L U N D   U N I V E R S I T Y

School of Economics and Management

Determinants of corporate CDS spreads in the Eurozone

- Is there a spillover effect from sovereign to corporate credit risk? -

Master Thesis in Finance

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Abstract

We study the determinants of corporate CDS spreads for 125 companies headquartered in the Eurozone, with an emphasis on sovereign CDS spreads as a main determinant of corporate CDS spreads in levels and changes. This is done by analyzing financial companies, as well as non-financial companies. The period of analysis is from January 2004 to April 2014, which has been divided into 3 sub-periods; before, during, and after the global financial crisis. We found evidence of a spillover effect in credit risk from private-to-public during the global financial crisis, and public-to-private after the crisis, mainly with the onset of the European sovereign debt crisis. The effect of sovereign-to-corporate credit risk spillover is more pronounced for companies headquartered in GIIPS countries and non-financial companies, especially after the global financial crisis.

Keywords: CDS determinants, spillover effect, corporate credit risk, sovereign credit risk, credit default swaps, Eurozone.

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1. Introduction

1.1. Background

With the onset of the global financial crisis, credit markets have been subject to extraordinary reprising of credit risk. The bankruptcy of Lehman Brothers in September 2008 pushed financial institutions into massive losses, causing damaged investor confidence in the financial system.

The aftermath of the financial crisis resulted in governmental intervention in the form of bailouts and fiscal stimulus, which tremendously increased public sector deficit and sovereign debt levels. This unprecedented increase in sovereign debt levels increased the default risk of sovereigns, making a default of a developed sovereign real for the first time. Shifting risk from the financial sector to the sovereign, led governments into financial distress and shifted the debt burden from sovereign to corporate again. During the global financial crisis and the following European sovereign debt crisis between 2007 and 2012, the credit spreads (CDS spreads) of corporates and financials experienced a lot of fluctuation. The CDS index (Figure 1), which represents the overall development of the corporate credit market in Europe, increased between the years 2007 and 2008, from a stable level of 50 bps, to around 200 bps. In the following two years, due to governmental and central bank intervention, the level of corporate CDS spreads stabilized at around 100 bps.

In May 2010 the sovereign debt crisis in the Eurozone intensified, which caused a widening of corporate CDS spreads to approximately 200 bps once again. European central bank interventions and announcements by Mario Draghi in the summer of 2012, calmed down the economic turmoil in the Eurozone and yet again stabilized the corporate CDS spreads at approximately 75 bps. For the companies located within the struggling Eurozone countries, GIIPS[1], the widening of the corporate CDS spreads was more pronounced compared to non-struggling companies headquartered in CORE[2] countries in the Eurozone. As Bedendo and Colla (2013) show, there are signs of a spillover effect from sovereign credit risk to corporate credit risk in the Eurozone,

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[1] Portugal, Italy, Ireland, Greece and Spain

[2] Austria, Belgium, France, Finland, Germany, Luxembourg, Netherlands

which previous research by (Collin-Dufresne et al. (2001), Campbell and Taskler (2003), Tang and Yan (2008) and Darwin et al. (2012)) have overlooked as a possible determinant of corporate credit risk.

1.2. Problem discussion

Motivated by the aforementioned development; this paper will focus on the analysis of the determinants of corporate CDS spreads in levels, as well as changes, with a focus on the spillover effect from sovereign to corporate credit risk as an additional explanatory variable for corporate CDS spreads in the Eurozone. The reason for our interest in the spillover effect as a determinant of corporate CDS spreads, lays in the fact that previous research has overlooked the sovereign credit risk as a potential determinant of corporate CDS spreads in the Eurozone. Typically, the effect of sovereign credit risk on the corporate sector has been investigated for emerging markets. This paper aims to find evidence of this relationship for developed economies, specifically the Eurozone countries.

In line with previous research on credit risk (Longstaff et al. (2005), Pan and Singelton (2008)), CDS spreads are the price of credit risk and can therefore be used as a proxy for measuring the corporate credit spread. These credit derivatives, which are traded in the Over-The-Counter (OTC) market and therefore provide us with daily market prices ensuring ample liquidity, have been developed to provide corporations and investors a relatively easy vehicle to transfer credit risk. The choice of CDS spread as a dependent variable, is undermined by the fact that in frictionless markets the spread of the corporate bond should be equal to the CDS spread for the same underlying entity due to arbitrage forces (Beinstein and Scott (2006), Fontana and Scheicher (2010)).

In addition, we examine if the determinants of corporate CDS spreads have changed before, during, and after the global financial crisis. This is analyzed from January 2004 to April 2014 by dividing our entire sample into three sub-periods in order to identify changes in drivers of corporate CDS spreads between the sub-periods. The first sub-period is from January 2004 to April 2008, which coincides with the time before the first significant increase in corporate CDS spreads. The second sub-period covers the period from May 2008 to April 2010; this period is characterized as the peak of the global financial crisis following the bankruptcy of Lehman Brothers. Lastly, the third sub-period is between May 2010 and April 2014, which includes the impact of the European sovereign debt crisis. Further, we divide our dataset consisting of 125 companies headquartered in the Eurozone into financials and non-financials, GIIPS and CORE, and sectors[3], in order to identify if there are common factors affecting corporate CDS spreads or if they differ depending on the categories denoted.

The analysis of the determinants is based on the theoretical arguments used in the structural credit risk model by Merton (1974), and extended by several global market-factors including our main contribution to existing literature in adding the sovereign CDS spread as an additional explanatory variable of the corporate CDS spreads. Before analyzing the determinants of corporate CDS spreads in levels and changes, we test for common factors in order to identify the nature of the communalities in corporate CDS spreads.

This paper will help investors, practitioners as well as academic researchers, understand the most recent determinants of credit spreads, which is important when investing in fixed income securities with an inherent credit risk.

1.3. Purpose

The main purpose of this paper is to analyze determinants of corporate CDS spreads in the Eurozone before, during, and after the global financial crisis.

In addressing the main purpose, the analysis is centered around two main points. Firstly, the determinants of corporate CDS spreads are identified to see whether the determinants have changed between the three sub-periods. Secondly, the main focus, which lies on the risk transfer between the sovereign and corporate sector, i.e. whether there is spillover from the sovereign to corporate credit risk, and whether the magnitude of this spillover has changed over time and across our defined panels[4].

[3] Auto & Industrials, Consumer, Energy, Financial services and TMT. The selection of the sectors is based on sub-indicies of the iTraxx Europe 125 index.

[4] Panel A: All 125 companis, Panel B: Non-financials, Panel C: Financials, Panel D: CORE, Panel E: GIIPS, Panel F: Auto & Industrials, Panel G: Consumer, Panel H: Energy, Panel I: Financial services and Panel J: TMT (see appendix Table 9-28).

1.4. Outline

The rest of the paper is organized as follows: *Section 2* presents the structure of CDS contracts, followed by the description of the Merton (1974) model that serves as a starting point for our choice of theoretical determinants of corporate CDS spreads. Additionally, we also present previous literature and introduce the theoretical framework for the spillover effect.

Section 3 describes the data and introduces the main variables as well as the methodology for the empirical investigation.

Section 4 presents the analysis of our main empirical results for the different panels, including principal component analysis and Granger's causality test.

Finally, *section 5* concludes and discusses limitations of the analysis, as well as further research implications.

2. Theoretical Background

2.1. Credit Default Swaps

Credit spread is defined as the difference between the yield of the risky security and the risk-free rate, where both have identical time to maturity. A financial instrument that is widely used as a proxy; as a measure of the credit spread and that has been used extensively after the financial crisis and received considerable attention; is the credit default swap (CDS). The CDS works as a measure of pure credit risk Longstaff et al. (2005). The CDS can be interpreted as an insurance premium for protection against the credit risk exposure, often referred to as the CDS spread (Ericsson et al., 2009). A CDS contract provides a safety net for the exerciser, acting as an insurance against the exposure to credit risk. The CDS transfers the credit risk from the buyer to the seller, however in exchange, the buyer must make regular payment to the insurer (the seller). In case of default, the buyer is fully compensated by receiving the difference of the initial amount of the loan and its recovery value from the seller (insurer).

CDS's are widely used as hedging instruments as they separate interest rate and currency risk from the credit risk, enabling the holder of the contract to hedge his credit risk exposure without selling the loan or the bond (Naifar and Abid, 2005). In this thesis, we use CDS spreads as a measure of credit risk. The major advantage of using CDS spreads instead of bond spreads, is that they provide a more accurate measure of the credit risk of the issuer (see Pan and Singleton (2008), Longstaff et al. (2005), and Longstaff et al. (2011)). The findings of the latter studies proves that bond spreads are determined by multiple factors, one being the liquidity premium, which plays a vital role. Since sovereign and corporate bonds are traded on the secondary market, illiquidity is not of concern; this ensures similar liquidity for both the sovereign and corporate CDS as we use the 5-year CDS spread, which has the most liquid maturity. This is also in line with previous research by (Longstaff et al. (2011), Pan and Singleton (2008), and Archarya et al. (2011)), who also made use of CDS spreads as a measure of credit risk. This, in accordance with previous research, shows that CDS spreads are a more accurate measure of the issuer's creditworthiness.

A shift in creditworthiness could erupt into financial difficulties if a negative development in a country's or company's creditworthiness was to cause an increase in probability of default, or decrease in distance to default, it would result in an increase in the credit spread and CDS spread, respectively. The opposite is true if a country or company experiences a positive development in their creditworthiness. Under these conditions, they would enjoy a decrease in their probability of default, causing an increase in distance to default and a decrease in the credit spread (Merton, 1974).

2.2. Credit Risk Models

Researchers such as Collin-Dufresne et al. (2001), Ericsson et al. (2009), Black and Cox (1976), and Bryis and De Varenne (1997) have based their respective studies' on the structural credit risk model by Merton (1974) when examining how changes in firm-specifics affect the probability of default and hence, the CDS spread. The Merton model is referred to as the structural credit risk model due to its dependence on the structural characteristics of the borrowing firms; leverage (financial risk); volatility of total assets (business risk); and the value of total assets. As an interruption in creditworthiness occurs for a country or entity, there will be a change in the probability of default. This in turn affects the distance of default, which finally affects the credit spread, and its equivalent CDS spread of the country or entity (Hull et al., 2004).

Further, the intuition behind the Merton model is based on the principles of option pricing developed by Black-Scholes (1973). However, the interruption in creditworthiness only occurs when the value of the company's assets is lower than the nominal value of debt at maturity of the debt. Consequently, the company will no longer be able to uphold its contractual obligations towards its debt holders. The Merton (1974) model used as a starting point in Bryis and de Varenne's (1997) study investigates the event of default. They argue that the advantage of using structural models is that it provides an economic intuition behind the event of default.

Previous research based on the characteristics of the structural model by Merton (1974), investigates factors affecting CDS spreads. Darwin et al. (2012) include both firm-specific variables (such as leverage and market-to-book) and macroeconomic variables (the slope of the yield curve, time to maturity of the underlying bond etc), which shows that a number of these variables, in many cases, are significant determinants of credit spreads. Collin-Dufresne et al. (2001) found a relatively low explanatory power in explaining the variation of the model with an adjusted R-squared of 25%. In order to better understand the nature of the remaining variation, they applied a principal component analysis on the residuals and found that common systematic factors in credit risk existed. Researchers after Collin-Dufresne et al. (2001) applied market-wide variables when investigating determinants of CDS spreads (Dullmann and Sosinska (2007), Tang and Yan (2008), Shan et al., 2014)). Researchers like Delianedis and Geske (2001), Longstaff and Schwartz (1995) and Longstaff et al. (1995) found three variables that are significant determinants of changes in the bond spread; changes in the spot rate, the slope of the yield curve, and a change in the CDS premium (market price of default risk). This is in accordance with Darwin et al. (2012) findings, which show that, on average, that a positive change in such variables is associated with reductions in the credit spreads. Delianedis and Geske's (2001) study shows that increases in liquidity in the bond market decreases the non-default component of the spread, however, it does not affect the default component.

Tang and Yan (2012) found that changes in firm and market fundamentals are the most significant determinants of corporate CDS spread changes. Secondly, they found a high explanatory power for CDS spread changes, an adjusted R-squared of 40% for the US market, and that firm level and market fundamentals account for two-thirds of the explained variation. Furthermore, they also found higher explanatory power compared to Ericsson et al. (2009) whose study was conducted before Tan and Yang (2012). An interesting finding in their study was that the VIX (same measure as VSTOXX in our paper) remains stable before and during the crisis, where volatility is more pronounced for non-financials and leverage is more pronounced for financials. This is explained by the fact that financials adjust leverage more frequently based on market conditions, which could potentially explain why individual firms' default risk is the driver of the co-movement in corporate CDS spreads during the crisis, rather than market sentiment.

