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Analysing Credit Default Swap Spreads of European Banks

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Abstract

This paper investigates the determinants of the credit default swaps changes of 34 European banks between January 2004 and December 2013. The sample period is further divided into four sub-periods covering both calm and turbulent times (pre-crisis, acute phase and less acute phase of the financial crisis, and the most recent European sovereign debt crisis). We show that CDS spread changes are not entirely driven by credit risk. Our main finding is that liquidity, and market and sector specific factors are embedded in the CDS spreads. Moreover, the influence of these determinants appears to be time-varying. We prove that the credit risk specific to the banking sector as well as the CDS liquidity manifest an influence on the changes in the CDS spread in all the sub-samples. Nonetheless, the market volatility changes do not seem to play any role, whereas equity liquidity has explanatory power only prior to the financial crisis. Moreover, we include an alternative channel for explaining CDS spread changes by means of which we control for time-specificity instead of including the market and sector specific variables. This analysis reveals that changes in accounting leverage do not explain CDS spreads fluctuations.

Keywords: Credit Default Swaps, Credit Risk, European Banks, Structural Models of Credit Risk, Credit Ratings, Liquidity, Market Factors

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1. Introduction

1.1. Background

Credit institutions had a prominent role in the financial crisis with the financial sector experiencing one of the biggest shocks during this period (Coro et al., 2013). As a consequence of this event, the timely and accurate assessment of credit risk in large banks has become important in order to bypass severe sectors' disruptions (Belke and Gokus, 2011). Since financial institutions are often considered opaque entities that impede the credit risk assessment from their annual reports only (Dullmann and Sosinska, 2007), the information derived from the credit derivatives markets can be additionally employed in assessing the credit risk of banks. This market information can contribute to the timely evaluation of the financial stability in the banking industry.

A common type of credit derivative is the credit default swap (CDS) which is a contingent claim generally used as an insurance against the default of a reference entity, thus allowing the transfer of credit risk between two parties: the protection buyer and seller (Ericsson et al., 2009). A major aspect of CDS is that they enable financial institutions to manage credit risk more effectively "by synthetically creating or eliminating credit risk exposures" (Naifar and Abid, 2005: 2). Credit default swaps are being perceived as one of the most meaningful developments of the past decade (Shim and Zhu, 2013) as they "turned out to clearly dominate other types of credit derivatives such as credit linked notes or total return swaps" (Norden and Weber, 2009: 530). These instruments have evolved rapidly, displaying an exponential growth until the beginning of the financial crisis and a significant decline afterwards. The Bank of International Settlements (2013) reports that the CDS notional amount outstanding peaked USD 58 trillion in 2007, and then decreased to USD 24 trillion in 2013. Given the significant development in the CDS market as well as the broader range of maturities, the CDS achieved "a prominent role as market based credit indicator" (Annaert et. al, 2013: 445).

One of the important characteristics of credit default swaps is the credit premium, also referred to as the CDS spread or, more broadly, the credit spread. Understanding the particular factors that drive the variation in financial institutions' CDS spreads has important implications for market participants. Practitioners and academic researchers should adjust their market expectations depending on whether the changes in banks' CDS premium are related to the default or non-default elements. More specifically, if the market participants fail to account for the non-default element of the CDS spread, this "will have an unfortunate consequence of overstating the default premium" (Lin et al., 2009: 3). Furthermore, the information contained in the banks' credit spreads is particularly relevant to the bank supervisors who use it for financial stability monitoring and monetary policy. According to Annaert et al. (2013), single-name CDS spreads are now a part of the financial regulators' agenda.

Prior to the financial crisis, the CDS spreads were considered a pure measure of credit risk (Longstaff et al., 2005). However, this belief is brought under scrutiny because of the significant increase of the CDS spreads during the financial turmoil. Moreover, the widening of the CDS spreads persists in the subsequent European sovereign debt crisis due to the loss of confidence in the debt markets (Calice et al., 2013). Even though some try to justify the rise in CDS spreads by the aggravation of credit risk, the deterioration in credit markets' liquidity spawns new insights. In this respect, Bao et al. (2011) argue that it is uncertain which driver - liquidity or credit risk - causes the increase in the corporate bond spreads. Furthermore, Pu (2009) links the corporate bond and CDS markets by finding a common liquidity factor between the two. Therefore, the CDS spread may also incorporate a liquidity premium on top of the credit risk premium, which restrains the value of CDS spreads as credit risk indicators.

Additionally, the financial turmoil has also exacerbated the decrease in liquidity of asset prices (Coro et al., 2013). This suggests that the CDS market can be affected by the illiquidity of other markets. Since, according to Das and Hanouna (2008), the equity and CDS markets are interconnected via hedging activities, the decrease or increase of liquidity in the equity market might have an impact on banks' CDS spreads.

Furthermore, the CDS spread may be influenced by additional market-wide factors. This is documented by Collin-Dufresne et al. (2001) who find the existence of a common component in the residuals of the regression on credit spreads after taking into account firm-specific variables. Moreover, according to Dullmann and Sosinska (2007), financial institutions' CDS spreads are exposed to systematic risk factor, thus, showing the importance of taking into consideration market factors while examining the information content of financial institutions' CDS.

Research work is inconclusive when it comes to capturing the actual determinants of credit spread changes. This is even more pronounced in the financial sector, for banks in particular. The scarcity of studies in this area is related to the specific features of the financial institutions, such as asset opacity, regulatory requirements, capital structure, the possibility to borrow from the lender of last resort and the high exposure to systematic risk. These characteristics make traditional credit risk models less applicable. We address this problem by decomposing the CDS spread while taking into consideration a wide range of variables on top of those originally derived from the Merton (1974) model. Moreover, it is important to further investigate the liquidity impact on banks' CDS spreads and assess its dynamics throughout different periods. For instance, the monitoring of financial institutions should be enhanced if the CDS spread increase is driven by credit risk, but not if it is influenced by liquidity changes in the equity or CDS markets. Furthermore, banks are exposed not only to entity-specific credit risk, but also are highly affected by systematic risk, thus it is relevant to address both sources of risk in more detail.

Our study aims to extensively investigate the determinants of credit default swap spread changes for a sample of financial institutions. In order to achieve this, we use a panel data model in which the dependent variable is given by the CDS spread changes. CDS spread changes are investigated pre-crisis, during the financial crisis (acute and less acute phase), and the European sovereign debt crisis as well as throughout the whole period in order to take into consideration their large fluctuations. Our starting point is based on the theoretical determinants of default risk, such as leverage, volatility and the risk-free rate. We further extend our analysis by incorporating CDS and equity market liquidity, business cycle and business climate proxies, general state of economy and sector specific drivers. We employ two different approaches in exploring the information content of CDS spread changes. Firstly, we run pooled models containing the examined determinants. In the second approach, we aim to account for the role of market factors in explaining the CDS spread changes by controlling for time-specificity using two panel data estimators, namely fixed effects and random effects models.

1.2. Purpose

The main objective of our study is to determine the drivers of European banks' CDS spread changes. Broadly speaking, the main reason we research the information content in the banks' CDS spread changes is that it has implication for the financial stability of the European banking industry.

Our study aims to extend the related body of empirical works on credit default swaps in a number of ways. Some of the previous studies exclude banks altogether because of their specificity and asset opacity. Other papers use the same framework to account for the CDS determinants of both financial and non-financial entities. Therefore, our study is one of the very few concerned with analysing the CDS of banks. Since the bulk of empirical literature mainly concentrates on U.S. banks, we aim to further enhance it by tackling European banks in particular. Moreover, we contribute to the existing literature by investigating four time periods, respectively before and throughout the financial crisis as well as during the European sovereign debt crisis. To our knowledge, this is the first study that examines the composition of the CDS spreads of banks post the financial crisis.

