	3.669^{C}	3.841^{B}	0.935	3.000^{C}
DENMARK	0.454	1.065	5.241^{A}	2.801^{C}	1.740	3.052^{C}
AUSTRIA	0.557	0.011	7.224^{A}	7.497^{A}	2.604	3.653^{C}
BULGARIA	4.860^{A}	2.567^{C}	2.035	3.050^{B}	0.1841	1.238
CZECH REP.	1.926^{C}	2.102^{B}	6.827^{A}	2.856^{A}	3.195^{B}	3.449^{B}
POLAND	0.819	3.316^{A}	3.737^{A}	6.193^{A}	3.477^{A}	4.572^{A}
SLOVAKIA	0.907	1.3682	1.605	0.324	1.785	3.194^{C}
FINLAND	2.256	2.795^{C}	0.987	1.182	5.087^{A}	2.135^{C}
SWEDEN	0.711	0.334	2.938^{C}	3.609^{C}	1.547	2.029
HUNGARY	6.474^{A}	3.005^{A}	7.251^{A}	0.045	na	na
LATVIA	0.194	1.098	1.5722	0.5503	na	na

Table 4: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with traditional cointegrating vector. Pre-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	**Gonz-Grang**	**HAS**$_1$	**HAS**$_2$	**MID**
IRELAND	na	na	na	na	na	na
	-0.069^{A}	0.017	0.200	0.147	0.118	0.133
	-0.033^{A}	0.009	0.215	0.174	0.140	0.157
	-0.009	0.007^{B}	0.462	0.695	0.651	0.673
ITALY	-0.011^{B}	0.013^{B}	0.551	0.506	0.575	0.541
	na	na	na	na	na	na
	-0.005	-0.001	0	0.016	0.004	0.010
	-0.002	-0.002	1.000	0.571	0.246	0.409
SPAIN	-0.013	0.025^{A}	0.655	0.918	0.933	0.926
	na	na	na	na	na	na
	-0.022	0.023^{A}	0.519	0.955	0.982	0.969
	na	na	na	na	na	na
FRANCE	-0.061^{A}	0.049^{B}	0.446	0.450	0.393	0.421
	-0.064^{A}	0.079^{A}	0.551	0.667	0.615	0.641
	-0.061^{A}	0.035^{C}	0.368	0.292	0.240	0.266
	na	na	na	na	na	na
NETHERLANDS	-0.248^{A}	-0.003	0	0.013	0.007	0.010
	-0.262^{A}	-0.004	0	0.020	0.013	0.016
	-0.240^{A}	-0.002	0	0.008	0.004	0.006
	-0.121^{A}	-0.002	0	0.050	0.038	0.044
DENMARK	-0.074^{A}	0.001	0.015	0.015	0.031	0.023
	-0.097^{A}	0.001	0.005	0.002	0.009	0.006
	-0.070^{A}	-0.002	0.021	0.028	0.049	0.039
	-0.038^{B}	-0.002	0	0.078	0.053	0.066
AUSTRIA	-0.085^{A}	0.167^{B}	0.661	0.224	0.252	0.238
	-0.083^{A}	0.178^{A}	0.680	0.255	0.285	0.270
	-0.090^{A}	0.146^{B}	0.618	0.166	0.190	0.178
	-0.002	0.013^{B}	0.887	0.816	0.834	0.825
SWEDEN	-0.079^{A}	-0.001	0	0.004	0.002	0.003
	-0.085^{A}	0.010^{B}	0.108	0.267	0.289	0.278
	-0.064^{A}	0.003	0.050	0.066	0.075	0.070
	-0.033^{B}	0.004	0.119	0.314	0.332	0.323

Table 5: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with augmented cointegrating vector. Pre-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation.