Moreover, they found that the stock return volatility, both at the firm level and at the market level, in explaining corporate CDS spread changes, is consistent with previous research conducted by (Ericsson et al. (2009), Zhang et al. (2009), Campbell and Taskler (2003)) who also concluded that volatility is the key determinant of CDS spreads in levels. The second most significant firm-level variable in changes, leverage, accounts for approximately 13% of the variation in CDS spreads. All firm-level variables together amount to an adjusted R-squared of 31% in explaining CDS spread changes.

The study of Darwin et al. (2012) which examines the determinants of bond spreads in Australia, found that many of the variables used in their analysis are highly significant with an R-squared of around 80% in levels and an adjusted R-squared of around 5% in changes. In particular, they found that the leverage is highly significant and negative; an indication that firms with a higher leverage ratio tend to have lower CDS spreads on average. However, it must be noted the study was done with a sample including financials, making it an imperfect measure of leverage. A remedy for this was to exclude financials from the sample; the model specification now shows that leverage is insignificant for the sample, but significant and negative for financials.

2.3. The Spillover Effect

Research within the field of studying determinants of corporate CDS spreads and credit spreads, has primarily focused on firm-fundamental variables and various control variables. However, the onset of the global financial crisis following the bankruptcy of Lehman Brothers has attracted attention in regards to concerns about how sovereign creditworthiness affects the credit risk of corporate sector. Therefore, the so-called transfer risk should be considered as a determinant of corporate CDS spreads. The definition of transfer risk can be viewed as a spillover from sovereign to corporate credit risk; where the government shifts the debt burden from the public sector to the private sector by increasing corporate taxes, or in extreme cases seizes private investments (Bedendo and Colla, 2013).

The transmission channels of the risk transfer from public-to-private can be explained by government linkage to the corporate sector. Firstly, government controlled firms, which is often the case for public hold telecommunications and energy (TMT and Energy sector) companies, enjoy cheaper borrowing costs and debt guarantees from the government. Faccio et al. (2006) studied 450 firms from 35 countries and found that politically connected firms are more likely to enjoy government backing compared to similar unconnected firms. Secondly, financial institutions enjoy similar governmental backing in terms of guarantees. This is underlined by the "too-big-too-fail" argument because they are typically heavily exposed to domestic governments since they hold large amounts of domestic government bonds as assets.

A decrease in sovereign creditworthiness is often connected to disruptions in the domestic credit markets. A credit disruption would cause deleveraging of banks, which in turn would have negative effects on corporate lending. In other words, companies with higher proportions of bank debt could find it more difficult to renew existing loans, and are more vulnerable to credit disruptions, i.e. changes in sovereign credit risk. In addition, Borenztein et al. (2013) show that corporate credit ratings are significantly affected by sovereign credit ratings, this is even more pronounced in countries with capital restrictions and higher political uncertainty.

Moreover, Almeida et al. (2013) found that firms, which are bounded by sovereign credit rating, reduce investment and leverage more in comparison to other companies. While research of sovereign to financial sector spillover is more extensive and has uncovered a significant spillover effect from the banking sector to the government during bailouts; after the bailout period the opposite spillover effect is evident (Adelino and Ferreira (2014), Ejsing and Lemke (2011) and Archarya et al. (2013)). However, the credit risk transfer from sovereign to non-financial companies is not an area that is as extensively studied.

Since previous research has mainly focused on the period before and during the crisis, this paper will also take into consideration the period after the global financial crisis. Separating our sample into financial and non-financial companies makes our research more comprehensive and sheds light upon the development of the spillover effect from sovereign credit risk to non-financial credit risk, as well as financial credit risk. Hence, this is done after controlling for the traditional determinants of corporate CDS spreads used in previous research, as well as adding a spillover variable that has been fairly neglected - the sovereign CDS spread.

3. Data sample and methodology

3.1. Data

In this paper we will use a final sample comprising of monthly data on CDS quotes of 125 companies headquartered in the Eurozone[5]. Out of the 125 companies, 100 are non-financials and 25 are financial companies. CDS quotes were retrieved from Thomson Reuters DataStream and accounting data from S&P Capital IQ. We opted to

[5] We only consider the original 12 Eurozone members, which joined the European Monetary Union before 2002: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain

choose senior CDS contracts (modified modified restructuring[6]), denominated in euro with a maturity of 5 years quoted as mid-prices. We have elected to use five year CDS contacts since they represent the most liquid and frequently traded maturities (Pan and Singleton (2008), Dieckmann and Plank (2011), and Benkert (2004)).

The sample data covers the period from January 2004 to April 2014. The starting date is chosen as January 2004 as a very limited amount of CDS quotes are available before this date. Nevertheless, we have enough data points before the onset of the global financial crisis in order to examine if there is a structural break in the determinants of corporate CDS spreads before, during, and after the crisis. In accordance with Tang and Yan (2012) we use a monthly frequency of CDS quotes, due to the fact that some CDS contracts are not frequently traded.

In constructing our final sample, a special filtering technique is used to end up with a final sample of 125 companies headquartered in the Eurozone. This was done by starting with all available CDS contracts in DataStream. The CDS in DataStream are separated in two sources; CMA and Thomson Reuters. For the first data source (CMA), data was available from the beginning of 2004 to the end of 2010, while for the latter source; data was available from the beginning of 2008 until today. Therefore, we had to match the two sources in order to get one time series of CDS quotes for the full time period starting in January 2004 and ending in April 2014. Due to this matching procedure we excluded companies, which did not have data available from both sources. To justifying our matching approach, we had to make sure that the overlapping data points of the two sources (beginning 2008 to the end of 2010) included the same CDS quotes, as well as the same restructuring clause in a credit event. As a last step, we excluded all non-listed companies. Ultimately, the filtering process left us with the most frequently traded and largest companies (measured by market capitalization) in the Eurozone.

[6] The current ISDA agreement offers four options for treating the issue of restructuring. Under the modified-modified restructuring introduced in 2003, which is the most popular in Europe, deliverable obligations can be maturing in up to 60 months after a restructuring.

3.2. Variables

3.2.1. Dependent Variable

Credit Default Spread (CDS Spread): The aim of the paper is to investigate which determinants explain corporate CDS spreads before, during, and after the global financial crisis. Hence, the dependent variable is the monthly CDS quote of senior CDS contracts (modified modified restructuring, introduced in 2003) with a maturity of 5 years.

3.2.2. Independent Variable

The structural model framework of Merton (1974) provides us with an indication of which independent variables should be chosen. The probability of default is a function of financial leverage, asset volatility, and the risk free rate. In addition to these firm-specific variables, we use market wide variables as explanatory variables. In order to better understand how the selected variables affect corporate credit spreads (CDS spreads), we will discuss them individually.

Firm-specific variables

Financial Leverage: An increasing leverage (financial risk) is usually seen as a default trigger; where the probability of default increases, the distance to default decreases, resulting in an increase in corporate credit spreads. Thus, there is a positive correlation between leverage and credit spreads. As a measure of financial leverage, we use the ratio of total debt in relation to total debt plus market value of equity. Due to the fact that the market value is changing everyday and total debt is a quarterly accounting data, we get a daily measure of financial leverage.

$$Financial\ leverage = \frac{Total\ debt}{Total\ debt + Market\ value\ of\ equity}$$

Equity Volatility: In the Black-Scholes model (1973) increasing volatility leads to an increase in the call option price and the put option price. In the Merton model, the debt holder claims are represented by a short position in the put option. With increasing volatility, the likelihood that the asset value will fall below the threshold increases resulting in wider corporate credit spreads. Since the asset value volatility is not observable, we use the equity volatility as a proxy. According to Ito's lemma, a positive relationship between these two is seen to exist. Following Alexander and Kaeck (2008) we use a statistical volatility measure based on daily historical stock returns. For the historical volatility calculation, we use the firm's annualized historical volatility of equity returns (assuming 252 trading days), computed as rolling standard deviation over the past 90 days to reflect current market conditions.

Firm's stock price: A higher share price (ex-post return) increases the equity value of the company. This results in a less levered firm implying a lower probability of default. A lower probability of default should drive down the firm's credit spread. We use the monthly stock price and stock price changes for the specific company as an independent variable.

Market-to-book ratio: According to Fama and French (1993), firms that have a higher market-to-book ratio (a high stock price relative to book value) tend to have persistently high earnings on assets. With higher future earnings, potential future contractual debt obligations are more likely to be met, thus decreasing the probability of default, as well as the corporate credit spread. We use the monthly market-to-book ratio as our measure.

Firm Size: Fama and French (1993) argue that firm size is related to profitability. After controlling for market-to-book ratio, big firms tend to have higher earnings on assets than small firms. "The fact that small firms can suffer a long earnings depression that bypasses big firms", means that there is a positive relation between size and earnings potential. As aforementioned, this will lead to a decreasing probability of default, and hence a tighter corporate credit spread. We use monthly data of the market value of equity as our firm size measure.

Market-wide variables

Risk free interest rate (spot rate): A higher spot rate increases the risk-neutral drift for the firm value (asset value). The reason for this is that an increasing drift increases the distance to default, and therefore reduces the probability of default, which results in a decreasing corporate credit spread. As a proxy for the spot rate, we use the yield on a 1 year German government bond. This is justified by the fact that an AAA rating from all three major rating agencies was assigned to the German government bond during the whole sample period. Throughout the European sovereign debt crisis the highly liquid German government bond was considered the only risk free instrument in the Eurozone.

The slope of the yield curve: According to Estrella and Mishkin (1997), the slope of the yield curve can be associated with a proxy for the business cycle movements. An increasing slope signals expectations about brighter economic activity. In consequence, this should result in a higher future spot rate, which will result in a lower probability of default due to the higher risk-neutral drift of the firm's asset value (Ericsson et al., 2009) Hence, the steepness is therefore negatively related to the corporate credit spread. Consistent with Darwin et al. (2012); we calculate the slope of the yield curve as the difference between the 10 year and 1 year German government bond yield.

Market wide volatility: Market wide volatility, which is used to capture market stress, displays a positive relationship with the corporate credit spread. This is due to the fact, higher volatility leads to higher uncertainty about the economic outlook. The market wide implied volatility is forward-looking as it captures the volatility of the asset returns in an option pricing model (Lopez and Navarro, 2012). To achieve this, we use the VSTOXX volatility index, which is calculated using the option prices on the EuroStoxx 50.

Eurozone stock market: In accordance with a number of prominent studies on determinants of corporate credit spreads by Collin-Dufresne et al. (2001), Campbell and

Taksler (2003), and Ericsson et al. (2009); we have opted to use a Eurozone stock market index as an indicator of the overall state of the economy. A stronger development of the stock market index in the Eurozone is expected to have a negative effect on corporate credit spreads, since favorable business conditions are expected to lower the probabilities of default and increase recovery rates, overall. More specifically, we use the EuroStoxx 50 index to capture the overall economic condition in the Eurozone.

Local stock market: Succeeding the asymmetric shock of the global financial crisis, the Eurozone has become increasingly divided into groups of countries following quite diverging parts in terms of real GDP growth rates (Landmann, 2011). As such, they have experienced different stock market developments. In order to account for the diverging development in the Eurozone, we use each countries own benchmark stock index. An improved development of each countries' benchmark stock index, should result in a lower corporate credit spread.

General state of the macro-economy: In addition to a lot of prominent studies, which mostly use overall stock market indices as an indicator of the overall state of the economy; we use the monthly industrial production index in the Eurozone as an independent variable for the business climate. The choice of this variable is based on the fact that the industrial production is historically highly correlated with GDP, but has the main advantage of being available in a monthly frequency, consistent with our data sample frequency. This proxy should be negatively related to the corporate credit spread.

3.2.3. The Spillover Variable

Sovereign credit spread: Based on the theoretical argument of the sovereign-to-corporate credit risk spillover where a government in financial distress is likely to shift the debt burden from the public sector to the private sector; we shall assume that a higher sovereign credit spread results in a higher corporate credit spread. The measure for the sovereign credit spread is the monthly sovereign CDS quote of CDS contracts with a maturity of 5 years. As mentioned previously, 5 year sovereign CDS contracts a highly liquid. Even so, changes to legislation governing sovereign CDS contracts in November 2011, which banned naked CDS positions and thus dried up liquidity, should be considered when interpreting the empirical results for the period after the global financial crisis (Capponi and Larsson, 2013).