In addition, our analysis deepens the knowledge into the credit risk and liquidity components of banks' CDS premium. On top of the market proxy for leverage, we include a balance sheet metric capturing leverage which as far as we are concerned is insufficiently addressed in the previous studies on the drivers of financial institutions' CDS spreads. Only the research of Chiaramonte and Casu (2013) utilizes one balance sheet ratio as a proxy for leverage while analysing banks' CDS spreads. Moreover, our paper incorporates credit ratings downgrades and upgrades as explanatory variables of the CDS spread changes. To our knowledge, this approach has not been directly implemented on the CDS spreads of banks. Lastly, we assess the importance of both the CDS liquidity and the equity liquidity of financial institutions' CDS spreads, thus further complementing the existing studies.

1.3. Scope and Delimitations

We limit our study by taking into consideration only listed European banks. The final sample is highly influenced by the availability of data on CDS quotes. Our research covers the period January 2004 to December 2013. We do not take into account the first quarter of 2014 as in our analysis we also incorporate accounting data that is not available at the start of the study.

In this paper, we employ the alternative structural approach and not the direct reduced form or structural form credit risk models. In this approach, we utilize the possible drivers of the credit spreads as explanatory variables in the regressions instead of treating them as inputs in the credit risk models. We are interested in explaining banks' CDS spreads rather than predicting CDS spreads for the next period, therefore we limit our research to examining only contemporaneous variables. Due to the lack of data on the components of liquidity measures in the bond market, we do not address bonds illiquidity impact on CDS spreads.

1.4. Outline

The rest of the paper is organised as follows. Section 2 presents in detail the CDS contracts and their mechanics as well as the benefits of CDS spreads as credit spreads. This is followed by a description of credit risk models, with a particular emphasis on the Merton model (1974) that serves as a basis for our choice of theoretical determinants of the CDS spreads. The section ends with the review on the literature in the credit risk area. In Section 3, we consider the methodology underpinning our research, including the choice of data, variables, descriptive statistics and models specifications. The following section presents the empirical results of our analysis. We conclude our study in Section 5.

2. Theoretical Framework

2.1. Credit Default Swaps

Invented in the mid-1990s, credit derivatives are over-the-counter instruments that allow credit risk transfer from one party to another (Shim and Zhu, 2013). Generally speaking, credit default swaps can be seen as insurance contracts against the default of an underlying entity, in which the seller of protection pays compensation if a credit event occurs, while in return the buyer of protection makes regular payments based on the credit default swap premium, often referred to as the spread (Ericsson et al., 2009). CDS can be classified into three types: single-name CDS, CDS indices and basket CDS (ECB, 2009). The European Central Bank (2009: 9) defines a single-name CDS as a contract that "offers protection for a single corporate or sovereign reference entity". Blanco et al. (2005) further describe single-name CDS as the credit derivatives exhibiting the highest liquidity and forming the basis for building more complicated credit products.

The other type of CDS is CDS indices which can be characterized as an insurance against “default risk on the pool of names in the index” (Amato and Gyntelberg, 2005: 74). CDS indices have the specific feature that in a credit event, which can be triggered by bankruptcy, restructuring or a failure to pay, the CDS contract is not terminated (Alexander and Kaeck, 2008).

The last type of CDS is the basket CDS. Hull and White (2000) define the basket CDS as an instrument involving multiple reference entities and providing a payoff once the first of these entities defaults. ECB (2009) gives a classification of the specific types within the basket CDS, which includes: first-to-default CDS, untranched basket, synthetic CDO and full basket CDS.

The use of credit default swaps both for hedging and trading purposes contributes to enlarging the view of market participants regarding the information on the financial health of the reference entity. Hedging with CDS isolates the credit risk from interest rate and currency risks by allowing an entity to hedge its credit exposure without selling the loan or bond (Naifar and Abid, 2005). Additionally, trading CDS enables the shift of risk from those with highly concentrated positions to those who want additional exposure.

Other benefits of CDS are visible in the bond market. In this respect, hedge funds managers can take advantage of the pricing differences between the CDS and the bond market without having a direct exposure to the reference entity. Moreover, borrowers can gain from the trading of CDS which presumably reduces the cost of bond issuance and increases the liquidity of bond portfolio. Finally, the CDS protection seller can “take exposure to the desirable credit in the exact maturity of its choice” (Naifar and Abid, 2005: 3).

The financial turmoil disclosed several imperfections of the CDS market, such as the shortfall of transparency in connection with CDS opening positions and a lack of counterparty credit risk management (Gupta, 2012). In response to these shortcomings, the Basel Committee adjusted the beneficial treatment for structured credit positions with respect to the capital requirements (ECB, 2009) indicating that regulators are concerned with the risk in the credit derivatives market. Nevertheless, the ECB (2009) recognizes the overall contribution of the CDS to the market completeness and the fact that these derivatives enable the pricing of risk as some underlying assets exhibit liquidity scarcity.

2.2. CDS Spreads as Credit Spreads

The credit spread, which captures the credit risk of an entity can be represented by the CDS spread or bond yield spread. The CDS spread is "the cost per annum for protection against the default by the company" (Hull et al., 2004: 2), while the corporate bond spread is given by the corporate bond yield minus the corresponding risk-free rate (Chen et al., 2007). Hull et al. (2004) show that given certain assumptions these two credit spreads are firmly connected. However, the swap spread is often preferred to the bond spread due to a number of advantages. Ericsson et al. (2009) argue that CDS spreads are straightforwardly captured and thus are not associated with the choice of a riskless benchmark. The benefits of not having to select a reference risk-free asset and to eliminate coupon effects are further emphasized by Houweling and Vorst (2005). Moreover, Delatte et al. (2012) verify that the CDS market holds a dominant position with regard to the information transmission in the bond and CDS markets. Furthermore, one recent study by Coudert et al. (2013) finds that the CDS of financial institutions contribute more to the price discovery process than bonds.

Another advantage of default swap spreads is that they are said to capture fluctuations in credit risk more accurately and quickly than bond yield spreads (Zhu, 2006). One explanation is that the market and additional factors affect the credit premium of bonds to a great extent. Indeed, corporate bond spreads are highly impacted by other determinants, such as liquidity and tax rates. Previous research reveals the time-varying dynamics of the liquidity component. In this respect, Nielsen et al. (2012) observe that at least a part of the credit spread widening at the onset of the financial crisis can be attributable to a decrease in bond liquidity. Furthermore, Longstaff et al. (2005) address the tax impact on the bond yield spread.

2.3. Credit Risk Models

Studies that address the pricing of credit risk reveal a dichotomy between reduced form and structural form models. Reduced form models "treat default as an unpredictable event governed by a hazard rate process" (Naifar and Abid, 2005: 4), while the structural models assume that default is triggered when the value of a firm's assets falls below a particular threshold, expressed as a function of the amount of debt outstanding (Collin-Dufresne et al., 2001). According to Naifar and Abid (2005: 4), even though there are considerable differences between these two types of models, they both are “rooted in the no arbitrage analysis of Black-Scholes-Merton (1974)”. Following Black-Scholes-Merton (1974) findings, structural models use firm specific variables to model the default process, while the reduced form models remain silent on the theoretical framework for the drivers of the prices of defaultable securities (Ericsson et al., 2009). Structural models have the advantage of offering an economic context underlying the event of default.

The Merton model often constitutes a point of departure in the discussion on structural credit risk models. Merton (1974) develops his model for pricing corporate debt in accordance with the Black–Scholes (1973) option valuation method, as this framework relies on observable variables that enable empirical testing.