Ticker	λ_1	λ_2	**Gonz-Grang**	$\mathbf{HAS}_1$	$\mathbf{HAS}_2$	**MID**
BELGIUM	-0.006^A	-0.001	0	0.075	0.043	0.059
	0.007^A	0.003^C	0	0.237	0.184	0.211
	-0.019^C	0.003	0.140	0.034	0.069	0.052
GREECE	-0.012^A	0.002	0.148	0.019	0.064	0.042
	na	na	na	na	na	na
	-0.003	-0.001	0	0.054	0.015	0.035
IRELAND	-0.094^A	-0.008	0	0.018	0.035	0.026
	-0.107^A	-0.005	0	0.005	0.015	0.010
	-0.092^A	-0.002	0	0	0.007	0.003
ITALY	-0.021^A	0.001	0.052	0.002	0.015	0.009
	na	na	na	na	na	na
	-0.006^C	-0.003	0	0.190	0.137	0.163
SPAIN	0.003	0.018^A	1	0.994	0.993	0.994
	0.004	0.016^A	1	0.983	0.981	0.982
	-0.024	0.026^A	0.524	0.806	0.817	0.811
FRANCE	-0.002^B	0.000	0	0	0.008	0.004
	0.009	0.010	1	0.570	0.635	0.602
	-0.065^A	0.030	0.316	0.209	0.163	0.186
NETHERLANDS	-0.249^A	-0.003	0	0.014	0.007	0.011
	-0.262^A	-0.005	0	0.024	0.016	0.020
	-0.238^A	-0.003	0	0.009	0.004	0.006
AUSTRIA	-0.083^A	0.177^A	0.681	0.256	0.286	0.271
	-0.091^A	0.173^B	0.655	0.214	0.243	0.228
	-0.095^A	0.072	0.429	0.042	0.053	0.047
BULGARIA	-0.003^B	0.000	0.002	0	0.003	0.001
	na	na	na	na	na	na
	0.003	0.000	0	0.451	0.410	0.431
CZECH REP.	0.000	-0.015^A	1	1.000	0.998	0.999
	na	na	na	na	na	na
	-0.001	0.009	0.861	0.807	0.830	0.818
FINLAND	-0.329^A	0.111	0.252	0.128	0.103	0.116
	-0.147^B	0.000	0	0	0.009	0.004
	-0.163^B	0.047	0.222	0.101	0.064	0.082
SWEDEN	-0.089^A	0.003	0.029	0.022	0.028	0.025
	-0.094^A	0.006	0.064	0.105	0.118	0.112
	-0.070^A	0.004	0.052	0.072	0.081	0.076

Table 6: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with traditional cointegrating vector. Post-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	**Gonz-Grang**	**HAS**$_1$	**HAS**$_2$	**MID**
IRELAND	0.000	0.035^A	0.988	0.914	1.000	0.957
	0.012	0.035^A	1	0.999	0.940	0.970
	-0.001	0.033^A	0.972	0.904	0.995	0.950
	0.001	0.025^A	1	0.931	1.000	0.965
ITALY	na	na	na	na	na	na
	0.019	0.054^A	1	0.987	0.856	0.921
	-0.003	0.021	0.863	0.811	0.976	0.893
	na	na	na	na	na	na
PORTUGAL	na	na	na	na	na	na
	-0.041^A	0.031^C	0.433	0.197	0.476	0.336
	0.000	0.007	0.939	0.878	0.994	0.936
	na	na	na	na	na	na
BULGARIA	-0.009	0.004^A	0.329	0.808	0.957	0.883
	na	na	na	na	na	na
	-0.006	0.002^C	0.209	0.680	0.874	0.777
	na	na	na	na	na	na
CZECH REP.	na	na	na	na	na	na
	-0.011^A	0.004	0.289	0.096	0.279	0.187
	0.003	0.012^C	1	0.998	0.929	0.964
	na	na	na	na	na	na
LATVIA	0.003^C	0.001^A	0	0.839	0.747	0.793
	0.005	0.004^A	0	0.978	0.928	0.953
	0.000	0.001	0.675	0.947	0.990	0.968
	-0.001	0.000	0.423	0.844	0.926	0.885

Table 7: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with augmented cointegrating vector. Post-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation.