Table 1: Expected Sign of Variables

Variable	Expected sign
Leverage	(+)
Volatility of firm's equity returns	(+)
Firm's stock price	(-)
Market-to-book ratio	(-)
Size (market capitalization)	(-)
Spot rate	(-)
Slope of the yield curve	(-)
VSTOXX	(+)
EuroStoxx 50	(-)
Local stock index	(-)
Industrial production euro area	(-)
Sovereign credit spread	(+)

3.3. Methodology

3.3.1. Firm-Fixed-Effects Model

Given the theoretical arguments and empirical research previously discussed to determine factors affecting corporate CDS spreads, we estimate the following panel regression models (levels):

$$
\begin{aligned}
CDS_{it} = \; & \beta_0 + \beta_1 LEV_{it} + \beta_2 VOLA_{it} + \beta_3 PRICE_{it} + \beta_4 MBV_{it} + \beta_5 MV_{it} + \beta_6 SPOT_{it} \\
& + \beta_7 SLOPE_{it} + \beta_8 VSTOXX_{it} + \beta_9 STOXX50_{it} + \beta_{10} L\_INDEX_{it} \\
& + \beta_{11} IP\_EU_{it} + \beta_{12} SCS_{it} + \varepsilon_{it}
\end{aligned}
$$

Where CDS stands for firms' credit default spread premium in basis points; LEV is firm leverage, defined as book value of debt divided by market value of firm plus book value of debt; $VOLA$ is the 90-day historical volatility of firm's equity returns; $PRICE$ is the firm's stock price; MBV is market-to-book ratio, defined as market value of firm divided by book value of firm; MV is the market value of the firm (market capitalization) as a measure of size; $SPOT$ represents the one-year risk free government bond yield; $SLOPE$ is the difference between 10-year and one-year risk free government bond yield; $VSTOXX$ is a proxy for market stress using implied volatilities; $STOXX50$ represents the devolopment of the overall European stock market; L_INDEX represents the level of the local stock market index; IP_EU stands for the Industrial Production Index in the Eurozone; and SCS stand for the sovereign credit spread, defined as the credit default spread premium in basis points.

Due to the obstacles that present themselves when using panel data, such as autocorrelation, heterogeneity etc. we have to specify our regression model accordingly to achieve unbiased and efficient estimators. Since we have heterogeneity properties in the cross-section dimension (see Table 6), we have to use either fixed effects or random effects specification. In applying the Hausman test, we shall reject the null hypothesis which states that the random effects model is well specified, and instead use fixed effects in the cross-section dimension. This approach is a remedy for the heterogeneity properties in the panel data sample.

Introducing firm-fixed effects results in the following model estimation

$$CDS_{it} = \beta_0 + \beta_1 LEV_{it} + \beta_2 VOLA_{it} + \beta_3 PRICE_{it} + \beta_4 MBV_{it} + \beta_5 MV_{it} + \beta_6 SPOT_{it} + \beta_7 SLOPE_{it} + \beta_8 VSTOXX_{it} + \beta_9 STOXX50_{it} + \beta_{10} L\_INDEX_{it} + \beta_{11} IP\_EU_{it} + \beta_{12} SCS_{it} + \mu_i + \varepsilon_{it}$$

Where μ_i is fixed for each firm in the cross-section, and all other variables represent the same meaning as previously mentioned.

After accounting for heterogeneity in the data sample, we have to account for autocorrelation as well. An average Durbin-Watson test statistic value between 0.10 and 0.20 signals a highly positive autocorrelation in error terms, which provides us with biased and inefficient estimators. A remedy for autocorrelation is first-differencing our variables. Since we have non-stationary CDS spreads in our data sample, using first-differencing also accounts for the potential non-stationarity problem. According to the augmented Dickey-Fuller test, with time trend and intercept the null hypothesis of unit root in CDS levels is only rejected for 15 out of 125 companies at the 5% significance level. Using changes in CDS spreads the variables are stationary.

3.3.2. First-Differencing Model

The model in first difference form is estimated as follows (changes):

$$\Delta CDS_i = \beta_0 + \beta_1 \Delta LEV_i + \beta_2 \Delta VOLA_i + \beta_3 \Delta PRICE_i + \beta_4 \Delta MBV_i + \beta_5 \Delta MV_i + \beta_6 \Delta SPOT_i + \beta_7 \Delta SLOPE_i + \beta_8 \Delta VSTOXX_i + \beta_9 \Delta STOXX50_i + \beta_{10} \Delta L\_INDEX_i + \beta_{11} \Delta IP\_EU_i + \beta_{12} \Delta SCS_i + \varepsilon_i$$

Where Δ stands for the change in the given variable.

After getting rid of the autocorrelation and the heterogeneity in the panel data we account as a last step for heteroscedasticity in the residuals by using robust standard errors.

In summary, we use two multivariate regression models for the determinants of levels and changes in corporate CDS spreads. Specifically a firm fixed effects model and a first-differencing model, of which both are estimated by the Ordinary Least Squared method. The reason for using these two model specifications lays in the fact that in the case of a time period of two (T=2), the fixed effects estimator and the first-difference estimator are numerically equivalent (Wooldridge, 2002). However, when T is greater or equal to 3, the two estimators can differ depending on the serial correlation in the error terms (Wooldridge, 2002). The Firm fixed effects estimator only outperforms the first-difference estimator in efficiency when the error terms are serially uncorrelated. Due to their similarities, we therefore consider both estimators in our model specification, bringing it in line with Darwin et al. (2012).

3.3.3. Principal Component Analysis

Before conducting any regressions, we run a Principal Component Analysis, in order to find sources of communalities (common factors) in corporate CDS spreads. The Principal component analysis (PCA) approach, describes the variation in multivariate-setting using linear combinations of variables. The purpose of the PCA approach is to extract the principal component that best explains the variation in corporate CDS spreads, and then implement regression analysis to determine which of our variables has the highest correlation with the extracted principal component (PC). PC1 is the linear combination of the variables that together stand for the highest variance. PC2 is the linear combination of the variables with the highest variance of the remaining variables and so forth. Furthermore, PC1 and PC2 have to be uncorrelated with each other (Johnson and Wichern, 2002).

$$PC_1 = \beta_{11}(x_1) + \beta_{12}(x_2) + \cdots + \beta_{1x}(x_x)$$

Where the PC1 represents the first extracted principal component, β_{1p} represents the loading observed for variable x and x_x represents the score of variable x.

3.3.4. Granger-Causality Test

In this paper we use the Granger's causality test to examine how much of the current corporate CDS spreads can be explained by historical sovereign CDS spread changes. Our model specification assumes throughout the paper that there is a spillover effect from sovereign credit to corporate credit, especially for GIIPS compared to CORE. Additionally, we apply this approach to our different panels (Financials vs. non-financials, GIIPS vs. CORE). This is done in order to see if the Ganger causality test is in line with our econometric results. The Granger's causality model is expressed as follows:

$$X_t = \sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + e_t$$

$$Y_t = \sum_{j=1}^{m} C_j X_{t-j} + \sum_{j=1}^{m} D_j Y_{t-j} + \eta_t$$

In the equations above, m represents the number of lags included in the model, and the two error-terms e_t and η_t are assumed to be two white-noise (heteroscedastic and no autocorrelation) (Granger, 1969). The first equation is interpreted in the following; Y_t is granger causing X_t if b_j is not zero. The null hypothesis is that Y does not granger cause X, which basically means that:

$$H_0: b_1 = b_2 = \ldots = b_n = 0.$$

If the granger's causality test shows that $b_1 \neq b_n$, this indicates that Y granger causes X, then we reject the H_0 since there is evidence that $b_1 \neq b_n$ (non-zero). Further, if Y granger causes X and the opposite is evident that X granger causes Y at the same time then we have a bidirectional effect (Hassan, Ngene and Suk-Yu, 2011).

4. Empirical Results

In this section, we present our results with a main focus on LEV and SCS. LEV is an important determinant of corporate CDS spreads in both levels and changes across all sub-periods. According to our findings, and from a Merton model perspective, it is the variable that explains most of the variation in the dependent variable. In addition, our new variable SCS and our contribution to existing research, is emphasized in our analysis of our multiple panels (A-J). Before analyzing the determinants of corporate CDS spreads, we first show the results from our principal component analysis.

4.1. Principal Component Analysis

Table 7 shows the summary statistics of the principal component analysis of the correlation matrix of levels in corporate CDS spreads, as well as changes between January 2004 and April 2014, including the sub-periods. The first principal component in levels for the overall period explains 69.85% of the total variation. The second principal component explains 15.31%, and lastly, the third principal component 3.06% of the variation. The first five principal components explain approximately 92% in levels. When taking changes into regard, instead of levels, the first principal component explain 44.62% of the total variation, the second principal component explains 10.23%, the third principal component explains 5.56%, and the first five principal components explain approximately 67% of the total variation. These findings, although slightly higher, are supported by (Bedendo and Colla, 2013) who finds 47% for the first principal component and 60% for the first five principal components in changes. Conversely, these findings are slightly lower than Collin-Dufresne (2001), who finds that the first PC explains 75% whilst the second explains an additional 6%. When using our market-wide explanatory variables, and measuring the correlation with the first principal component (Table 8), we can conclude that the two most common factors we use in our multivariate analysis show the highest correlation; $STOXX50$ and $VSTOXX$. These findings confirm that corporate CDS spreads are co-vary with these two general market indicators, which still cannot take into account all the changes in corporate CDS spreads.

4.2. Overall Results

Table 9 and 10, firm fixed effects specification and first-difference specification, respectively, represent the results from the multivariate regressions designed to investigate the determinants of corporate CDS spread levels and spread changes. Comparing our two model specifications, the firm fixed effects model explaining levels has a better fit in terms of R-squared in comparison to the first difference model explaining the changes of corporate CDS spreads, which exhibits lower R-squared, and are in line with Darwin et al. (2012). The explanation for this is that in first-differencing the variables information is lost, resulting in a lower fit of the regression model.

Overall, some variables are no longer significant in changes across all sub-periods. However, for our main variable of interest, SCS is significant for both model specifications across all panels. In terms of the firm fixed effects model, we can see that many of the variables chosen for this analysis are highly significant before, during, and after the global financial crisis. Together, the variables explain around 65-85% of the corporate CDS spread levels; in line with Darwin et al. (2012) study' of determinants of bond spreads using levels and changes, which finds an explanatory power of 80% to 86% for the levels of bond spreads. This is a significantly higher explanatory power compared to the R-squared of 40% found by Tan and Yang (2012).

When comparing the signs of our variables we notice that they are mostly in line with the expected sign (Table 1), with minor deviations depending on if the sub-period is before, during, or after the global financial crisis. We find a significant positive relationship between sovereign CDS spreads (SCS) and corporate CDS spreads. This effect is notably stronger after the global financial crisis, which could be an indication that that the spillover effect from sovereign to the corporate sector has intensified after the global financial crisis with the onset of the European sovereign debt crisis, as supported by (Bedendo and Colla, 2013). Before the crisis, a one unit increase in SCS increased the corporate CDS spreads by 0.1 unit on average; during the crisis an increase in SCS increased the corporate CDS spread by 0.13; and after the crisis this figure amounted to 0.57, which exhibits the increased importance of this variable after the crisis compared to before, in levels.

After the crisis, the variation explained by LEV and SCS significantly increased to around 85% of the total variation. The size of company measured by market capitalization (MV) is not in line with the expected sign of the MV variable. Since our data sample is biased due to a selection of the largest companies in the Eurozone, the results are not in line with the expected sign (Table 1). $SLOPE$ and $SPOT$ are significant, in line with the expected signs (see Table1), and in accordance with Longstaff and Schwartz (1995) and Longstaff et al. (1995) research. However in our paper, we find that $SPOT$ has a higher effect on corporate CDS spreads after the crisis in comparison to $SLOPE$.