Lyden and Saraniti (2000) describe Merton’s framework as a closed form solution for valuing a zero-coupon corporate bond by modelling the firm’s equity as a call option on the firm’s asset value, assumed to follow the lognormal process implied by the Black-Scholes model. The firm is considered to default if the asset value drops below a particular threshold, given by the face value of debt (Blanco et al., 2005).

The Merton model is utilized to derive the expressions for the probability of default (Hull et al., 2004). In order to achieve this, Bharath and Shumway (2008:1344) document that Merton relies on the following two equations.

The first is the Black-Scholes-Merton equation that expresses the equity value as a function of the firm value:

$$E = V*N(d_1) - e^{-rT}*F*N(d_2), \quad (1)$$

$$d_1 = \frac{ln\left(\frac{V}{F}\right)+\left(r+0.5*\sigma_V^2\right)*T}{\sigma_V*\sqrt{T}},$$

$$d_2 = d_1 - \sigma_V * \sqrt{T},$$

where *E* is the market value of the firm’s equity, *V* is the total value of the firm, *N(.)* is the cumulative standard normal distribution function, *r* is the instantaneous risk-free rate, and *F* is the face value of the firm’s debt.

The second equation is concerned with the volatility of the firm's equity and is based on Ito's lemma:

$$\sigma_E = \left(\frac{V}{E}\right) * \frac{\partial E}{\partial V} * \sigma_V, \tag{2}$$

where σ_E is the volatility of equity and σ_V is the volatility of the firm's assets.

These two non-linear equations enable the derivation of the value of the firm's assets and the firm's volatility, which are otherwise not directly observable. These inputs are used to calculate the distance to default as:

$$DD = \frac{ln\left(\frac{V}{F}\right)+\left(\mu-0.5*\sigma_V^2\right)*T}{\sigma_V*\sqrt{T}}, \tag{3}$$

where μ is the expected return on the firm's assets.

Finally, the resulting distance to default is substituted into a cumulative density function in order to calculate the default probability i.e. that the firm value will be less than the face value of debt at the forecasting horizon (Bharath and Shumway, 2008):

$$\pi_{Merton} = N\left(\left(- \quad \frac{ln\left(\frac{V}{F}\right)+\left(\mu-0.5*\sigma_V^2\right)*T}{\sigma_V*\sqrt{T}}\right)\right) = N\ (\text{-}DD) \tag{4}$$

Ericsson et al. (2009) posit that the main drawback of structural models is given by the practical difficulties in their implementation. This fact presumably leads to the employment of the alternative structural approach in the studies of credit risk. Starting with the notable research of Collin-Dufresne et al. (2001), this alternative structural approach is utilized in finding the theoretical drivers of the credit spreads. These determinants are "used as explanatory variables in regressions for changes in corporate credit spreads, rather than inputs to a particular structural model" (Ericsson et al., 2009: 110). Following the Black-Scholes-Merton (1974) findings, the drivers of default are investigated to be entity leverage, asset volatility and the risk-free rate. Higher leverage and asset volatility lead to a higher probability of default and higher credit spread. The increase in the risk-free rate lowers probability of default, and consistently reduces the credit spread. In our study, we aim to make use of this structural approach.

2.4. Literature Review

This section is organised according to the evolution of research in the credit risk area. We first emphasize the research on the determinants of credit spreads, then we address the literature that discusses CDS in more detail, and finally we concentrate on the studies that cover financial institutions' CDS.

The strand of literature on credit risk is influenced by the notable study of Collin-Dufresne et al. (2001). This study examines the effect of factors implied by default risk models on the changes of the credit spread measured as the individual bond yield spread. They find relatively low explanatory power of the examined determinants and hence emphasize the deficiency of structural models, such as the Merton (1974) model. However, after employing a principal component approach on the residuals, Collin-Dufresne et al. (2001) prove that the residuals are highly cross-correlated and underline the existence of some common systematic factor in credit risk. Later research works (Das et al., 2006; Dullmann and Sosinska, 2007; Tang and Yan, 2008; Annaert et al., 2013; and Core et al., 2013) support these findings by incorporating market-wide variables when examining the determinants of the credit spread.

The substantial development of the credit derivatives market led the literature on credit risk to focus more on CDS. Nonetheless, throughout the past years a limited amount of studies (Hull et al., 2004; Naifar and Abid, 2005; Das et al., 2006; Chen et al., 2007; Tang and Yan, 2008; Ericsson et al., 2009; Das and Hanouna, 2008; and Core et al., 2013) are devoted to the CDS. Some of these papers concentrate on non-financial institutions, whereas others combine financial and non-financial entities.

Hull et al. (2004) question the CDS and bond spreads anticipation of credit ratings announcements. Their study proves that the CDS market foresees the rating events and finds that positive credit announcements are less influential than negative ones. Similarly, Naifar and Abid (2005) investigate ratings on top of other sources of influence on CDS such as maturity, equity volatility, risk free rate and the slope of the yield curve. Their study uncovers that almost all the employed variables are statistically significant and highlights that the credit rating is the most relevant determinant of the CDS spreads. Relative to this paper, our study analyses downgrades' and upgrades' effect on the CDS spread changes, and distinguishes itself by taking into consideration the pre-crisis as well as the financial crisis, and the European sovereign debt crisis period.

More recently, Ericsson et al. (2009) examine the relationship between the CDS spreads and the traditional determinants of default risk, such as companies' leverage, volatility and risk-free rate. They observe that volatility and leverage are statistically significant in both univariate and multivariate regressions, thus proving the importance of the explanatory variables originally derived from the Merton (1974) model. Our analysis further complements this study by incorporating sector specific, market factors and proxies for general economic conditions in addition to the variables derived from the Merton (1974) model.

In the empirical research of Das et al. (2006), cross-sectional regularities in CDS prices are analysed rather than their time-series dynamics. They undertake a comparison of models that are correspondingly based on either entity accounting data or market-wide variables. One of the main conclusions of the study is that the hybrid model containing both market and accounting variables exhibits the best fit. Following this paper, we incorporate a balance sheet ratio of leverage when analysing the CDS spread changes.

The study of Chen et al. (2007) addresses the drivers of CDS spreads with an increased interest into the liquidity element. One of the main findings in this research is that, opposite to the bond market in which there is a negative relation between liquidity and the bond spread, the more liquid credit default swaps should have a broader spread. The liquidity of CDS is further examined by Tang and Yan (2008) and Coro et al. (2013). Tang and Yan (2008) observe that liquidity is priced in the CDS market, while Coro et al. (2013) ascertain the dominant role of liquidity in comparison with entity-specific credit risk drivers.

Another study that covers the issue of liquidity is that of Das and Hanouna (2008). This research assesses the impact of the equity market illiquidity on the CDS spread. They assert that the equity and CDS markets are connected via hedging activities and find that the equity liquidity of the reference entity has a negative relation with the CDS spread.

However, according to Raunig and Scheicher (2009), most of the empirical studies on CDS spreads do not differentiate between the financial and non-financial entities or just eliminate banks from their samples, thus leaving only several studies concentrating in more detail on the financial sector. Some notable examples, which include Dullmann and Sosinska (2007), Calice et al. (2012), Raunig and Scheicher (2009), Chiaramonte and Casu (2013) and Annaert et al. (2013), are analysed below.

One of the early research works that entirely focuses on banks is that of Dullmann and Sosinska (2007). This study analyses the CDS spreads and investigates their usefulness as market indicators by assessing the explanatory power of liquidity, idiosyncratic credit risk and systematic credit risk factors. Their research concludes that liquidity and market factors are important determinants of banks' CDS, whereas the idiosyncratic credit risk proxy varies in significance for different samples.

The study of Raunig and Scheicher (2009) explores the differences in market pricing of credit risk between the financial and non-financial sectors. They emphasize the financial markets' discrimination between the CDS of the major US and European banks and non-financial companies. One of their main findings is that the risk premium demanded by investors for taking the risk exposure is time-varying and this effect is stronger for non-financial companies.