Ticker	λ_1	λ_2	**Gonz-Grang**	**HAS**$_1$	**HAS**$_2$	**MID**
IRELAND	-0.002	0.003^C	0.607	0.893	0.861	0.877
	-0.033^A	0.009	0.215	0.174	0.140	0.157
	-0.009	0.007^B	0.462	0.695	0.651	0.673
ITALY	-0.015	0.043^A	0.737	0.662	0.899	0.781
	-0.029^A	0.006	0.167	0.026	0.193	0.109
	-0.011	0.025^B	0.696	0.607	0.860	0.734
FRANCE	0.000	0.000	1	0.732	0.680	0.706
	0.000	0.000	1	0.794	0.747	0.770
	-0.154^A	0.056	0.267	0.045	0.080	0.063
NETHERLANDS	-0.042^B	0.036^B	0.462	0.371	0.545	0.458
	-0.038^C	0.067^A	0.637	0.655	0.813	0.734
	-0.010	0.018^C	0.639	0.667	0.810	0.738
DENMARK	-0.035^A	0.003	0.085	0.001	0.023	0.012
	-0.124^A	-0.002	0	0.014	0.007	0.010
	-0.132^A	-0.001	0	0.006	0.002	0.004
AUSTRIA	-0.034^C	0.019^B	0.357	0.406	0.661	0.534
	na	na	na	na	na	na
	-0.033^C	0.019^B	0.362	0.416	0.671	0.543
BULGARIA	-0.049^A	-0.003^B	0	0.256	0.105	0.181
	-0.065^A	-0.003^C	0	0.154	0.039	0.096
	-0.031^A	0.000	0.008	0.004	0.083	0.044
POLAND	na	na	na	na	na	na
	-0.012^A	-0.003	0	0.054	0.022	0.038
	-0.004	-0.001	0	0	0	0
FINLAND	-0.041^A	-0.035^B	0	0.349	0.277	0.313
	na	na	na	na	na	na
	-0.039^B	0.020	0.339	0.137	0.214	0.176
SWEDEN	-0.023^A	-0.004	0	0.014	0.040	0.027
	-0.004	-0.003^C	1	0.935	0.970	0.952
	-0.002	-0.003	1	0.027	0.032	0.030
HUNGARY	-0.077^A	0.017	0.178	0.049	0.211	0.130
	-0.085^A	0.028^C	0.247	0.101	0.305	0.203
	-0.009	0.002	0.153	0.038	0.173	0.106
LATVIA	0.005^B	0.002^A	0	0.751	0.652	0.701
	-0.007^A	-0.001^B	0	0.391	0.290	0.341
	-0.001	0.001	0.404	0.833	0.915	0.874

Table 8: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with traditional cointegrating vector. 2010 period. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	Gonz-Grang	HAS_1	HAS_2	MID
IRELAND	0.069	0.222^A	1	0.783	0.904	0.844
	na	na	na	na	na	na
	0.059	0.197^A	1	0.772	0.911	0.842
	0.002	0.012	1	0.628	0.981	0.804
SPAIN	0.124^B	0.161^A	1	0.925	0.712	0.818
	0.130^B	0.195^A	1	0.851	0.807	0.829
	0.054	0.072^A	1	0.912	0.727	0.820
	0.091^B	0.120^A	1	0.918	0.721	0.819
AUSTRIA	na	na	na	na	na	na
	0.006	0.057^A	1	0.861	0.992	0.926
	-0.050^C	0.072^A	0.485	0.240	0.704	0.472
	na	na	na	na	na	na
CZECH REP.	-0.068^B	0.1036^B	0.603	0.270	0.718	0.494
	-0.107^A	0.107^C	0.498	0.160	0.596	0.378
	-0.020	0.018	0.480	0.160	0.546	0.353
	0.001	0.004	1	1.000	0.842	0.921
SWEDEN	-0.041^A	0.059^B	0.592	0.308	0.241	0.274
	-0.038^A	0.088^A	0.699	0.558	0.489	0.523
	-0.027^A	0.055^B	0.671	0.490	0.413	0.451
	-0.019^B	0.047^B	0.705	0.582	0.499	0.541

Table 9: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. CDS vs bond spreads with augmented cointegrating vector. 2010 period. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation.

Ticker	λ_1	λ_2	Gonz-Grang	HAS_1	HAS_2	MID
SPAIN	0.141^B	0.195^A	1	0.891	0.764	0.827
	0.158^B	0.223^A	1	0.877	0.782	0.830
	0.014	0.016^C	1	0.982	0.570	0.776
AUSTRIA	0.009	0.036^A	1	0.963	0.941	0.952
	0.007	0.049^A	1	0.905	0.980	0.942
	-0.007	0.005	0.404	0.172	0.589	0.381
CZECH REP.	-0.102^A	0.100^C	0.495	0.163	0.591	0.377
	-0.010	0.067^A	0.870	0.650	0.970	0.810
	-0.020	-0.014	0	0.202	0.004	0.103
POLAND	-0.013	-0.014^C	1	0.916	0.252	0.584
	-0.174^A	-0.076	0	0.171	0.105	0.138
	0.000	-0.002	1	0.613	0.992	0.802
SWEDEN	-0.040^A	0.089^A	0.689	0	0	0.000
	-0.035^A	0.006	0.152	0.006	0.001	0.004
	-0.001	0.026	0.949	1	0.986	0.986

2.2 Market Reactions and Volumes

Table 10: Average reaction after bad news. CDS and bond spreads. */**/*** means significant levels at 10%/5%/1%.