Analyzing LEV and SCS in changes, it is evident that LEV is only highly significant after the crisis with a significant positive effect on corporate CDS spreads in changes. The SCS is highly significant before and after the financial crisis, but insignificant during. The $SLOPE$ and $SPOT$ are highly significant before and during the crisis where the signs are in-line with the expected signs. The IP_EU is highly significant before and during the crisis with the correct expected sign when analyzing it in changes. In level terms, IP_EU exhibits the wrong expected sign. An explanation for this could be that Industrial Production measures real output, which means that there will be an increasing positive trend in the time-series making it non-stationary. This positive increasing trend will push down corporate CDS spreads in the long run; hence, the levels cannot capture this effect since it measures the development along linearity. However, in changes, it captures this effect since it measures changes between periods, and gives the right expected sign. The overall fit of the first-differencing model ranges from 11% before, to 27% after the crisis.

4.3. Non-financials vs. Financials

Table 11 (non-financials) and Table 13 (financials) show the determinants of corporate CDS spread levels, which of the variables are the major determinants, and how they differ depending on if the company is a financial company or a non-financial company.

As mentioned in section 2, there's a linkage between financials and the respective government. This is because financials hold exposure towards governments in form of bond holdings on their balance sheet, and are intuitively more likely to be affected by the government's creditworthiness. As the creditworthiness of a country is negatively affected, it will affect financials more compared to non-financials, as evident in Table 11 to 14 and supported by Almeida et al. (2013), Borenztein et al. (2013) and particularly Faccio et al. (2006) study', which finds that politically connected firms are more likely to enjoy government backing compared to unconnected firms. This is especially the case for financials, since they are vital for a well-functioning society. However, the results differ depending on if we were to measure it in levels or changes.

In level terms, a one unit increase in SCS before the global financial crisis increased the CDS spreads by 0.122, during the crisis it increased by 0.403, and after the crisis it increased by 0.616 units for financials in levels (Table 13). These results in comparison to the changes (Table 14) in SCS; where a unit increase in the change of SCS before implies a 0.096 increase in the change of the corporate CDS spread before, 0.387 during and 0.285 unit increase after the crisis for financial institutions.

For non-financials, the SCS is highly significant during all sub-periods, and also displays a slightly greater effect of SCS in levels compared to changes (Table 11 and 12). In accordance with our theoretical arguments in section 2, financial companies do show evidence of a larger spillover effect from sovereign credit risk to corporate credit risk in the firm fixed effects specification. Due to the fact, financials hold some exposure in the form of government bonds, they enjoy some government guarantee. This is supported by Faccio et al. (2006) study' that politically connected firms are more likely to be bailed-out compared to unconnected ones.

Another interesting finding, is that non-financials were seen as a safe haven during the global financial crisis as the SCS is significant at the 5 % significance level and negative, which explains the shift in the flow of capital from financials to non-financials during the crisis; as supported by Bedendo and Colla (2013).

Analyzing the most widely used firm-specific variable LEV, and its effect for financials compared to non-financials, we can see that it is insignificant for both panels and model specifications during all periods, except for the firm fixed effects model after the global financial crisis.

4.4. CORE vs. GIIPS

Table 17 exhibits a significant and steady increase of the effect of SCS on corporate CDS spread levels, where a unit increase in changes for corporate CDS spreads ranging from 0.07 before to 0.549 unit increase after the global financial crisis in levels for GIIPS. An adjusted R-squared of 76% before the financial crisis to an adjusted R-squared of 85.2% after the financial crisis, could potentially explain the increased importance of the SCS after the financial crisis compared to before for companies headquartered in GIIPS countries. The LEV is highly significant during all sub-periods with a slight decrease during the crisis but with an increasing impact of the LEV on corporate CDS spreads in the after period.

When comparing the CORE with GIIPS (Table 15 and 17) countries, we can see that there is a similar increasing trend in SCS in levels from before to the after period with a slight deviation where the SCS is insignificant during the financial crisis. This is an interesting indication that shows us that this particular variable was an insignificant determinant of corporate CDS spreads during the crisis, compared to after where it is highly significant with an R-squared of 82% compared to an R-squared of 73% before the crisis. The impact of SCS in changes shows an interesting pattern for GIIPS (table 18) where the SCS variable is significant before and after, but insignificant during the crisis. The impact of SCS exhibits a significant increase from the before period to the after period. Another important indicator of the increasing importance of the SCS after the global financial crisis, is the increasing adjusted R-squared of 12% to 34% in the after period.

We notice that the LEV variable is not only highly significant but has a large effect on corporate CDS spreads before, during, and after where a one unit increase in LEV implies a 187.7 unit increase in the corporate CDS spreads before the financial crisis. This is in comparison to its increasing importance after the financial crisis where this unit increase now implies a 540.1 unit increase in corporate CDS spreads, which is a significant increase of the effect of the LEV on corporate CDS spreads in levels. The fact that LEV is highly significant, apart from the SCS variable in our paper, and it being one of the major determinants of corporate CDS spreads is supported by Tang and Yan (2012), Ericsson et al. (2009) and Darwin et al. (2012).

The impact of the LEV variable is interesting when looking at the changes where it is insignificant before and during the crisis, but reasonably high after the crisis for GIIPS countries. The similar pattern is evident for the CORE countries, however, the impact of LEV in the after crisis period is greater for CORE compared to GIIPS. A potential explanation for this could be that market participants consider firm-specific variables like LEV more for companies headquartered in CORE countries, whereas companies headquarters in the GIIPS countries consider SCS as a more relevant driver of corporate CDS spreads.

The adjusted R-squared differ slightly between GIIPS and CORE where it increases from 12% to 34% for GIIPS and 10% to 23% for CORE. This could be an indication that there could be other variables besides SCS and LEV that better explains the determinants for corporate CDS spreads for the CORE countries before, during and after.

When looking at the single countries within GIIPS and CORE (Table 29), we see that SCS is overall highly significant for the companies headquartered in Portugal, Italy, Spain, and Greece and where the magnitude of the effect follows the same order where SCS in Portugal shows 0.711 and 0.003 for Greece. However, the magnitude of the effect of the SCS on corporate CDS spreads in the respective countries changes after the crisis with Italy (0.712) being the country with the highest effect of SCS is evident, followed by Portugal (0.530), Spain (0.348) and Greece (0.002).

Overall, the result show that the effect of SCS increases for these four countries over time, with the exception of Portugal, which exhibits a slightly lower SCS effect on corporate CDS spreads after the crisis. An explanation to this could be that the spillover effect for companies headquartered in GIIPS countries is overall more evident compared to the CORE countries, who are significant at 5% level with a minor effect of sovereign CDS spread changes explaining corporate CDS spread changes. It is interesting to add that we expected Greece to be the country where the SCS would normally be the driving factor of corporate CDS spreads, but it is not the case since there is a decoupling starting in August 2011, when the sovereign CDS spread of Greece increased significantly reaching extreme values (see Figure 2) whilst on the other hand, the corporate CDS spreads of companies headquartered in Greece kept moving sideways.

4.5. Sector-Specific Results

As evident in section 4.2 where non-financials during the financial crisis were seen as a safe haven when market participants started shifting capital from the struggling financial sector to the non-financial, we now analyze this relationship even further by analyzing sectors within the non-financials. Overall, the non-financial sectors show that the SCS is highly significant for all sectors - Auto & Industrials, Consumer, Energy, Financial services and TMT (Table 19-28) for both specification models.

Looking at the sectors during the crisis and the effect of SCS, we see that SCS is highly significant for all sectors with one exception; TMT (Table 27), which is insignificant in levels. What is interesting when analyzing the sectors individually, is that the safe haven argument is not only evident but also valid for two sectors; Energy and TMT. Both the Energy and TMT (Table 24 & 28) sector do enjoy some sort of government backing, either in terms of government bond holdings or government guarantees. This is particularly evident during the crisis where the SCS is highly significant and negative. This implies that the pattern we saw in section 4.2 that corporate CDS spreads were decreasing when sovereign CDS spread increased during the global financial crisis was evident for these two sectors, indicating that there was a shift in the flow of capital from financials to non-financials and more specifically these two sectors.

For the Energy sector we can see that a one-unit change increase in SCS shows that the corporate CDS spreads decrease by 0.382 units. The same pattern is evident for the TMT sector but is stronger; a one-unit change increase in SCS shows a 0.552 unit decrease in corporate CDS spreads. The opposite was true after the financial crisis; a change in a one unit increase in SCS shows a change of 0.294 unit increase in CDS spreads of corporate CDS spreads for the Energy sector. The same pattern is repeated in the TMT sector but with a slightly higher effect of the SCS on corporate CDS spreads (0.389). This repeating argument further strengthens the safe haven argument for non-financials, as both Energy and TMT sectors are to some extent backed by their respective government. An explanation could be that during the financial crisis, only financials were in real trouble and on the verge of collapse, which caused a shift in capital allocation for market participants seeking safe havens to allocate their capital. These safe havens were companies categorized as non-financials, more specifically the Energy and TMT sector as our results show.

The fact that the SCS and the corporate CDS spreads are positive after the financial crisis, could explain that capital that was invested in the Energy and TMT sector during the crisis was later invested elsewhere. This is because before the global financial crisis the thought of countries going bankrupt was non-existent, but when the financial crisis, caused by the bankruptcy of Lehman Brothers, hit the global financial markets and shook it to its core, it made market participants start to believe that countries could go bankrupt. This is supported by the fact that SCS and corporate CDS spreads are not only positive but also highly significant, both in terms of significance level and the effect of SCS on corporate CDS spreads after the financial crisis. This analysis shows that the spillover effect from sovereign credit risk to corporate credit risk is more evident after the financial crisis, and that the effect of the SCS variable has increased in magnitude across all sub-periods, but especially following the recent global financial crisis and European sovereign debt crisis.

Running all the regressions without our SCS variable and comparing the adjusted R-squared with the regressions including the SCS variable we can see that the R-squared increase in changes is greater for financials 98.6% compared to non-financials 31.2% when looking at the period, overall. The same pattern is repeated for GIIPS compared to CORE, where GIIPS exhibits a 104% increase in adjusted R-squared compared to 2% increase in the adjusted R-squared for the CORE countries. Looking at the sub-periods, we notice a clear pattern which shows that after the global financial crisis the increase in adjusted R-squared is more pronounced compared to before and during the crisis. Including the SCS variable after the crisis, increases the adjusted R-squared to approximately 50%. This analysis underlines the increased importance of SCS as a determinant of corporate CDS spreads after the global financial crisis, in particular for companies headquartered in the GIIPS countries.

4.6. Additional Results

Table 30 shows the summary statistics of the Granger causality test using three lags representing three months. In order to do so, we test the causality of each company with its respective sovereign. Out of the 125 bivariate Granger causality tests, the average and median p-value is calculated, as well as the number of pairs for which the causality using three lags is significant at the 5% level. In addition we show the results for our panels: financials vs. non-financials and GIIPS vs. CORE.

There is evidence that after the global financial crisis and with the onset of the European sovereign debt crisis, the three historical lags of the sovereign CDS spread changes are better in explaining today's changes in corporate CDS spread changes.

However, this not as evident for the historical corporate CDS spread changes in explaining today's sovereign CDS spread changes. In other words, it means that sovereign CDS spread changes are Granger cause corporate CDS spread changes. We can conclude that the direction of the spillover effect after the global crisis goes from sovereign credit risk to corporate credit risk, and is even more pronounced for the companies headquartered in the GIIPS countries.

During the global financial crisis period, we can see the opposite causality while this effect is less pronounced, which is supported by Corzo et al. (2012). They conclude that during the period of Lehman Brother's collapse, a private-to-public risk transfer took place, whereas for the European sovereign debt crisis period they found a risk transfer from public-to-private. This evidence does not only support our findings in the empirical results section that the effect of the SCS variable after the global financial crisis is more important in explaining level and changes in corporate CDS spreads, but also since unidirectional causality from sovereign to corporate is evident.

5. Conclusion

Based on a sample of 125 companies headquartered in the Eurozone, our investigation based on the theoretical arguments of the Merton model including additional theoretical arguments and variables, found evidence that only leverage is an important firm-specific driver that affects corporate CDS spreads, while the rest of the variation is mainly explained by common factors such as VSTOXX. However, the most significant explanatory variable in explaining determinants of corporate CDS spreads is the sovereign CDS spread, especially after the global financial crisis. Including our main contribution to existing research, the sovereign CDS spread increases the fit of our multivariate model by 50% proportionally after the financial crisis, which is a quite remarkable result.