Another research work undertaken on banks is that of Calice et al. (2012), where the focus is on influence of the market for CDS indices on the world's banking industry. They examine the relationship between the banks' stock returns and CDS indices. Their results posit a negative relation between the two and additionally uncover that the CDS market volatility affects the volatility of financial institutions' equity returns.

Chiaramonte and Casu (2013) further expand the research on financial institutions by making use of accounting data to investigate the viability of CDS spreads as a proxy for bank risk. More specifically, they study the relationship between bank balance sheet ratios and bank CDS spreads. Their analysis proves that the CDS spread drivers fluctuate over time depending on the existing state of the economy. The overall result is that the risk revealed by balance sheet ratios is reflected in banks CDS spreads, especially during the financial crisis.

Finally, to our knowledge, there is only one study by Annaert et al. (2013) that explicitly takes into account the CDS spreads of the financial institutions and examines their decomposition. The main determinants of CDS spreads are categorized into credit risk, marketability and market wide factors. The CDS liquidity components as well as the market and business cycle variables are found to have explanatory power on the CDS spreads in addition to the Merton inspired variables. We complement this research by taking into consideration the most recent European sovereign debt crisis period and utilizing a larger sample of banks. In addition, we consider a wider range of CDS spread changes determinants, among which the interest rate swap, accounting leverage, credit ratings, and equity liquidity.

3. Methodology

3.1. Data

In this paper, we use a sample comprising of monthly data on the CDS quotes of 34 listed European banks (Appendix A). Firstly, we restrict our sample by including the European banks that have CDS data available. Moreover, we exclude banks that are acquired during the sample period. We further limit our sample by including only listed entities. Our final sample incorporates banks from Austria (2), Belgium (1), Denmark (1), France (4), Germany (1), Greece (4), Ireland (1), Italy (6), Portugal (3), Spain (5), Sweden (4), and The United Kingdom (2).

The CDS quotes include the bid, ask and mid prices that we use for the bid-ask spreads and the CDS spreads. The Credit Market Analysis (CMA) ended their agreement with Thomson Reuters Datastream in 2010, hence imposing limitations on the availability of CDS quotes after this date in Datastream. Therefore, we resort to the S&P Capital IQ platform in order to retrieve the CDS quotes. We choose senior unsecured CDS contracts with a maturity of 5 years as they are the most frequently traded. Data on credit ratings is obtained from Moody's due to the historical data availability. Equity and benchmark government bond yields are retrieved from Thomson Reuters Datastream, whereas accounting data is taken from S&P Capital IQ.

The sample data covers the period starting from January 2004 to December 2013. The starting date is chosen as January 2004 as a very limited amount of CDS quotes is available before this date. December 2013 is taken as a closing date in order to complement the existing literature on credit default swaps by including the most recent data. The selected end date is compatible with the accounting data availability.

The choice of a monthly CDS frequency is twofold. First, Tang and Yan (2008) report sparsity in the daily CDS transactions. Second, the highest frequency at which the accounting data is available is on quarterly basis. Following the method of Collin-Dufresne et al. (2001), we use linear interpolation to obtain monthly estimates of the quarterly accounting data.

3.2. Dependent Variable

As Figure 1 shows, the median of the CDS spread in levels experienced a rapid increase since the start of the financial crisis, whereas an even higher rise occurred during the European sovereign debt crisis (further referred to as the Eurozone crisis). In addition, the fluctuation in the median of the CDS spread is visible since the mid of 2007 and it becomes particularly pronounced since 2011. This proves the importance of examining the differential impact of the chosen explanatory variables on the CDS spreads over sub-periods as well as the full period.

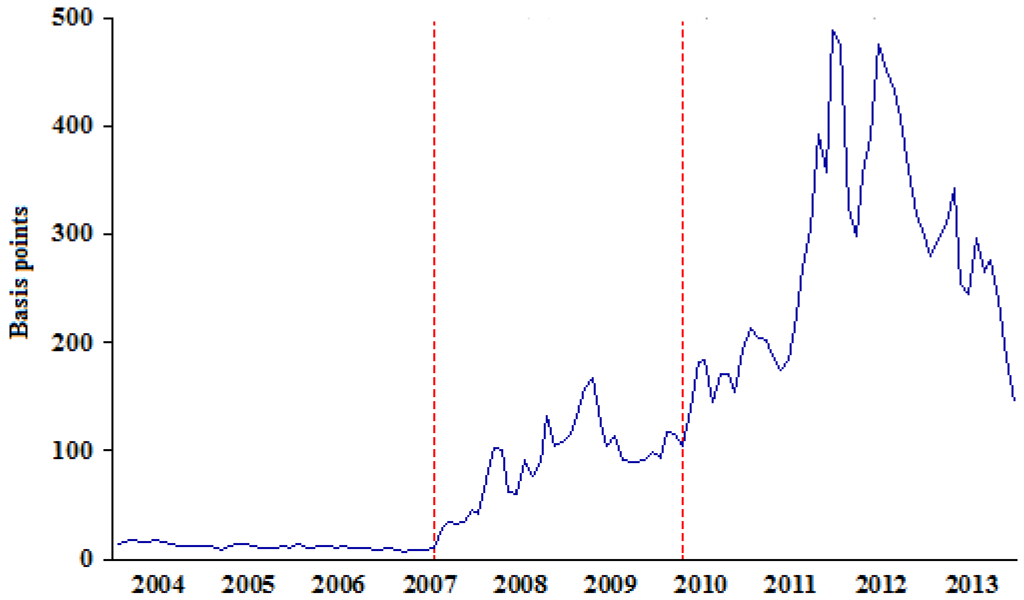

Figure 1. Median of CDS spreads

The figure displays the sample median of the CDS spread. The first dotted vertical line corresponds to the start of the financial crisis (July 2007). The second line depicts the employed beginning of the European sovereign debt crisis (April 2010).

The analysed period is further divided into four sub-periods: pre-crisis, acute phase and less acute phase of the financial crisis, and the post financial crisis period which covers the Eurozone crisis. According to Ivashina and Scharfstein (2010), and Chiaramonte and Casu (2013), the financial crisis began in July 2007. Figure 1 depicts the sudden changes in the CDS since July 2007, confirming the choice of the pre-crisis period to be January 2004 - June 2007. Consistently with Chiaramonte and Casu (2013), in our analysis, the financial crisis encompasses two phases: an acute phase (July 2007 – March 2009) and a less acute phase (July 2007 – March 2010). Even though Arghyrou and Kontonikas (2012) state that the beginning of the European sovereign debt crisis is November 2009, according to Lane (2012), the bond market experienced the first signs of this crisis only in 2010 with the widening of the Greek 10-year government bond redemption yields. As CDS and bond markets are interconnected, the beginning of the Eurozone crisis is chosen to be April 2010. This is supported by the considerable increase in the median of the CDS spread since this date (Figure 1). Therefore, the last sub-period covers April 2010 – December 2013.

Moreover, it can be observed that the CDS spread series may not be stationary. Thus, we test the CDS spread for non-stationary. Non-stationary series have a time-varying mean or time-varying variance or both and can lead to spurious regressions (Gujarati, 2004). In order to tackle this issue, we employ a univariate unit root test for the CDS spreads of each cross-sectional entity for the whole sample period. In this respect, the Augmented Dickey-Fuller (ADF) test uncovers that the banks' CDS spreads are non-stationary, with the exception of Erste Group Bank (see Appendix B). This finding justifies taking first differences of the CDS spread since this adjustment induces stationarity according to the ADF test on first differences (not reported). Therefore, our study examines the changes in the CDS spreads instead of the CDS levels.