Countries / Days after	1	2	3	4	5
CDS spreads					
Belgium	1.128	3.874*	3.411	3.552	1.196
Greece	40.765*	71.524*	71.004	63.189	28.625
Ireland	12.194*	21.874**	20.751*	16.129	7.129**
Italy	4.325	9.704	12.999	12.221	4.201
Portugal	16.391	36.647	33.671	30.287	6.421
Spain	9.801	16.444	18.599	12.401	4.095
France	0.381	1.016	0.822	0.850	0.411
Netherlands	-0.427	-1.119	-1.710**	-0.967*	-1.519*
Austria	-0.181	-0.981	-0.579	-0.102	-0.374
Denmark	-0.486	-0.737	-1.683*	-0.751	-1.689*
Sweden	-0.275	-1.576	-2.602*	-1.984	-1.756
Finland	-1.106*	-1.816	-2.149	-2.176	-2.362*
Bond spreads					
Belgium	1.486	7.514	7.986	6.071	0.529
Greece	39.286*	57.186	77.643	83.500	17.486
Ireland	12.086**	21.429*	24.843	22.371	0.614
Italy	1.786	5.343	8.229	6.800	-0.757
Portugal	14.343*	32.314*	39.143*	37.443*	8.343
Spain	4.429	9.943	12.057	8.114	-2.414
France	0.471	1.043	0.657	-0.243	-2.314
Netherlands	0.400	0.286	2.200	1.071	-0.414
Austria	0.600	1.986	1.429	1.286	-0.129
Denmark	-0.029	1.514	0.014	-0.514	-1.086
Sweden	1.157	1.987***	0.910	-0.263	1.079
Finland	0.443	0.671	0.929	0.057	-1.629

Table 11: Average reaction after bad news. CDS and bond spreads differences. */**/*** means significant levels at 10%/5%/1%.

CDS spreads - Bond spreads					
Countries / Days after	**1**	**2**	**3**	**4**	**5**
Belgium	-0.358	-3.640	-4.575	-2.519	0.668
Greece	1.479	14.338	-6.639	-20.311	11.139
Ireland	0.108	0.446	-4.091	-6.243	6.515
Italy	2.539	4.361	4.770	5.421	4.959
Portugal	2.049	4.333	-5.471	-7.156	-1.922
Spain	5.372	6.501	6.541	4.287	6.509
France	-0.090	-0.027	0.165	1.093	2.725**
Netherlands	-0.827	-1.404	-3.910	-2.039	-1.104
Austria	-0.781	-2.967	-2.007	-1.388	-0.246
Denmark	-0.457	-2.251	-1.697	-0.237	-0.603
Sweden	-1.432	-3.564**	-3.512	-1.721	-2.835
Finland	-1.549	-2.488	-3.077	-2.234	-0.734

Table 12: Volumes and CDS spreads. F-statistic values. A, B, and C denote respectively 1%, 5% and 10% significance values. - means that the AIC criterion selects zero lag. Δ means first differences, while Δ% growth rates.

Countries	**level CDS do not cause Δ%netvol**	**Δ CDS do not cause Δ%netvol**	**level CDS do not cause Δ%mktvol**	**Δ CDS do not cause Δ%mktvol**	**level CDS do not cause Δ%ncont**	**Δ CDS do not cause Δ%ncont**
BELGIUM		-		-	4.1552^B	-
PORTUGAL	5.435^A	3.296^C		2.713^B	5.177^A	5.173^A
FRANCE	4.932^B	4.788^B		3.660^B	10.939^A	9.830^A
NETHERLANDS		-	7.804^A		7.218^A	10.287^A
DENMARK		-	8.022^A	-	11.187^A	-
AUSTRIA			9.972^B	-	4.912^A	-
FINLAND		-	3.197^C	4.860^B	8.265^A	13.831^A
SWEDEN	5.161^B	-	5.479^B	-	7.349^A	-
HUNGARY		-	7.176^A	14.155^A	7.730^A	15.552^A

Table 13: CDS spreads and volumes. Granger causality test with VAR(4). F-statistic values. */**/*** denote respectively 1%, 5% and 10% of significance levels. Δ means first differences, while volumes are expressed in growth rates.