Depending on the model specification as well as the panel selection in determining the corporate CDS spreads, our estimates measured in changes show on average that a one unit increase in sovereign CDS spread implies a 0.3 unit increase in the corporate CDS spread over the whole period. Analyzing the period after the financial crisis, we find that for companies headquartered in the GIIPS countries a one unit increase in sovereign CDS spread implies a 0.34 increase in corporate CDS spread on average. Whilst for the companies headquartered in the CORE countries, a one unit increase in sovereign CDS spreads implies only a 0.09 unit increase in corporate CDS spreads on average. This shows that the sovereign-to-corporate spillover effect is evident for both, but more pronounced for companies headquartered in GIIPS countries. However, changes in the legislation for sovereign CDS contracts in November 2011 banned naked CDS positions and therefore dried up liquidity, which should be kept in mind when interpreting our empirical results.

When comparing the direction of the spillover effect from sovereign-to-corporate versus corporate-to-sovereign, we found that during the global financial crisis the spillover effect goes from financials to sovereign, which means that there was a private-to-public risk transfer. Conversely, after the crisis the spillover effect is more pronounced for public-to-private, namely sovereign to non-financials.

The asymmetric shock of the global financial crisis brought up the macroeconomic imbalances in the Eurozone. In consequence, the Eurozone became increasingly divided into groups of countries following quite diverging parts. This divergence was not only apparent in GDP growth rates, unit labor costs, trade and capital flows and public-sector debt, but also in diverging borrowing costs for sovereigns and the private sector. With the onset of the European sovereign debt crisis the companies headquartered in the GIIPS countries lost their competitive advantage compared to companies headquartered in the CORE as a result of higher borrowing costs for the sovereigns. This translates into higher borrowing costs for the private sector due to the apparent sovereign-to-corporate spillover effect. A number of reforms to restore the GIIPS countries competitiveness, rein in new public deficits, as well as the ECB's Outright Monetary Transactions program, have helped to strengthen investors confidence in the GIIPS countries creditworthiness. With regard to this initiative, corporate CDS spreads in the GIIPS have decreased sharply, which coincides with a reduce in firm's borrowing cost, which in turn can foster economic growth in the Eurozone. Implementing measures that address loosening the relation that amplifies sovereign-to-corporate spillover effects may help stabilize corporate borrowing costs in the Eurozone.

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Appendix

Table 2: Detailed description of explanatory variables

This table provides a detailed description of the explanatory variables included in the firm fixed effects model. The same variables are included in the first-differencing model, where Δ stands for the change in the given variable. In addition, the variable's data source is shown.

Variable	Desciption	Source
	Firm-specific variables	
LEV	Firm's leverage, defined as total debt divided by market value of firm and total debt	Capital IQ
VOLA	Firm's annulized historical volatility of equity returns, computed as rolling standard deviation over the past 90 days	Datastream
PRICE	Firm's stock price	Datastream
MBV	Market-to-book ratio, defined as market value of firm divided by book value of firm	Datastream
MV	Market value of firm (market capitalization) as a measure of size	Datastream
	Market-wide variables	
SPOT	1-year risk free government bond yield (AAA Germany)	Datastream
SLOPE	Difference between 10-year and 1-year risk free government bond yield (AAA Germany)	Datastream
VSTOXX	Annualized implied volatility of the EuroStoxx 50	Datastream
STOXX50	EuroStoxx 50 index	Datastream
L_INDEX	Local stock market benchmark index of single eurozone country	Datastream
IP_EU	Industrial production index of the eurozone	Datastream
	Spillover variable	
SCS	Sovereign credit spread, defined as 5-year sovereign CDS spread	Datastream

Table 3: Summary Statistics

This table shows summary statistics of corporate CDS spreads, firm-specific variables and sovereign credit spread (sovereign CDS spread) for Panel A-J. The summary statistics are presented for the overall period, January 2004 to April 2014. All variables are presented in levels.

Panel A: All 125

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	156.38	0.49	27.08	32.80	1.79	19504.33	9844.57	157.85
Median	83.424	0.43	17.06	23.48	1.48	11221.26	7054.24	29.98
Std.dev.	23.74	0.27	41.86	31.64	3.23	21284.91	10397.72	1167.10
Obs.	13777	13777	13777	13777	13777	13777	13777	13777
Firms	125	125	125	125	125	125	125	125

Panel B: Non-Financials

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	142.79	0.40	28.00	35.40	1.97	19630.14	8737.54	91.65
Median	80.34	0.35	18.61	26.58	1.63	11502.90	6916.50	29.14
Std.dev.	204.71	0.21	43.05	31.49	3.58	21594.03	9130.59	761.38
Obs.	10867	10867	10867	10867	10867	10867	10867	10867
Firms	100	100	100	100	100	100	100	100

Panel C: Financials

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	207.11	0.84	23.65	23.06	1.12	19034.51	13978.62	407.71
Median	102.81	0.87	9.71	10.15	0.94	10260.90	8289.30	39.33
Std.dev.	327.50	0.14	36.85	30.25	0.91	20085.15	13375.54	2058.45
Obs.	2910	2910	2910	2910	2910	2910	2910	2910
Firms	25	25	25	25	25	25	25	25

Panel D: Core

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	127.94	0.43	32.97	42.03	1.82	19099.67	5756.18	32.72
Median	78.29	0.36	23.12	32.33	1.58	11047.73	6291.90	25.42
Std.dev.	178.87	0.26	45.11	37.38	1.57	20690.58	2618.14	34.06
Obs.	11352	11142	11280	11281	10798	11281	11656	11656
Firms	94	94	94	94	94	94	94	94

Panel E: GIIPS

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	234.91	0.65	9.51	10.59	1.78	18840.20	21326.66	523.35
Median	112.20	0.70	5.59	6.30	1.23	9546.08	14755.20	104.92
Std.dev.	334.37	0.24	17.17	13.53	6.00	22034.53	14664.14	2271.39
Obs.	3611	3611	3611	3611	3611	3611	3611	3611
Firms	31	31	31	31	31	31	31	31

Panel F: Auto&Industrials

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	142.94	0.40	38.79	44.99	1.64	17687.60	8550.75	36.78
Median	78.92	0.36	29.11	39.20	1.49	10213.93	6670.04	23.16
Std.dev.	198.21	0.21	61.65	32.21	0.87	19278.55	8966.98	51.42
Obs.	4041	4041	4041	4041	4041	4041	4041	4041
Firms	38	38	38	38	38	38	38	38

Panel G: Consumer

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	166.68	0.35	25.34	36.71	2.15	15410.44	6103.55	50.35
Median	84.00	0.30	19.93	31.16	2.12	10542.96	6665.06	32.49
Std.dev.	225.60	0.22	20.05	26.66	0.89	15169.17	3072.87	79.73
Obs.	1883	1883	1883	1883	1883	1883	1883	1883
Firms	18	18	18	18	18	18	18	18

Panel H: Energy

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	88.98	0.47	19.49	27.67	2.41	30885.29	13336.73	89.82
Median	60.00	0.43	20790,00	19.08	1.55	22402.82	8643.00	39.70
Std.dev.	100.24	0.25	23.73	29.56	8.13	29058.56	11689.37	132.53
Obs.	1915	1915	1915	1915	1915	1915	1915	1915
Firms	16	16	16	16	16	16	16	16

Panel I: Financial Services

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	107.04	0.37	37.72	50.12	1.17	20361.70	9686.89	42.16
Median	75.04	0.32	21.25	28.68	1.04	19213.40	6937.17	25.49
Std.dev.	130.99	0.18	39.17	43.03	0.58	17085.17	10506.68	59.44
Obs.	964	964	964	964	964	964	964	964
Firms	8	8	8	8	8	8	8	8

Panel J: TMT

	CDS	LEV	VOLA	PRICE	MBV	MV	L_INDEX	SCS
Mean	187.32	0.37	12.66	15.72	2.41	16498.70	6795.71	271.66
Median	102.24	0.35	9.58	14.17	2.08	6692.11	5728.58	29.50
Std.dev.	272.45	0.18	11.56	11.93	1.74	21150.38	8031.04	1746.33
Obs.	2064	2064	2064	2064	2064	2064	2064	2064
Firms	20	20	20	20	20	20	20	20

Table 4: Summary Statistics for market-wide variables

This table shows the summary statistics for the market-wide variables used in the regression analysis. These variables are the same for all 125 companies in the sample. The summary statistics are presented for the overall period, January 2004 to April 2014. All variables are presented in levels.

	SPOT	SLOPE	VSTOXX	STOXX50	IP_EU
Mean	1.70	1.46	23.68	828.16	103.92
Median	1.51	1.76	21.38	817.22	103.07
Std.dev.	1.56	0.89	9.14	141.74	5.96
Obs.	13777	13777	13777	13777	13777
Firms	125	125	125	125	125

Table 5: Headquarters by country

The table shows the distribution of the 125 companies' headquarters in the data sample by countries.

Headquarters

Country	Total	Share
France	38	30.4%
Germany	33	26.4%
Italy	14	11.2%
Netherlands	10	8.0%
Spain	9	7.2%
Finland	6	4.8%
Portugal	3	2.4%
Greece	3	2.4%
Belgium	3	2.4%
Austria	3	2.4%
Ireland	2	1.6%
Luxembourg	1	0.8%

Table 6: Firm heterogeneity

The following table shows the unobserved heterogeneity in our data sample for different panels as well as sub-periods. A higher increase in adjusted R-squared is a proxy for more evident heterogeneity. In the case of no heterogeneity there should be no increase in adjusted R-squared when using fixed effects since the cross-section dummies have no explanatory power. Using firm fixed effects is a remedy for the existing heterogeneity.

Increase in adjusted R-squared using firm fixed effects compared to pooled regression

	Overall	Before	During	After	Average
Panel A: All 125	42.49%	314.93%	228.89%	58.57%	161.22%
Panel B: Non-Financials	64.12%	187.05%	113.47%	91.31%	113.99%
Panel C: Financials	10.20%	12.81%	147.98%	27.29%	49.57%
Panel D: PIIGS	20.88%	427.60%	168.98%	43.72%	165.30%
Panel E: Core	96.30%	204.49%	189.31%	158.24%	162.09%
Panel F: Auto&Industrials	35.94%	140.82%	109.71%	34.43%	80.22%
Panel G: Consumer	22.09%	22.21%	28.46%	39.70%	28.12%
Panel H: Energy	11.27%	18.92%	47.82%	35.08%	28.27%
Panel I: Financial Services	18.60%	37.25%	42.70%	3.23%	25.44%
Panel J: TMT	52.20%	128.86%	65.10%	58.86%	76.25%
	37.41%	149.49%	114.24%	55.04%	**89.05%**

Table 7: Principal Component Analysis

The following tables report the summary statistics for the principal component analysis of the correlation matrix of monthly levels in corporate CDS spreads, as well as monthly changes in corporate CDS spreads between January 2004 and April 2014 (Overall). In addition, results are presented for the sub-periods before, during and after. The percentage of variance explained is reported for the first five components.

Principal component analyses in CDS levels

	Overall		Before		During		After	
Principal Component	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)
First	69.85	69.85	72.05	72.05	68.50	68.50	65.84	65.84
Second	15.31	85.16	10.65	82.70	12.31	80.81	13.38	78.78
Third	3.06	88.22	4.39	87.09	5.09	85.90	5.30	84.08
Fourth	2.24	90.46	3.03	90.12	4.09	89.99	4.25	88.33
Fifth	1.79	92.25	1.59	91.71	2.31	92.30	2.63	90.96

Principal component analyses in CDS changes

	Overall		Before		During		After	
Principal Component	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)	Variation Explained (%)	Total (%)
First	44.62	44.62	55.03	55.03	46.01	46.01	56.65	56.65
Second	10.23	54.85	7.22	62.25	13.53	59.54	7.20	63.85
Third	5.56	60.41	4.71	66.96	8.86	68.40	3.43	67.28
Fourth	3.58	63.99	3.47	70.43	6.07	74.47	3.35	70.63
Fifth	3.19	67.18	2.80	73.23	5.21	79.68	2.76	73.39

Table 8: Correlation with first principal component

The following tables report the linear correlation coefficients between the first principal component (Table 7) and the global market-wide factors as defined in section 3.2.2. in levels as well as changes. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Correlation with first principal component in levels			
	Overall	Before	During	After
SPOT	-0.700***	-0.038	-0.267	-0.308**
SLOPE	0.590***	0.106	0.325	0.017
VSTOXX	0.765***	0.602***	0.868***	0.693***
STOXX50	-0.451***	-0.035	-0.876***	-0.804***
IP_EU	-0.513***	0.224	-0.502***	0.009

	Correlation with first principal component in changes			
	Overall	Before	During	After
ΔSPOT	-0.398***	-0.601***	-0.439**	-0.444***
ΔSLOPE	0.181*	0.536***	0.267	0.053
ΔVSTOXX	0.542***	0.616***	0.371*	0.702***
ΔSTOXX50	-0.646***	-0.702***	-0.581***	-0.799***
ΔIP_EU	-0.256***	-0.123	-0.439**	-0.121

Table 9-28: Determinants of corporate CDS spread levels and changes

The following tables show the multivariate results for the determinants of corporate CDS spread levels using a firm fixed effects model (a) and determinants for changes in corporate CDS spreads using a first-differencing model (b). All regressions are fitted using the Ordinary Least Squared method and heteroscedastic robust standard errors. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively. The results are presented for all 10 panels (A-J). The time period is split into three sub-periods. Before is defined from January 2004 to April 2008, during from May 2008 to April 2010 after from May 2010 to April 2014 and overall from January 2004 to April 2014.