3.3. Explanatory Variables

The explanatory variables are classified into six groups of determinants, respectively structural model based, ratings upgrades and downgrades, CDS liquidity, equity liquidity, market-wide and sector specific. The further description of each group and the corresponding variables is provided in the subsequent sections.

3.3.1. Structural Model Based Variables

Structural models use firm specific variables to model the default process. The variables encompassing credit risk are chosen in accordance with the Merton (1974) model framework which is based on the following drivers of default: financial leverage, asset volatility and the risk free rate.

3.3.1.1. Financial Leverage

Financial ratios are exposed to accounting standards and practices that may to some extent affect the information contained in them regarding the prospects of banks. However, Das et al. (2006) contend that accounting data incorporates additional information on credit risk that is not fully captured by market based models. Therefore, we include a balance sheet proxy for leverage. To our knowledge, the use of a balance sheet proxy for leverage in the structural model approach framework while investigating financial institutions has not been exploited before and deserves to be analysed. Only the study of Chiaramonte and Casu (2013) employs accounting variables when examining the CDS spreads of banks. However, their study is entirely focused on balance sheet ratios. Consistently with the research of Chiaramonte and Casu (2013), leverage is defined as Total Equity/Total Assets and it is expected that an increase in this ratio should lead to a lower CDS spread change. The reason for this is that holding total assets constant and diminishing equity should correspond to an increased Debt/Total Assets ratio, and thus to a higher probability of default.

Following the studies of Collin-Dufresne et al. (2001), Blanco et al. (2005), and Avramov et al. (2007), for robustness we use bank stock returns as a second proxy for leverage. This choice is motivated by the difficulty to arrive at a reliable market value of leverage. Moreover, stock returns are expected to have the opposite effect on the CDS spreads since negative stock returns is related to an increase in leverage, and thus should lead to a higher credit spread. The studies of Collin-Dufresne et al. (2001) and Avramov et al. (2007) confirm the negative relation between stock returns and changes in credit spreads.

3.3.1.2. Equity Volatility

As underlined in the Merton model section, another theoretical determinant of the CDS spread is the firm value volatility. Since this variable is unobservable, it can be proxied by a measure of equity volatility. This follows from Ito’s lemma (equation 2), which posits a positive relationship between the two. In theory, we expect an increase in equity volatility to lead to an increase in firm’s value volatility, which in turn will raise the probability of the firm value hitting the default barrier. This will translate into a positive effect on the CDS spread changes. Naifar and Abid (2005) find that the relationship between CDS spreads in levels and equity volatility is positive, whereas Ericsson et al. (2005) confirm the existence of the positive link when analysing the changes of CDS spreads. However, the study of Annaert et al. (2013) reveals inconsistent results and in some cases an intuitively implausible negative relation between banks' CDS spread changes and equity volatility. Following Alexander and Kaeck (2008), we use a statistical volatility measure calculated from the historical stock return data.

3.3.1.3. Risk-free Interest Rate

The introduction of the risk-free rate as a determinant of the CDS spread is rooted in the Merton model, in which the risk-free rate constitutes the risk-adjusted drift of the firm value (Ericsson et al., 2009). The risk free interest rate is expected to be inversely related to the CDS spread. This stems from the fact that the static effect of a higher interest rate is to increase the risk-neutral drift of the firm's assets, which in turn reduces the probability of default leading to a lower credit spread (Blanco et al., 2005). The dependency between risk-free interest rates and credit spread changes is empirically covered in the study of Collin-Dufresne et al. (2001), which presents the latter as a decreasing function of the former. Thus, a negative relationship is expected between changes in CDS spreads and interest rates. Nevertheless, Raunig and Scheicher (2009) investigate that the sign of the risk-free rate coefficient estimate is not consistent as it does not take a negative value on all occasions.

We use two proxies for the risk-free rate. The yields on government bonds are the most common metric, thus, we first use monthly observations on the benchmark 10-year government bond yields provided by the European Central Bank (ECB).

Moreover, the unobservable risk-free rate can also be measured by the interest rate swaps instead of government bond yields. Blanco et al. (2005: 2261) assert that government bond yields are affected by "taxation treatment, repo specials, scarcity premium, and benchmark status". The interest rate swaps constitute a better alternative since they are liquid and quoted on a constant maturity basis. Our second proxy of the risk-free rate is given by the International Swaps and Derivatives Association (ISDA) 5-year euro interest rate swap.

3.3.2. Ratings

Daniels and Jensen (2005) describe credit ratings as the paramount source of information on credit risk. Moreover, Micu et al. (2004) emphasize one of the main benefits of credit ratings, namely the standardization of risk categories that enables the comparison between the entities.

Since the CDS market is said to anticipate the credit rating announcements (Hull et al., 2004), it can be used as an alternative to the bond market. Furthermore, research by Naifar and Abid (2005) uncovers that the credit rating is a prominent determinant of credit default swaps, which is consistent with the relationship between ratings and default probabilities.

To our knowledge, the assessment of the explanatory power of credit ratings upgrades and downgrades on banks' CDS spread changes is not sufficiently addressed. Only the study of Annaert et al. (2013) takes into consideration financial institutions' credit ratings, however instead of employing credit rating change as an independent variable, Annaert et al. (2013) divide the sample based on ratings.

The credit market is led by three rating agencies: Fitch, Moody's and Standard & Poor's (Tichy, 2011). Credit ratings by Moody's are employed in our study due to the availability of historical data on credit ratings on Moody's website. Moody's credit ratings comprise of a scale from Aaa to C. This can be divided into investment grade ratings ranging from Aaa to Baa3, and below investment grade ratings situated between Ba1 and C (Tichy, 2011).

In order to account for the upgrade and downgrade of the entity's rating, two dummy explanatory variables are constructed. A dummy variable essentially is a vector containing values of 0 and 1. The downgrade variable takes the following values:

$$DGRD = \begin{cases} 1, \text{in case of a downgrade} \\ 0, \text{otherwise} \end{cases}$$

If the entity is downgraded, then the first dummy variable takes the value of 1 and otherwise it obtains a value of 0. Similarly, an upgrade dummy variable is defined as:

$$UGRD = \begin{cases} 1, \text{in case of an upgrade} \\ 0, \text{otherwise} \end{cases}$$

If an upgrade occurs, then this variable gets a value of 1 and in all other cases the dummy is designated a value of 0.

Intuitively, the credit spread is negatively related to the credit rating: the lower the credit rating, the higher is the credit spread (Hull et al., 2004). This is further confirmed in the study of Naifar and Abid (2005), where it is observed that CDS spreads of entities with better credit ratings are lower. All in all, a negative link can be anticipated: the upgrade should lead to the lower CDS spread change, whereas the opposite is expected for the downgrade.

3.3.3. CDS Liquidity

Hicks (1962) describes liquidity as the possibility to promptly undertake a transaction. Even though the term liquidity first arose in studies on the equity market, an interest with regard to liquidity is also manifested in bond and credit derivatives markets. Some research works (Collin-Dufresne et al., 2001; Chen et al., 2007; Bao et al., 2011; Nielsen et al., 2012) express an increased attention to the possibility of illiquidity of corporate bonds being a factor in the credit spread puzzle, whereas a limited amount of studies focus on the liquidity of CDS. Pu (2009) adopts market depth, associated with the number of CDS quotes contributors, and the proportion of zero daily spread changes as measures of credit market liquidity, whereas Chen et al. (2010) propose the use of the CDS bid-ask spread as a liquidity proxy. In a study by Tang and Yan (2008), it is suggested to employ liquidity measures such as the number of contracts outstanding, spread volatility to the number of quotes, bid-ask spread and the ratio of quotes to trades.