	Gross positions		Net positions		N. Contracts	
Countries	**Volumes do not cause Δ CDS**	**Δ CDS do not cause Volumes**	**Volumes do not cause Δ CDS**	**Δ CDS do not cause Volumes**	**Volumes do not cause Δ CDS**	**Δ CDS do not cause Volumes**
BELGIUM	2.821**	1.593	2.043*	0.872	5.089***	2.192*
GREECE	1.347	2.958**	0.586	0.435	1.381	11.086***
IRELAND	2.752**	0.772	1.068	0.249	0.813	1.436
ITALY	3.490***	1.341	3.408***	1.197	5.202***	1.666
PORTUGAL	2.138*	1.549	0.553	2.374**	3.821***	2.804**
SPAIN	1.026	2.205*	0.920	0.869	0.881	3.915***
FRANCE	1.517	3.334***	1.821	2.859**	2.320*	3.545***
NETH.	3.945***	1.783	1.825	0.202	1.855	1.392
DENMARK	2.752**	0.567	0.490	1.545	3.243**	1.573
AUSTRIA	2.035*	1.227	0.564	2.520**	3.584***	2.982**
BULGARIA	0.587	0.959	0.780	0.645	0.740	0.529
CZECH	0.817	0.355	1.218	0.486	1.063	0.277
POLAND	0.749	0.485	0.536	2.725**	2.127*	0.269
SLOVAKIA	1.785	1.421	0.118	1.724	1.184	0.330
FINLAND	0.636	2.722**	0.505	1.797	2.837**	3.211**
SWEDEN	3.455***	1.662	0.601	5.045***	5.308**	3.717***
HUNGARY	1.699	1.053	0.353	2.257**	1.458	1.061
LATVIA	0.405	3.811***	0.608	7.175***	2.593**	3.130**
UK	1.447	2.973**	3.331***	1.402	1.566	3.748***
USA	2.715**	1.212	3.241**	2.375**	5.006***	1.398
JAPAN	3.434***	7.791***	1.144	0.440	3.775***	4.341***

2.3 Sovereign CDS Spreads vs Corporate CDS Spreads

Table 14: Long-run relationship between SovX and different iTraxx indices. Estimated cointegrating vectors. All periods. A, B and C stand for 1%, 5% and 10% significance level.

PRE-LEHMAN PERIOD							
Index	**SovX**	**iTraxx**	**constant**	**SovX**	**iTraxx**	**spread**	**constant**
iTraxx Europe	1	-0.213^A	0	1	-0.208^A	-0.01	0
				1	-0.214^A	-0.01	0.23
	1	-0.206^A	na	1	-0.180^A	-0.033^A	na
iTraxx Sen. Fin.	1	-0.257^A	0	1	-0.499^A	0.287^A	0
	1	-0.188^A	-3.832^A	1	-0.222^A	0.04	-3.875^A
	1	-0.181^A	na	1	-0.189^A	0.01	na
iTraxx cross	1	-0.033^A	0	1	-0.024^A	-0.100^A	0
	1	-0.052^A	6.819^A	1	-0.063^A	0.04	9.130^A
	1	-0.049^A	na	1	-0.043^A	-0.032^A	na
POST-LEHMAN PERIOD							
iTraxx Europe				1	-1.002^A	0.650^A	0
				1	-2.049^A	1.309^A	90.195^A
				1	-1.005^A	0.372^B	na
iTraxx Sen. Fin.				1	-0.767^A	0.09	0
				1	-0.730^A	-0.04	na
iTraxx cross				1	-0.158^A	0.496^A	0
				1	-0.178^A	0.24	na
2010 PERIOD							
iTraxx Europe				1	-1.624^A	1.917^A	0
				1	-1.736^A	4.201^A	-47.762^A
				1	-1.588^A	2.671^A	na

Table 15: Granger causality test for SovX and different CDS indices. F-statistic values. All periods. A, B and C stand for 1%, 5% and 10% significance level.