Table 9: Panel A (All 125) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	329.916***	-404.723***	1091.989***	-776.508***
LEV	341.221***	174.567***	340.597***	349.963***
VOLA	0.206***	0.135***	0.201***	-0.401***
PRICE	-1.535***	-0.183***	-1.391***	-0.561
MBV	0.282	-0.026	-89.703***	-11.198***
MV	0.003***	-0.001	0.007***	0.003***
SPOT	-27.462***	-33.699***	-72.907	-43.164***
SLOPE	-58.187***	-9.697	-151.949**	-21.049**
VSTOXX	3.051***	2.663***	3.416***	3.361***
STOXX50	0.063**	0.043	-0.181	0.098
L_INDEX	-0.002**	-0.003***	-0.005***	-0.009***
IP_EU	-3.218***	4.089***	-5.650*	7.208***
SCS	0.722***	0.100***	0.131	0.569***
Observations	13777	5694	2778	5305
Firms	119	116	117	119
Adj. R-squared	0.648	0.739	0.676	0.857

Table 10: Panel A (All 125) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	1.112**	2.606***	-8.498***	1.791**
ΔLEV	81.068***	4.418	44.460	198.232***
ΔVOLA	0.144**	-0.004	0.232*	0.031
ΔPRICE	-0.691	0.016	-1.303	-0.253
ΔMBV	0.175	0.008	-37.493**	13.525
ΔMV	0.002***	0.001	0.004***	0.001
ΔSPOT	-24.806***	-12.783***	-104.893***	-10.121
ΔSLOPE	-27.596***	-6.365***	-115.565***	-3.855
ΔVSTOXX	0.995***	0.978***	-0.279	1.358***
ΔSTOXX50	-0.179***	-0.116***	-0.324***	-0.270***
ΔL_INDEX	-0.005***	0.001	-0.005*	-0.009***
ΔIP_EU	-2.653***	-2.014***	-3.906***	1.036
ΔSCS	0.307***	0.136***	-0.118	0.320***
Observations	13654	5575	2776	5303
Firms	119	116	116	119
Adj. R-squared	0.142	0.110	0.096	0.266

Table 11: Panel B (Non-Financials) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	348.333***	-414.157***	1270.002***	-322.427*
LEV	554.684***	247.85***	635.11***	568.101***
VOLA	0.332***	0.132***	0.275***	-0.122**
PRICE	-0.788***	-0.076	-2.202***	1.256***
MBV	-0.106	0.099**	-70.788***	-15.875***
MV	0.002***	-0.001	0.009***	-0.001
SPOT	-16.127***	-37.561***	-82.271	-16.878***
SLOPE	-49.326***	-10.697	-182.563**	-6.837
VSTOXX	3.754***	2.945***	4.04***	2.696***
STOXX50	0.088***	0.069	-0.081	0.103*
L_INDEX	-0.002***	-0.003***	-0.01***	-0.008***
IP_EU	-4.651***	4.055***	-8.275**	1.512
SCS	0.416***	0.084**	-0.083	0.436***
Observations	10867	4502	2185	4180
Firms	94	92	92	94
Adj. R-squared	0.620	0.752	0.682	0.809

Table 12: Panel B (Non-Financials) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.761	2.536***	-10.842***	1.027
ΔLEV	166.955***	9.422	161.713	308.053***
ΔVOLA	0.185**	-0.012	0.272*	0.056
ΔPRICE	-0.850	0.068	-1.724	0.625*
ΔMBV	-0.106	0.023	-25.515	-33.882***
ΔMV	0.002***	0.001	0.005**	0.002***
ΔSPOT	-24.331***	-13.957***	-106.149***	-6.69
ΔSLOPE	-28.726***	-7.566***	-114.913***	-10.976**
ΔVSTOXX	0.921***	1.156***	-0.428	1.269**
ΔSTOXX50	-0.134***	-0.115***	-0.289***	-0.168***
ΔL_INDEX	-0.007***	0.001	-0.009***	-0.008***
ΔIP_EU	-3.628***	-2.128***	-5.625***	-0.544
ΔSCS	0.321***	0.148***	-0.264**	0.359***
Observations	10770	4408	2184	4178
Firms	94	92	91	94
Adj. R-squared	0.126	0.111	0.104	0.262

Table 13: Panel C (Financials) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	-120.405	-401.633***	359.078	-2491.735***
LEV	-94.483**	-9.523	-13.113	125.854*
VOLA	-0.562***	0.117***	-0.223***	-1.301***
PRICE	-0.219	-0.139	0.604*	-4.810***
MBV	14.175	-6.740**	-136.410***	10.491
MV	0.005***	-0.001***	0.004***	0.008***
SPOT	-105.791***	-24.547***	-48.498*	-111.724***
SLOPE	-98.928***	-9.640	-68.688*	-50.766**
VSTOXX	4.830***	1.693***	0.326	3.601**
STOXX50	-0.173***	-0.004	-0.479***	-0.373***
L_INDEX	0.002*	-0.001***	0.002*	-0.005
IP_EU	5.718***	4.883***	3.865*	29.558***
SCS	0.941***	0.122***	0.403***	0.616***
Observations	2910	1192	593	1125
Firms	25	24	25	25
Adj. R-squared	0.791	0.526	0.739	0.898

Table 14 Panel C (Financials) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	2.814***	2.765***	-0.193	4.621**
ΔLEV	20.691*	0.202	-7.552	60.823
ΔVOLA	-0.126**	0.014	-0.093*	-0.255
ΔPRICE	-0.262	-0.090	0.173	-0.693
ΔMBV	31.325***	-5.850*	-83.267**	37.293***
ΔMV	-0.001	-7.230	0.003***	0.001
ΔSPOT	-24.957***	-8.371**	-90.626***	-17.755
ΔSLOPE	-23.736***	-2.377	-107.079***	20.529*
ΔVSTOXX	1.429***	0.298*	0.544	2.194***
ΔSTOXX50	-0.312***	-0.087**	-0.281***	-0.592***
ΔL_INDEX	-3.870	0.001	0.002	-0.004
ΔIP_EU	0.902	-1.493***	2.983**	5.952**
ΔSCS	0.296***	0.096***	0.387**	0.285***
Observations	2884	1167	592	1125
Firms	25	24	24	25
Adj. R-squared	0.254	0.139	0.209	0.349

Table 15 Panel D (CORE) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	289.148***	-408.951***	1127.497***	-515.821***
LEV	514.816***	187.758***	659.604***	540.120***
VOLA	0.259***	0.095**	0.182**	-0.013
PRICE	-0.647***	-0.096*	-1.044***	1.064***
MBV	-10.970***	-3.447	-88.124***	-5.057***
MV	0.002**	-0.001	0.008***	-0.002***
SPOT	-17.124***	-36.882***	-67.825	-30.811***
SLOPE	-43.546***	-12.592	-161.008**	-9.998*
VSTOXX	4.474***	3.024***	3.259***	1.261***
STOXX50	0.073***	0.034	0.026	-0.007
L_INDEX	0.004**	0.001	-0.038***	-0.015***
IP_EU	-4.439***	4.167***	-7.287**	4.959***
SCS	0.191***	0.129***	-0.095	0.141***
Observations	10166	4215	2041	3910
Firms	88	86	86	88
Adj. R-squared	0.583	0.733	0.673	0.821

Table 16: Panel D (CORE) – First differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.821	2.821***	-9.496***	0.874*
ΔLEV	130.393***	3.818	146.245	369.045***
ΔVOLA	0.156**	-0.008	0.231*	0.096***
ΔPRICE	-0.566	0.074	-1.322	0.190
ΔMBV	-11.610**	-1.418	-30.564	-13.78**
ΔMV	0.002***	0.001	0.004**	0.001
ΔSPOT	-25.641***	-14.109***	-110.383***	-18.648***
ΔSLOPE	-25.457***	-7.773***	-123.381***	-9.729**
ΔVSTOXX	0.260	1.086***	-0.312	0.183
ΔSTOXX50	-0.138***	-0.089***	-0.265***	-0.141***
ΔL_INDEX	-0.012***	-0.005	-0.015*	-0.016***
ΔIP_EU	-3.077***	-2.381***	-4.451***	0.688
ΔSCS	0.128***	0.162***	-0.155	0.091***
Observations	10075	4127	2040	3908
Firms	88	86	85	88
Adj. R-squared	0.092	0.110	0.091	0.235

Table 17: Panel E (GIIPS) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	38.142	-332.622***	831.925***	-2474.038***
LEV	18.774	145.095***	90.246***	224.595***
VOLA	-1.961***	0.220*	-0.139	0.343
PRICE	-3.452***	-0.248*	-0.359	-13.452***
MBV	1.025***	0.055**	'-68.200***	-5.781
MV	0.005***	0.001***	0.004***	0.006***
SPOT	-84.904***	-27.051***	-91.039*	-135.942***
SLOPE	-97.850***	-6.471	-143.190**	-48.501*
VSTOXX	4.753***	1.748***	2.296***	2.747
STOXX50	-0.296***	0.033	-0.371***	-0.585***
L_INDEX	0.003***	-0.003***	-0.004***	0.010***
IP_EU	4.064**	3.541***	0.053	29.094***
SCS	0.735***	0.070***	0.268***	0.549***
Observations	3611	1479	737	1395
Firms	31	30	31	31
Adj. R-squared	0.743	0.767	0.743	0.853

Table 18: Panel E (GIIPS) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	2.211**	2.024***	-5.647**	6.258**
ΔLEV	46.217***	5.040	4.558	90.590**
ΔVOLA	0.064	-0.016	0.121	-0.614
ΔPRICE	-2.417**	0.190	-1.082	-7.503**
ΔMBV	0.377	0.026*	-47.172*	31.001**
ΔMV	0.002***	-0.001	0.003***	0.002
ΔSPOT	-22.823***	-9.532**	-84.636***	-0.681
ΔSLOPE	-25.826***	-4.789	-90.086***	28.002***
ΔVSTOXX	2.030***	0.745***	-0.334	2.663**
ΔSTOXX50	-0.346***	-0.088***	-0.281***	-1.027***
ΔL_INDEX	0.002	0.001	-0.005	0.011***
ΔIP_EU	-0.897	-1.120**	-2.160	5.450*
ΔSCS	0.341***	0.089***	-0.043	0.337***
Observations	3579	1448	736	1395
Firms	31	30	31	31
Adj. R-squared	0.245	0.123	0.160	0.348

Table 19: Panel F (Auto&Industrials) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	463.342***	-363.785**	819.140	-195.769
LEV	517.654***	215.602***	1360.935***	208.133***
VOLA	0.303***	0.121	0.213**	-0.060
PRICE	-1.013***	0.331***	-2.732***	-0.954***
MBV	15.219***	-21.329***	10.780	7.276*
MV	0.002**	-0.001***	0.012***	0.002***
SPOT	-29.030***	-43.132***	-168.677**	-42.462***
SLOPE	-61.899***	-7.002	-290.46***	-24.620***
VSTOXX	5.102***	2.484***	5.648***	1.558***
STOXX50	0.131***	0.129**	-0.102	0.159***
L_INDEX	-0.010***	-0.008***	-0.014***	-0.032***
IP_EU	-5.303***	4.008**	-4.615	4.483***
SCS	0.215***	0.085**	-0.037	0.173***
Observations	4041	1655	816	1570
Firms	36	35	34	36
Adj. R-squared	0.578	0.748	0.564	0.902