Overall, in order to capture the liquidity element in CDS spreads, we choose to use the CDS bid-ask spread as a proxy of liquidity. The selection of this particular explanatory variable is in line with other studies. Dullmann and Sosinska (2007) prove that the CDS bid-ask spread is a significant explanatory variable of the CDS premium, whereas Tang and Yan (2008) show that the bid-ask spread is highly correlated with several other liquidity measures. Thus, they show the reliability of the CDS bid-ask spread as a liquidity measure. Consistently with Chen et al. (2007), we calculate the CDS bid-ask spread as the difference between the bid and ask prices divided by the bid-ask midpoint.

Intuitively, we expect a negative relationship between liquidity and the CDS spread. Therefore, a higher CDS bid-ask spread change should indicate a decrease in liquidity and imply a higher CDS spread change. However, the study of Chen et al. (2007) further confirms the positive relationship between liquidity and the CDS spread.

3.3.4. Equity Liquidity

The liquidity component is an attested determinant of credit spreads, with a number of studies documenting the relationship between bond market liquidity and bond yield spreads (Collin-Dufresne et al., 2001; Ericsson and Renault, 2006), and respectively between CDS market liquidity and swap spreads (Dullmann and Sosinska, 2007; Tang and Yan, 2007). On top of these findings, Das and Hanouna (2009) establish the existence of a relationship between the CDS spreads and equity market liquidity via hedging activities. Their reasoning is based on the fact that equity markets are used by CDS sellers to hedge their credit risk exposures. As such, a decrease in equity market liquidity will make hedging more expensive, thus raising the CDS spreads in order to compensate for the higher costs (Das and Hanuona, 2009). The effect of equity market liquidity on the CDS spread is further explored in the studies of Tang and Yan (2006), and Breitenfellner and Wagner (2012). The former paper finds a positive relationship between stock illiquidity and CDS spreads, while the latter study analyses the impact of the change in the Amihud illiquidity measure for a stock portfolio of iTraxx index constituents on the iTraxx spread change. Breitenfellner and Wagner (2012) also uncover a significant positive relationship between the stock market illiquidity and CDS spreads.

Amihud (2002: 32) argues that the bid-ask spread is a “finer and better” measure of liquidity, therefore we use it as a proxy for equity liquidity. Following Amihud and Mendelson (1986), we construct the bid-ask spread of the reference entities (banks) as the difference between the bid and ask prices divided by the average of the two. We expect that the increase in the bid-ask spreads of banks’ stock, which constitutes higher illiquidity, should lead to a rise in the CDS spread.

3.3.5. Market Factors

Previous research reveals that credit spreads can be impacted by the business cycle in multiple ways. Berndt et al. (2005) observe that the time-varying tendency of the credit risk premium is an indicator that investors’ risk aversion also depends on the business cycle. Annaert et al. (2013) observe that market frictions, which can constrain the free flow of capital, lead to a temporary high risk premium. In the light of this evidence, we expect changes in business, and market conditions to affect the changes in credit spreads.

3.3.5.1. The Slope of the Term Structure

According to Estrella and Mishkin (1997), the slope of the term structure constitutes a proxy for the business cycle. The increase in this explanatory variable is expected to negatively affect the credit spread change, since a high slope is indicative of higher economic growth. In a manner that is consistent with Collin-Dufresne et al. (2001), we measure the slope of the term structure as the difference between the 10-year and 5-year yields of benchmark government bonds provided by the ECB.

3.3.5.2. General State of the Economy

Following a number of prominent studies such as Dullman and Sosinska (2007), Ericsson et al. (2009) and Annaert et al. (2013), we use a stock market index as an indicator of the overall state of the economy. We assume that a stock return index is more appropriate to capture the overall economic conditions than the individual stock returns that are influenced by the information on the prospects of each entity.

The previous research works mostly utilize the S&P 500 index. However, our study concentrates on the European market, thus we employ the STOXX Europe 600 index. The reasoning behind this is that this particular index represents a large number of companies with different market capitalizations and it can be perceived as an adequate proxy for the state of economy.

The findings of Dullman and Sosinska (2007), Ericsson et al. (2009) and Annaert et al. (2013) affirm that the relationship between the CDS spread change and return on the chosen stock index is negative. The observed result is intuitive since favorable business conditions are expected to lower the probabilities of default and increase the recovery rates. Subsequently, we expect to find a negative link between the return on the STOXX Europe 600 index and banks' CDS spread changes.

3.3.5.3. Market Wide Volatility

Market wide volatility is used to capture the business climate. The positive link between changes in market wide volatility and credit spread, and the statistical significance of the market volatility as explanatory variable is observed in the study of Coro et al. (2013). This finding is theoretically plausible since higher volatility leads to higher uncertainty about the future economic prospects and higher credit spread changes. Accordingly, we also expect a positive relationship between changes in credit spreads and market volatility. We aim to use the market wide implied volatility, which is a forward-looking estimate that refers to the "volatility of the return of the asset underlying an option in an option pricing model" (Lopez and Navarro, 2012: 11909). To achieve this, we use the VSTOXX volatility index calculated using the prices of options on the Dow Jones EURO STOXX 50 (Lopez and Navarro, 2012).

3.3.6. Sector Specific Variable

The financial crisis raised awareness about banks' internal mechanisms, thus shifting attention to the financial variables that capture their intrinsic credit and funding risks, such as the swap spread.

3.3.6.1. Swap Spread

Eichengreen et al. (2012) document that the TED spread is one of the common factors in banks' credit default swaps spreads. This metric can be expressed as the difference between the interest rates on inter-bank loans (3-month LIBOR) and short-term government debt. Since the TED spread reflects liquidity or flight-to-quality risks on top of banks' credit risk, it can be decomposed into two components: LIBOR-OIS and OIS-government bond, where OIS is the 'overnight index swap'. The former captures the banking sector credit risk premium, while the latter gives the liquidity premium. In order to capture the credit and funding risks, we use the LIBOR-OIS differential, where the overnight index swap is given by the euro 3-month OIS. We expect a positive relationship between the changes on CDS spreads and the swap spread as intuitively higher credit risk should increase CDS spreads.

3.4. Descriptive Statistics

Before proceeding with the model specification it is desirable to analyse a number of descriptive statistics in order to capture the distribution of the variables.

Table 1 reports the mean, maximum (max.), minimum (min.) and standard deviation (std. dev.) of the CDS spread changes during the different periods in our sample. First of all, the distance between the maximum and the minimum values of the CDS spread changes is large especially during the financial crisis and the Eurozone crisis, which suggests that there is dispersion in the data. In addition to this, the increase in standard deviation from pre-crisis to crisis period as well as its heightened level during the Eurozone crisis indicates the time varying characteristics of the CDS spread changes. Thus, the CDS spread changes appear more volatile during turbulent times. Moreover, the Jarque-Bera test (not reported) rejects normality in all periods.

Table 1. **Descriptive statistics of the CDS spread changes**

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	-0,25	8,94	4,30	1,40	1,78
Max.	37,80	274,63	274,63	809,00	809,00
Min.	-27,80	-188,60	-229,70	-731,00	-731,00
Std. Dev.	3,42	33,42	35,14	111,34	78,38

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of CDS spread changes (basis points) during the four sub-periods as well as the whole period.

The descriptive statistics of the changes of explanatory variables are presented in Appendix C. The highest dispersion in data measured as the difference between maximum and minimum values is observed in Eurozone crisis for the following variables: Total Equity/Total Assets ratio, stock returns, equity volatility, benchmark government bond yield and the slope of the term structure. This is in line with the standard deviations being highest in the same period. Moreover, this result shows consistency with the high volatility in CDS data in Eurozone crisis. However, observations on changes in both CDS and equity liquidity have the highest dispersion in the pre-crisis period, whereas most of the market and sector specific variables are investigated to be more volatile during the financial crisis. Finally, it can be observed that there were no credit rating upgrades during the two phases of the financial crisis.