	Granger causality. F-test value					
	PRE		**POST**		**2010 Period**	
	SovX do not Granger cause iTraxx	**iTraxx do not Granger cause SovX**	**SovX do not Granger cause iTraxx**	**iTraxx do not Granger cause SovX**	**SovX do not Granger cause iTraxx**	**iTraxx do not Granger cause SovX**
iTraxx Europe	0.394	2.380^{A}	1.951	4.555^{B}	4.611^{A}	3.299^{B}
iTraxx Sen. Fin.	0.2596	2.565^{A}	0.0240	7.119^{A}	6.619^{A}	5.182^{A}
iTraxx cross	0.527	4.585^{B}	3.129^{C}	10.262^{A}	4.678^{A}	3.413^{B}

Table 16: Granger causality test. Sovereign CDS and banks' CDS spreads. F-statistic values. */**/*** denote respectively 1%, 5% and 10% of significance levels. VAR(5) methodology.

	POST-LEHMAN		**2010**	
Countries	**Banks' CDS do not cause Sov. CDS**	**Sov. CDS do not cause Banks' CDS**	**Banks' CDS do not cause Sov. CDS**	**Sov. CDS do not cause Banks' CDS**
BELGIUM	1.141	0.773	2.403**	1.923*
GREECE	1.885*	2.176*	7.264***	2.904**
IRELAND	0.092	4.919***	0.998	8.581***
ITALY	1.790	1.809	3.400***	2.800**
PORTUGAL	1.372	1.167	2.708**	11.353***
SPAIN	1.004	3.159***	1.830	10.635***
FRANCE	2.525**	1.289	1.412	5.185***
NETHER.	2.582**	0.808	0.191*	2.787**
DENMARK	1.076	1.668	3.424***	5.885***
AUSTRIA	1.589	7.395***	0.590	7.378***
SWEDEN	0.536	5.434***	1.857	3.670***

Table 17: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Different CDS indices, bivariate cointegrating vector. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation.

Ticker	λ_1	λ_2	**Gonz-Grang**	**HAS**$_1$	**HAS**$_2$	**MID**
			PRE-LEHMAN			
iTraxx general	-0.054^A	0.093^B	0.631	0.446	0.519	0.483
	na	na	na	na	na	na
	-0.053^B	0.094^B	0.638	0.462	0.534	0.498
iTraxx financial	-0.042^A	0.043^C	0.506	0.222	0.278	0.250
	-0.100^A	0.056	0.362	0.081	0.122	0.102
	-0.023^B	0.030	0.568	0.317	0.377	0.347
iTraxx crossover	-0.061^A	0.046	0.431	0.011	0.035	0.023
	-0.087^A	0.180	0.674	0.075	0.128	0.101
	-0.021^A	-0.010	0	0.005	0	0.005

Table 18: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Different CDS indices, cointegrating vector with two indices and the spread 3-month Euribor-Eurepo. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation.

Ticker	λ_1	λ_2	Gonz-Grang	HAS_1	HAS_2	MID
PRE-LEHMAN						
iTraxx general	-0.092^A	0.064^C	0.411	0.130	0.177	0.154
	-0.090^A	0.064^C	0.417	0.136	0.183	0.160
	-0.0890^A	0.068^B	0.434	0.153	0.203	0.178
iTraxx financial	-0.016^C	0.004	0.215	0.022	0.041	0.031
	-0.096^A	0.022	0.185	0.015	0.032	0.023
	-0.024^B	0.027	0.534	0.268	0.320	0.294
iTraxx crossover	-0.065^A	0.062	0.488	0.018	0.044	0.031
	-0.066^A	0.147	0.690	0.088	0.139	0.113
	-0.024^A	-0.031	1	0.035	0.013	0.024
POST-LEHMAN						
iTraxx general	0.009	0.034^B	1	0.996	0.801	0.898
	0.017^A	0.031^A	1	0.812	0.334	0.573
	-0.002	0.016	0.901	0.611	0.980	0.795
iTraxx financial	0.003	0.031^B	1	0.882	0.979	0.930
	-0.003	0.029^B	0.917	0.651	0.983	0.817
iTraxx crossover	-0.002	0.169^A	0.990	0.741	0.996	0.869
	na	na	na	na	na	na
	-0.004	0.034	0.904	0.348	0.795	0.572
2010-PERIOD						
iTraxx general	0.044	0.146^A	1	0.454	0.984	0.719
	0.010	0.103^B	1	0.370	0.999	0.684
	0.011	0.016	1	0.698	0.879	0.789