Table 20: Panel F (Auto&Industrials) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.993	2.756***	-10.242**	1.018
ΔLEV	127.175***	-7.161	515.250*	154.937***
ΔVOLA	0.219*	-0.055	0.283	0.083*
ΔPRICE	-1.509	0.137	-3.747	-0.412
ΔMBV	5.299	4.129	44.259	-20.626
ΔMV	0.003	-0.001	0.009	0.002***
ΔSPOT	-31.561***	-21.711***	-157.317***	-18.102**
ΔSLOPE	-34.114***	-5.220	-177.278***	-17.915***
ΔVSTOXX	-0.016	0.520**	-0.595	0.698*
ΔSTOXX50	-0.152***	-0.118***	-0.376**	-0.085*
ΔL_INDEX	-0.016***	-0.003	-0.020**	-0.020***
ΔIP_EU	-4.137***	-2.761***	-3.564*	0.025
ΔSCS	0.193***	0.159***	-0.155	0.189***
Observations	4004	1620	816	1568
Firms	36	35	34	36
Adj. R-squared	0.103	0.081	0.107	0.337

Table 21: Panel G (Consumer) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	192.471*	-413.464***	1812.396***	-993.456***
LEV	795.288***	314.552***	427.664**	819.571***
VOLA	0.242	0.070	1.204***	-0.044
PRICE	-4.971***	-1.387*	-8.139***	3.218***
MBV	44.916***	10.531	-93.595***	9.607
MV	0.011***	0.002	0.033***	-0.003**
SPOT	-20.350***	-49.342***	49.945	-20.872***
SLOPE	-26.752***	-11.202	-34.118	15.420
VSTOXX	6.012***	4.396***	1.106	2.092***
STOXX50	0.179***	0.075	-0.084	-0.117*
L_INDEX	0.005	0.007***	-0.023***	-0.024***
IP_EU	-5.995***	3.600**	-16.326***	9.424***
SCS	0.216***	0.132***	-0.046	-0.257***
Observations	1883	779	384	720
Firms	16	16	16	16
Adj. R-squared	0.736	0.828	0.846	0.883

Table 22: Panel G (Consumer) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.908	2.872***	-12.329***	0.629
ΔLEV	296.604***	63.002	409.462*	538.124***
ΔVOLA	0.166*	-0.090	0.524**	0.063
ΔPRICE	-2.784***	-1.740	-4.716*	-2.484**
ΔMBV	-11.473*	-4.860	-25.329	1.455
ΔMV	0.009***	0.006**	0.015***	0.008***
ΔSPOT	-25.431**	-15.667	-60.446*	-26.028
ΔSLOPE	-20.941*	-12.811	-48.652	-11.183
ΔVSTOXX	0.368	2.193***	-1.903	0.324
ΔSTOXX50	-0.119*	-0.065	-0.274*	-0.110
ΔL_INDEX	-0.017**	-0.008	-0.015	-0.023
ΔIP_EU	-3.222***	-2.040***	-7.339***	1.622
ΔSCS	0.107***	0.147***	-0.228	0.078*
Observations	1866	762	384	720
Firms	16	16	16	16
Adj. R-squared	0.164	0.177	0.190	0.195

Table 23: Panel H (Energy) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	-16.914	-339.160***	1039.691***	-425.868*
LEV	238.140***	42.568***	122.606***	393.507***
VOLA	0.024	0.062***	0.366***	-0.475*
PRICE	0.257***	-0.085*	1.566***	2.827***
MBV	0.007	-0.092***	-12.851	-91.722***
MV	0.001***	0.001***	0.001*	0.001
SPOT	-17.852***	-21.575***	-97.089**	4.667
SLOPE	-35.286***	-0.621	-170.009***	4.875
VSTOXX	2.365***	1.521***	3.561***	1.966**
STOXX50	-0.032*	0.007	-0.037	0.021
L_INDEX	-0.001	-0.001***	-0.005***	-0.004**
IP_EU	0.102	3.566***	-5.949*	3.069
SCS	0.345***	0.074***	-0.098	0.340***
Observations	1915	811	384	720
Firms	16	16	16	16
Adj. R-squared	0.710	0.712	0.575	0.780

Table 24: Panel H (Energy) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.449	1.638***	-6.656***	1.621
ΔLEV	80.696*	3.404	74.142	108.13
ΔVOLA	0.141***	-0.002	0.449***	0.129
ΔPRICE	0.261	0.139	0.909	3.456***
ΔMBV	0.035	0.009	-17.909	-77.636**
ΔMV	0.001**	0.001	0.001	0.002*
ΔSPOT	-14.214***	-5.642***	-80.509***	14.341**
ΔSLOPE	-21.106***	2.026	-110.334***	4.431
ΔVSTOXX	0.936***	0.574***	0.921*	0.769
ΔSTOXX50	-0.069*	-0.048**	-0.075	-0.279***
ΔL_INDEX	-0.003*	0.002**	-0.003	-0.003*
ΔIP_EU	-2.710***	-1.016***	-6.941***	-0.674
ΔSCS	0.209***	0.128***	-0.382***	0.294***
Observations	1899	795	384	720
Firms	16	16	16	16
Adj. R-squared	0.156	0.280	0.191	0.295

Table 25: Panel I (Financial Services) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	506.508***	-375.167**	1376.31***	-102.227
LEV	187.108***	140.655***	35.005	167.227***
VOLA	1.083***	0.481***	0.378	0.283***
PRICE	-1.940***	0.820***	-7.159***	0.939***
MBV	-71.710***	-72.742***	-148.62***	-64.643***
MV	0.004***	0.001	0.015***	-0.001
SPOT	-17.456***	-40.38***	-128.217*	-14.138***
SLOPE	-41.288***	-2.340	-216.741**	-6.714
VSTOXX	2.094***	2.543***	4.209**	1.005
STOXX50	0.034	0.075	-0.033	-0.040
L_INDEX	0.003***	-0.001**	0.005	-0.008***
IP_EU	-3.951***	4.123***	-5.960	2.739
SCS	0.334***	0.130***	0.568**	0.236***
Observations	964	412	192	360
Firms	8	8	8	8
Adj. R-squared	0.610	0.642	0.757	0.850

Table 26: Panel I (Financial Services) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.840	2.227**	-6.275	1.203
ΔLEV	-45.183	18.473	-91.612*	11.274
ΔVOLA	0.094	0.147***	0.189	0.134*
ΔPRICE	-0.037	-0.051	-0.022	0.409
ΔMBV	5.359	13.949	50.395	-110.188***
ΔMV	-0.001	-0.001	-0.003	0.001
ΔSPOT	-16.974*	-13.96**	-116.953**	0.078
ΔSLOPE	-27.276**	-21.415***	-164.558**	7.410
ΔVSTOXX	0.826	2.100***	1.363	0.142
ΔSTOXX50	-0.176***	-0.094*	-0.242*	-0.286***
ΔL_INDEX	-0.001	0.003*	0.002	-0.004
ΔIP_EU	-3.585	-2.441**	-6.990	2.463**
ΔSCS	0.215***	0.184***	0.026	0.128***
Observations	956	404	192	360
Firms	8	8	8	8
Adj. R-squared	0.126	0.209	0.080	0.441

Table 27: Panel J (TMT) – Firm fixed effects model

	Firm fixed effects model			
	Overall	Before	During	After
C	170.752	-228.334	1178.548	-1230.614
LEV	1029.159***	276.604	722.467***	1380.126***
VOLA	-1.678***	0.060***	-2.389***	-1.204***
PRICE	3.322***	-0.965	-1.301**	8.957***
MBV	-27.430***	8.116*	-206.128	5.544***
MV	0.001	-0.002***	0.014***	0.002
SPOT	-9.867**	-32.809***	-80.616***	-68.274*
SLOPE	-69.631***	-27.261***	-184.767*	-21.968***
VSTOXX	2.515***	4.014*	5.548***	1.494
STOXX50	0.045	0.028***	0.257***	-0.115
L_INDEX	-0.003***	-0.002	-0.017	-0.005
IP_EU	-2.999**	2.691***	-7.156***	8.385
SCS	0.509***	0.112	-0.219**	0.451**
Observations	2064	845	409	810
Firms	18	17	18	18
Adj. R-squared	0.686	0.742	0.799	0.774

Table 28: Panel J (TMT) – First-differencing model

	First-differencing model			
	Overall	Before	During	After
C	0.697	2.942***	-14.551***	2.768
ΔLEV	528.320**	23.752	322.799	1393.724***
ΔVOLA	0.122	0.030	0.369	-0.114
ΔPRICE	4.707***	0.246	4.145	9.254***
ΔMBV	-16.536**	-1.878	-54.087	-8.537
ΔMV	0.002	0.001	0.005**	0.003
ΔSPOT	-22.966**	-6.986	-79.723**	5.231
ΔSLOPE	-27.974***	-13.133	-64.047	-6.500
ΔVSTOXX	2.388***	1.662***	-0.514	2.656*
ΔSTOXX50	-0.099	-0.132**	-0.283**	-0.207
ΔL_INDEX	-0.004	-0.003	-0.010*	0.002
ΔIP_EU	-3.390**	-2.097***	-6.647***	-3.379
ΔSCS	0.390**	0.133**	-0.552**	0.389**
Observations	2045	827	408	810
Firms	18	17	17	18
Adj. R-squared	0.217	0.141	0.143	0.321

Table 29: Country heterogeneity in sovereign-to-corporate credit risk spillover

The following tables show the effects of a one unit change in sovereign CDS spread (SCS) on the corporate CDS spreads for the companies headquartered in the respective sovereign. The effect is measured in levels using a firm fixed effects model (a) and for changes using a first-differencing model (b). All explanatory variables from Table 9-28 are included in the multivariate regression but not reported, except SCS and ΔSCS. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively. The time period is split into three sub-periods. Before is defined from January 2004 to April 2008, during from May 2008 to April 2010, after from May 2010 to April 2014 and overall from January 2004 to April 2014.

	Firm fixed effects model			
	Overall	Before	During	After
Core:				
France	0.264***	0.111**	0.080	0.096*
Germany	0.239**	0.283***	0.747*	0.108
Netherlands	0.055**	0.015	0.098	-0.012
Finland	0.374***	0.249**	-0.225*	0.237*
Belgium	0.187***	0.012	0.195	-0.065
Austria	0.368***	0.126**	1.035***	0.190**
PIIGS:				
Italy	0.438***	0.098**	0.259	0.495***
Spain	0.344***	0.031	-0.201	0.307**
Portugal	1.268***	0.079**	0.283*	1.416***
Greece	0.005***	-0.000	0.005**	0.002***
Ireland	0.311**	0.405***	0.043	0.420*

	First-differencing model			
	Overall	Before	During	After
Core:				
France	0.083**	0.184***	-0.360**	0.068**
Germany	0.271***	0.196***	0.178	0.086**
Netherlands	0.088***	0.084*	-0.040	0.067**
Finland	0.142**	0.312**	-0.321**	0.250**
Belgium	0.081**	-0.006	0.110	0.058
Austria	0.322***	0.140*	0.979*	0.158***
Italy	0.456***	0.140**	-0.249	0.712***
Spain	0.312***	0.048*	-0.142	0.348***
Portugal	0.711***	0.067	0.323*	0.530**
Greece	0.003***	0.000*	0.000	0.002***
Ireland	0.287	0.534**	0.279	0.193

Table 30: Granger-Causality Test

This table shows the summary statistics of the Granger causality test using three lags representing three months. In order to do so, the causality of each company with its respective sovereign is tested. Out of the 125 bivariate Granger causality tests the average and median p-value is calculated as well as the number of pairs for which the causality using three lags is significant at the 5% level. The results are presented for Panel A-E and for the time during and after the global financial crisis.