3.5. Model

Our sample consists of a group of cross-sectional financial entities with observations throughout time which constitute a panel of data. Gujarati (2004: 637) indicates that a panel gives "more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency". Furthermore, panel data can assist better in studying the dynamics of change as it contains a number of the repeated observations in the cross sectional dimension (Gujarati, 2004). Finally, panel data makes it possible to tackle a more complex range of issues (Brooks, 2008) by enabling the control of entity heterogeneity and time-specificity.

In our study, we assess 34 European banks' CDS spread changes over 120 months. However, not all financial institutions have CDS over the full period, leaving fewer observations and constituting an unbalanced panel of data. Moreover, the sample allotment, which is organised according to sub-periods, respectively pre-crisis, acute crisis, less acute crisis, Eurozone crisis and the whole sample period, leads to an overall of five panels of data.

Before proceeding with the models specifications, it is important to check for multicollinearity which occurs when the explanatory variables are closely related. This constitutes a violation of one of the implicit ordinary least squares assumptions (OLS) that there should be no correlation between the independent variables (Brooks, 2008). The presence of multicollinearity causes difficulties in examining the individual contribution of the explanatory variables to the fit of the estimated regression. Moreover, the high correlation between the independent variables makes the regression sensitive to a marginal modification in the specification. Furthermore, multicollinearity affects the significance tests and may cause problems in drawing precise inferences (Brooks, 2008). Therefore, it is important to test for multicollinearity. A possible way to measure the correlation between the explanatory variables is to find the correlation matrix.

Table 2. **Correlation matrix for the whole sample period**

CORR.	CBA	CEA	CEQL	CEQV	CGLD	CIRS	CMVL	CSWP	CTSR	DGRD	MRET	SRET	UGRD
CBA	1,00	0,00	-0,01	-0,01	0,01	-0,01	0,06	0,04	0,01	0,00	0,04	0,04	0,03
CEA	0,00	1,00	0,00	-0,03	0,00	0,04	-0,02	-0,05	0,09	-0,05	0,09	0,10	0,00
CEQL	-0,01	0,00	1,00	-0,13	0,02	0,00	0,02	0,02	-0,06	-0,01	0,00	0,04	0,01
CEQV	-0,01	-0,03	-0,13	1,00	-0,07	0,00	-0,06	-0,08	0,15	-0,01	0,02	0,04	0,02
CGLD	0,01	0,00	0,02	-0,07	1,00	0,62	0,00	0,02	-0,04	0,00	0,14	0,02	0,02
CIRS	-0,01	0,04	0,00	0,00	0,62	1,00	-0,08	-0,11	-0,02	-0,01	0,33	0,15	0,02
CMVL	0,06	-0,02	0,02	-0,06	0,00	-0,08	1,00	0,39	0,11	-0,05	0,02	0,04	0,00
CSWP	0,04	-0,05	0,02	-0,08	0,02	-0,11	0,39	1,00	-0,10	0,00	-0,23	-0,12	0,00
CTSR	0,01	0,09	-0,06	0,15	-0,04	-0,02	0,11	-0,10	1,00	-0,04	-0,02	0,07	0,00
DGRD	0,00	-0,05	-0,01	-0,01	0,00	-0,01	-0,05	0,00	-0,04	1,00	-0,11	-0,11	-0,01
MRET	0,04	0,09	0,00	0,02	0,14	0,33	0,02	-0,23	-0,02	-0,11	1,00	0,50	0,00
SRET	0,04	0,10	0,04	0,04	0,02	0,15	0,04	-0,12	0,07	-0,11	0,50	1,00	0,01
UGRD	0,03	0,00	0,01	0,02	0,02	0,02	0,00	0,00	0,00	-0,01	0,00	0,01	1,00

The table reports the correlation matrix, which includes the pair-wise correlation coefficients of the explanatory variables over the period January 2004 – December 2013. CBA is the monthly change in the CDS bid-ask spread (in basis points). CDS bid-ask spread is calculated as the bid-ask quotes difference divided by the bid-ask midpoint. CEA is the monthly change in Total Equity/Total Assets ratio (percentage points). CEQL is the monthly change in equity liquidity proxied by the equity bid-ask spread. Equity bid-ask is computed as the bid-ask difference divided by the bid-ask midpoint. CEQV is the change in equity volatility, which is based on the monthly change in the historical standard deviation calculated based on a 12-month rolling window of the monthly stock returns of the corresponding entity (percentage points). CGLD is the monthly change in the 10-year benchmark government bond yield (percentage points). CIRS is the monthly change in the 5-year interest rate swap. CMVL is the monthly change in market volatility, where the VSTOXX index is used as a proxy for market volatility. CSWP is the monthly change in the LIBOR-OIS swap spread (percentage points). CTSR is the monthly change in the term structure slope (percentage points). DGRD is the credit rating downgrade. MRET is the market return, calculated as the return on the STOXX Europe 600 index. SRET is the monthly stock returns of the underlying bank. UGRD is the credit rating upgrade.

Gujarati (2004) suggests that according to a rule of thumb, multicollinearity causes severe problems only if the pair-wise correlations are in excess of 0,80. The strongest observable correlation is between changes in the benchmark government bond yield and the euro interest rate swap, respectively 0,62. However, both these measures are proxies for the change in the risk-free rate and are not simultaneously used in regressions. The other pair-wise correlation coefficients do not exceed 0,50 indicating that none of the other correlations is problematic. Correlation matrices are also constructed for all sub-periods (Appendix D), confirming that besides the two proxies for risk free rate none of the elements in the matrices is bigger or equal to the threshold of 0,80.

In this study, we utilize two approaches to account for CDS determinants, respectively pooled models and panel data estimators, namely fixed and random effects models.

3.5.1. Pooled Models

The starting point is the pooled regression which includes both cross-sectionally and time-varying explanatory variables. The pooled model treats data entirely as a cross-sectional regression without taking into consideration latent bank heterogeneity and time variation. By consequence, this model implies the same intercepts for each bank and each time period, and no correlation between the error terms.

We use two measures for leverage, namely the ratio of Total Equity/Total Assets and banks' stock returns. Thus, we have two pooled models to account for them. Each pooled model is run for the full period and also for the sub-periods.

We define the first pooled regression as follows.

Model 1:

$$CSPR_{i,t} = \alpha_0 + \alpha_1 CEA_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_3 CIRS_{i,t} + \alpha_4 DGRD_{i,t} + a_5 UGRD_{i,t} + \alpha_6 CBA_{i,t} + a_7 CEQL_{i,t} + +\alpha_8 CTSR_{i,t} + \alpha_9 MRET_{i,t} + \alpha_{10} CMVOL_{i,t} + \alpha_{11} CSWP_{i,t}, \quad \text{(I)}$$

where we denote $CSPR_{i,t}$ as the change in the CDS spread of bank i at time t; α_0 as the intercept; $CEA_{i,t}$ as the change in leverage proxied by Total Equity/Total Assets ratio; $CEQV_{i,t}$ as the change in equity volatility; $CIRS_{i,t}$ as the change in the risk-free rate proxied by the interest rate swap; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in the CDS bid-ask spread; $CEQL_{i,t}$ as the change in equity bid-ask spread; $CTSR_{i,t}$ as the change in the term structure slope; $MRET_{i,t}$ as the market return; $CMVOL_{i,t}$ as the change in market volatility; $CSWP_{i,t}$ as the change in the swap spread.

In addition to this, we test another model specification with the benchmark government bond yield as a proxy for the risk-free rate instead of the interest rate swap. The obtained results are presented in Appendix E.