Table 19: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Sovereign CDS vs banks' CDS spreads with traditional cointegrating vector. Post-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	Gonz-Grang	HAS_1	HAS_2	MID
GREECE	0.006	0.070^A	1	0.983	0.981	0.982
	0.007	0.070^A	1	0.983	0.981	0.982
	0.005	0.037^A	1	0.966	0.962	0.964
IRELAND	0.010	0.059^A	1	0.972	0.937	0.954
	-0.006	0.071^A	0.916	0.942	0.981	0.961
	0.001	0.024^B	1	1.000	0.994	0.997
ITALY						
	-0.002^A	-0.001	0	0.082	0.045	0.063
	0.005	0.019^A	1	0.949	0.926	0.937
PORTUGAL						
	-0.005^A	-0.004^B	0	0.285	0.011	0.148
	0.000	0.008	1	0.826	0.998	0.912
AUSTRIA						
	-0.016^B	0.013	0.447	0.119	0.453	0.286
	0.001	0.057^A	1	0.871	0.993	0.932

Table 20: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Sovereign CDS vs banks' CDS spreads with augmented cointegrating vector. Post-Lehman. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	**Gonz-Grang**	$\mathbf{HAS}_1$	$\mathbf{HAS}_2$	**MID**
IRELAND	0.011	0.048^{A}	1	0.935	0.880	0.908
	0.002	0.055^{A}	1	0.996	0.998	0.997
	0.001	0.016	1	1.000	0.987	0.993
ITALY	0.019^{B}	0.020^{B}	1	0.700	0.215	0.457
	-0.007^{A}	-0.003	0	0.095	0.040	0.067
	-0.002	0.011	0.850	0.607	0.975	0.791
PORTUGAL						
	0.019^{A}	0.013^{C}	0	0.220	0	0.220
	-0.006	0.026	0.826	0.565	0.950	0.757
FRANCE						na
	0.015^{A}	0.018^{C}	1	0.310	0.014	0.162
	0.002	0.009	1	0.999	0.807	0.903
NETHERLANDS	0.012	0.045^{A}	1	0.920	0.613	0.767
	-0.003	0.044^{B}	0.942	0.743	0.982	0.863
DENMARK	-0.021^{B}	0.060^{A}	0.740	0.460	0.742	0.601
	-0.021^{A}	0.061^{A}	0.744	0.469	0.750	0.609
	-0.007	0.051^{A}	0.873	0.733	0.930	0.831
AUSTRIA	-0.012	0.055^{B}	0.827	0.617	0.924	0.770
	-0.023^{B}	0.035^{C}	0.605	0.278	0.278	0.278
	-0.007	0.058^{B}	0.894	0.723	0.971	0.847
SWEDEN	-0.001	0.002	0.640	0.590	0.835	0.713
	-0.011	0.020^{B}	0.643	0.589	0.842	0.716
	-0.006	0.023^{B}	0.803	0.782	0.959	0.871

Table 21: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Sovereign CDS vs banks' CDS spreads with traditional cointegrating vector. 2010. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to the Johansen Trace test without and with constant. The third is dedicated to the DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	**Gonz-Grang**	$\mathbf{HAS}_1$	$\mathbf{HAS}_2$	**MID**
GREECE						
	0.007	0.181^{A}	1.000	0.795	1.000	0.897
	-0.030	0.007	0.182	0.065	0.446	0.255

Table 22: Contributions to price discovery. Gonzalo-Granger and Hasbrouck measures. Sovereign CDS vs banks' CDS spreads with augmented cointegrating vector. 2010. A, B and C stand for 1%, 5% and 10% significance level. The first two raws relate to Johansen Trace test without and with constant. The third is dedicated to DOLS estimation. The fourth row relates to classic cointegrating vector.

Ticker	λ_1	λ_2	**Gonz-Grang**	$\mathbf{HAS}_1$	$\mathbf{HAS}_2$	**MID**
GREECE						
	-0.049	0.198^{A}	0.801	0.651	0.984	0.818
	-0.011	-0.003	0	0.155	0.003	0.079
ITALY	-0.134	0.056	0.295	0.078	0.853	0.466
	-0.001	0.017	0.967	0.414	1.000	0.707

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