Granger causality: During period from May 2008 to April 2010

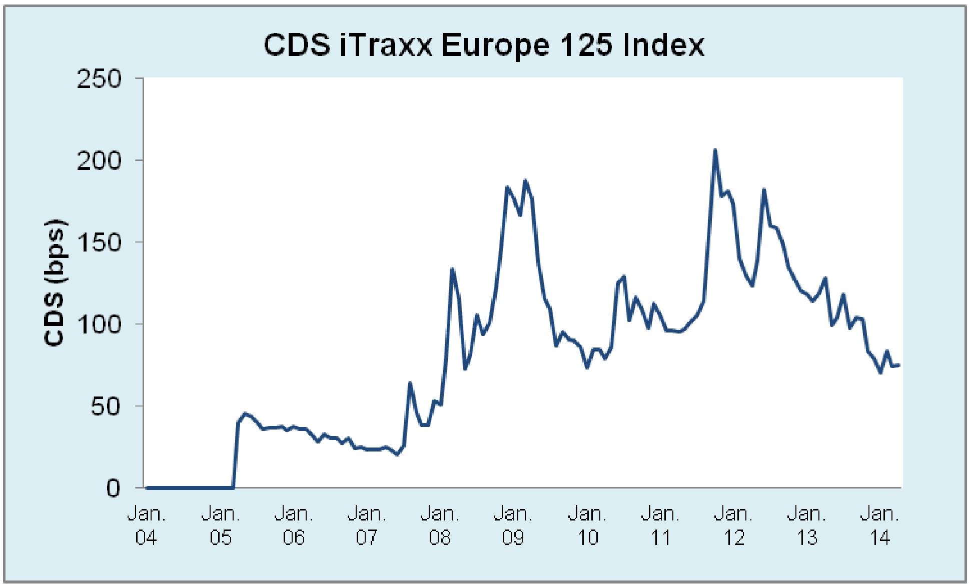
	Average p-value	Median p-value	Rejection of null hypothesis at 5% level	# Firms	Share of firms below 5% level
Null hypothesis: Corporate CDS does not Granger Cause Sovereign CDS					
Panel A: All 125	0.262	0.110	38	125	30.4%
Panel B: Non-Financial	0.250	0.088	35	100	35.0%
Panel C: Financial	0.306	0.265	3	25	12.0%
Panel D: Core	0.249	0.088	34	94	36.2%
Panel E: GIIPS	0.299	0.176	4	31	12.9%
Null hypotheis; Sovereign CDS does not Granger Cause Corporate CDS					
Panel A: All 125	0.282	0.176	25	125	20.0%
Panel B: Non-Financial	0.304	0.214	18	100	18.0%
Panel C: Financial	0.196	0.124	7	25	28.0%
Panel D: Core	0.309	0.217	13	94	13.8%
Panel E: GIIPS	0.202	0.081	12	31	38.7%

Granger causality: After period from May 2010 to April 2014

	Average p-value	Median p-value	Rejection of null hypothesis at 5% level	# Firms	Share of firms below 5% level
Null hypothesis: Corporate CDS does not Granger Cause Sovereign CDS					
Panel A: All 125	0.318	0.227	21	125	16.8%
Panel B: Non-Financial	0.318	0.227	16	100	16.0%
Panel C: Financial	0.319	0.288	5	25	20.0%
Panel D: Core	0.302	0.222	17	94	18.1%
Panel E: GIIPS	0.365	0.337	4	31	12.9%
Null hypotheis; Sovereign CDS does not Granger Cause Corporate CDS					
Panel A: All 125	0.203	0.102	46	125	36.8%
Panel B: Non-Financial	0.214	0.099	38	100	38.0%
Panel C: Financial	0.162	0.125	8	25	32.0%
Panel D: Core	0.228	0.117	30	94	31.9%
Panel E: GIIPS	0.129	0.028	16	31	51.6%

Figure 1: CDS iTraxx Europe Index

The CDS iTraxx Europe Index is a credit default swap index using the most 125 liquid CDS contracts (financial and non-financial) in Europe to represent the overall credit market development. The CDS iTraxx Europe Crossover Index uses only non-investment grade CDS contracts.



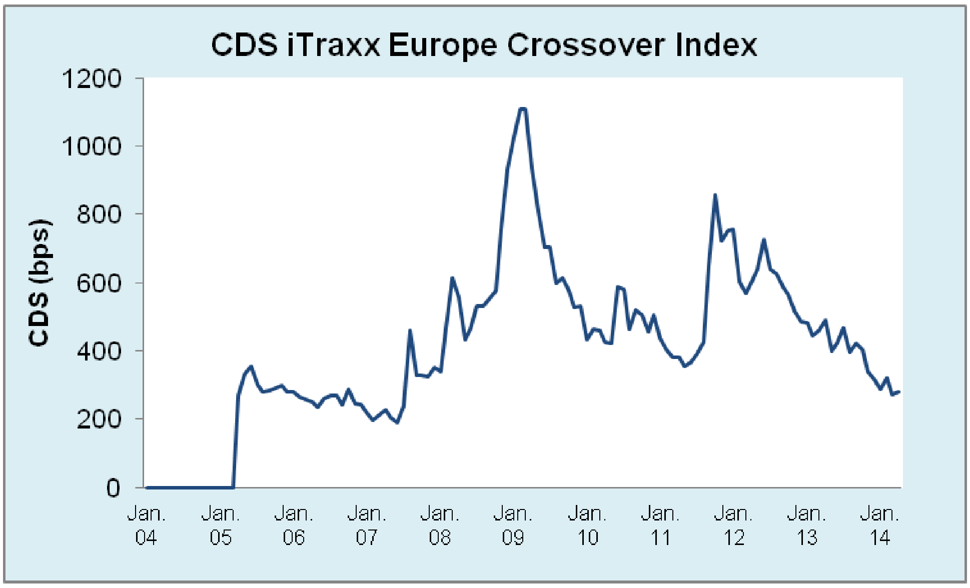
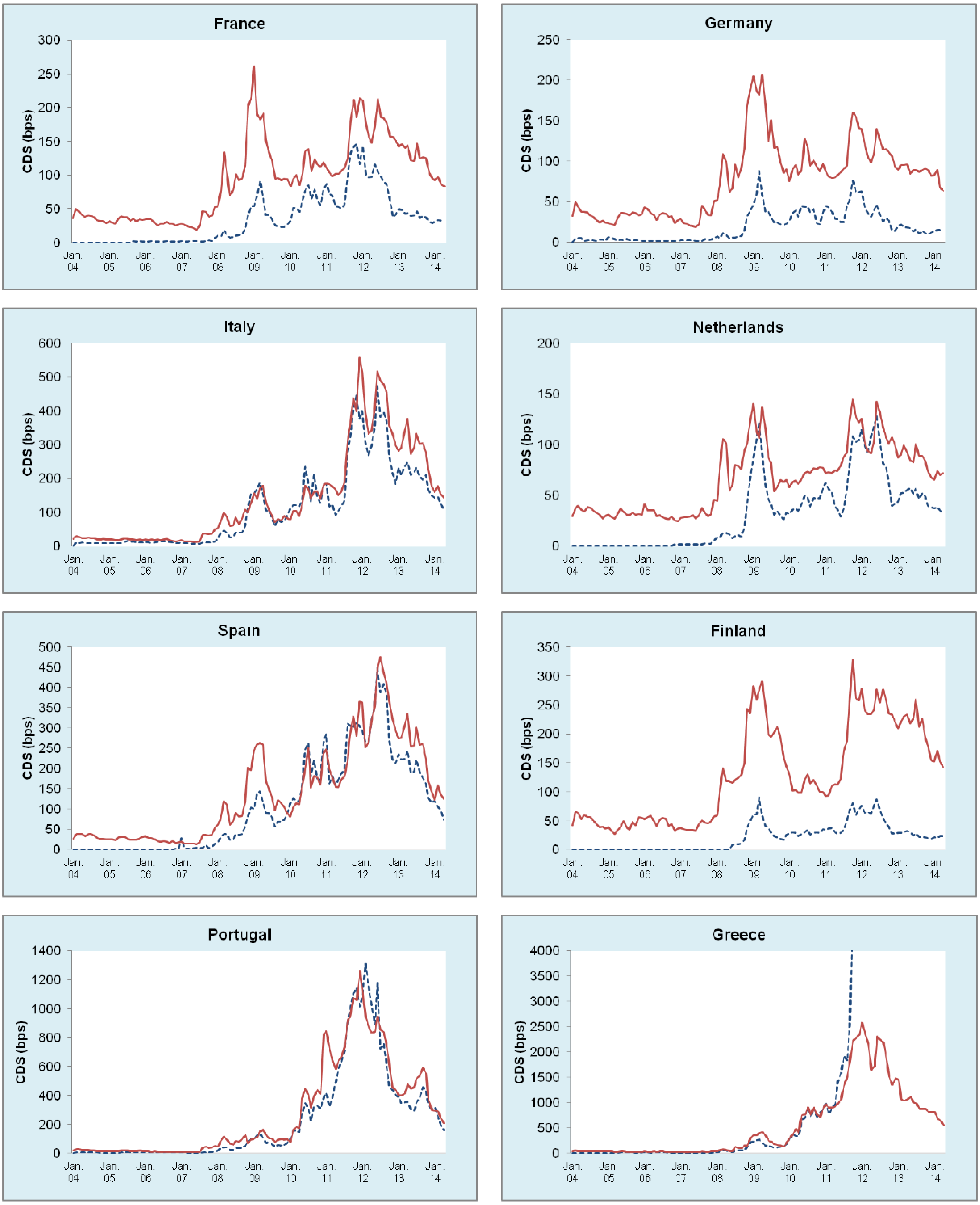
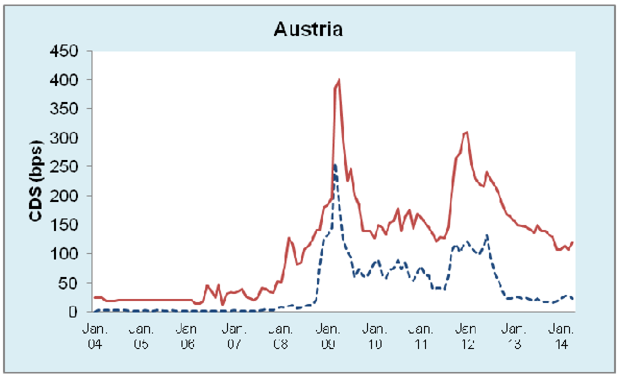
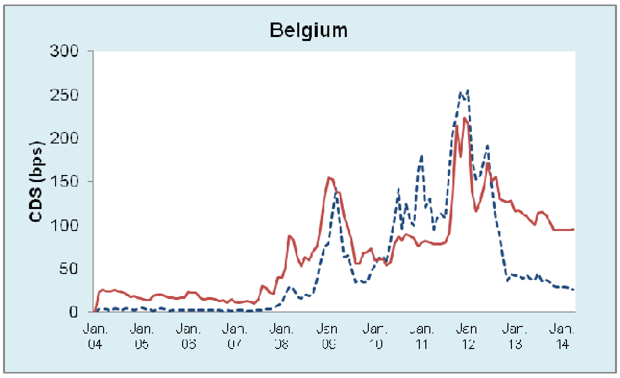


Figure 2: Sovereign and Corporate CDS spread in the Eurozone

The dashed blue line represents the 5-year sovereign CDS spread and the red sold line the 5-year median CDS spread computed across non-financial and finanal entities headquartered in a country.




Austria
450
400
350
300
250
200
150
100
50
0
CDS (bps)
Jan. 04
Jan. 05
Jan. 06
Jan. 07
Jan. 08
Jan. 09
Jan. 10
Jan. 11
Jan. 12
Jan. 13
Jan. 14


Belgium
300
250
200
150
100
50
0
CDS (bps)
Jan. 04
Jan. 05
Jan. 06
Jan. 07
Jan. 08
Jan. 09
Jan. 10
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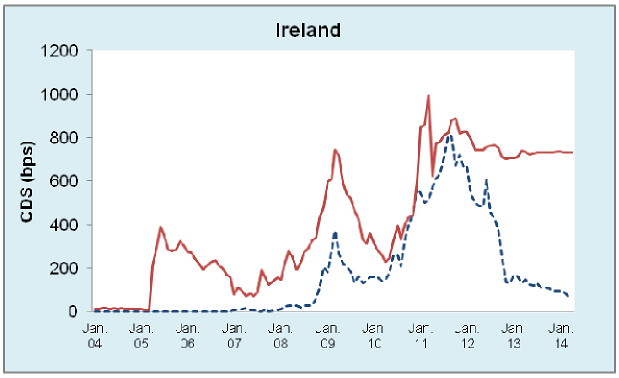
Jan. 12
Jan. 13
Jan. 14


Ireland
1200
1000
800
600
400
200
0
CDS (bps)
Jan. 04
Jan. 05
Jan. 06
Jan. 07
Jan. 08
Jan. 09
Jan. 10
Jan. 11
Jan. 12
Jan. 13
Jan. 14