Relatively to Model 1, in the second model the accounting leverage is substituted with the market proxy for leverage, namely entity-specific stock returns, yielding the following specification.

Model 2:

$$CSPR_{i,t} = \alpha_0 + \alpha_1 SRET_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_3 CIRS_{i,t} + \alpha_4 DGRD_{i,t} + \alpha_5 UGRD_{i,t} + \alpha_6 CBA_{i,t} + \alpha_7 CEQL_{i,t} + \alpha_8 CTSR_{i,t} + \alpha_9 MRET_{i,t} + \alpha_{10} CMVOL_{i,t} + \alpha_{11} CSWP_{i,t}, \quad \text{(II)}$$

where we denote $CSPR_{i,t}$ as the change in CDS spread of bank *i* at time *t*; α_0 as the intercept; $SRET_{i,t}$ as the banks' stock returns; $CEQV_{i,t}$ as the change in equity volatility; $CIRS_{i,t}$ as the change in the risk-free rate proxied by the interest rate swap; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in CDS bid-ask spread; $CEQL_{i,t}$ as the change in equity bid-ask spread; $CTSR_{i,t}$ as the change in the term structure slope; $MRET_{i,t}$ as the market return; $CMVOL_{i,t}$ as the change in market volatility; $CSWP_{i,t}$ as the change in swap spread.

In the same manner as above, we run an additional model, where we substitute the riskless rate proxy, namely the interest rate swap with the benchmark government bond yield. Appendix F reports the corresponding results.

In order to ensure the reliability of our results, we test the classical ordinary least squares assumption of homoscedasticity, which posits that "the variance of the errors is constant" (Brooks, 2008: 132). In the presence of non-constant variance, errors are heteroscedastic. The underlying issue associated with heteroscedasticity is that the inferences drawn from the regression are not reliable. In order to test for this problem, we manually perform the Breusch-Pagan-Godfrey (BPG) test, whose results are presented in the table below.

Table 3. BPG test results for Models 1 – 2

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Model 1					
F-statistic	2,07	3,85	2,71	5,45	5,06
Prob.	0,02	0,00	0,00	0,00	0,00
Model 2					
F-statistic	2,00	12,96	5,70	5,70	5,41
Prob.	0,03	0,00	0,00	0,00	0,00

The table shows the F-statistics and associated p-values (prob.) obtained in the BPG tests. The null hypothesis of this test posits that the errors are homoscedastic. The employed statistical significance level is 5 %. The heteroscedasticity test is run for the two pooled models in all the sub-periods as well as during the whole sample period. More specifically, Model 1 utilizes accounting leverage. Model 2 includes stock returns as a proxy for leverage. The BPG tests results for the additional tested specifications that differ from Model 1 and Model 2 by employing benchmark the government bond yield as risk-free rate proxy are presented in Appendix E and F.

The obtained BPG results posit that the null hypothesis of homoscedasticity can be rejected in Models 1 and 2 in all of the sub-periods as well as the whole period. This implies that errors are heteroscedastic. In order to eliminate the heteroscedasticity and correct the standard errors, we employ White’s robust standard errors.

3.5.2. Fixed and Random Effects Models

Some of the employed explanatory variables only vary over time but not over the cross-sections, mainly the market-wide factors, such as the term structure slope, the market return, market volatility and the swap spread. Therefore, in the second approach we aim to account for the role of these factors in explaining the CDS spread changes in a different manner than in the pooled regressions. Instead of including explanatory variables that only vary over time, we aim to account for them as well as the additional market influences by controlling for time-specificity using two panel data estimators, namely fixed effects and random effects models. This approach enables more insights into the explanatory power of the cross-sectionally varying determinants as the observed results are compared with the ones obtained in the pooled models. Moreover, in finding the appropriate model specification, we also test for the presence of cross-sectional heterogeneity.

Fixed effects and random effects models enable accounting for cross-sectional heterogeneity or for time specificity. The fixed effects model can take into consideration the variation in both the time and cross-sectional dimension (Brooks, 2008) at the same time, but due to the unbalanced panel of data, the random effects cannot. Moreover, the unbalanced panel of data restricts the estimation of the model with both fixed and random effects in different dimensions.

The fixed effects approach can be implemented by incorporating dummy variables, known as the least squares dummy variable model (LSDV). This approach captures the heterogeneity and leads to cross-sectionally different intercepts in the regression (Brooks, 2008). In case of time-fixed effects, the intercept becomes time-varying and captures the independent variables “that vary over time, but are constant cross-sectionally” (Brooks, 2008: 493). However, the period fixed effects cannot be included if the panel data contains determinants that do not vary across the entities. The reason behind this is the fact that incorporating regressors that only vary over time constitutes perfect collinearity with the period-fixed effects dummies. Finally, Gujarati (2004) addresses the drawback of the LSDV model, which is the large loss of degrees of freedom associated with the inclusion of a number of dummy variables.

The random effects model or error component model (ECM) circumvents the problem of the large loss of degrees of freedom and can be seen as a more efficient panel data estimator (Kennedy, 2009). The main difference of the error component model relative to the fixed effects model is given by the fact that “the intercept represents the mean value of all the (cross-sectional) intercepts and the error component represents the (random) deviation of individual intercept from this mean value” (Gujarati, 2004: 648). Moreover, Wooldridge (2002) addresses the fact that the random effects model imposes more assumptions beyond the ones of classical ordinary least squares (OLS). In particular, if there is a correlation between the explanatory variable and the individual error component, then the random effects model gives biased coefficient estimates (Gujarati, 2004).

We exclude the independent variables that vary only over time, such as the risk-free rate, the term structure slope, market return, market volatility, and the swap spread. The third model contains variables that vary both cross-sectionally and over time, allowing further insights into the explanatory power of these determinants. This model incorporates Total Equity/Total Assets ratio as a measure of leverage. The exact model specification can be seen below.

Model 3:

$$CSPR_{i,t} = \alpha_0 + \alpha_1 CEA_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_4 DGRD_{i,t} + \alpha_5 UGRD_{i,t} + \alpha_6 CBA_{i,t} + \alpha_7 CEQL_{i,t} \quad \text{(III)}$$

where we denote $CSPR_{i,t}$ as the change in the CDS spread of bank i at time t; α_0 as the intercept; $CEA_{i,t}$ as the change in leverage proxied by Total Equity/Total Assets ratio; $CEQV_{i,t}$ as the change in equity volatility; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in the CDS bid-ask spread; $CEQL_{i,t}$ as the change in the equity bid-ask spread.

Similarly to Model 3, the determinants utilized in the fourth model vary in both dimensions. However, the current model contains bank stock returns as a proxy for leverage instead of Total Equity/Total Assets. The form of this model is presented below.

Model 4:

$$CSPR_{i,t} = \alpha_0 + \alpha_1 SRET_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_3 DGRD_{i,t} + \alpha_4 UGRD_{i,t} + \alpha_5 CBA_{i,t} + \alpha_6 CEQL_{i,t}, \quad \text{(IV)}$$

where we denote $CSPR_{i,t}$ as the change in CDS spread of bank i at time t; α_0 as the intercept; $SRET_{i,t}$ as the banks' stock returns; $CEQV_{i,t}$ as the change in equity volatility; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in bid-ask spread; $CEQL_{i,t}$ as the change in equity bid-ask spread.

We aim to assess the presence of heterogeneity in the time or cross-sectional dimensions or both. In the case when there is heterogeneity, it implies that the error terms follow a correlation pattern. In particular, cross-sectional heterogeneity might cause error terms to systematically deviate from zero within each cross-sectional unit, whereas the presence of time-specificity might result in the residuals' correlation across banks during particular time periods.

The starting point in the selection of the appropriate fixed effects specification is a Redundant Fixed Effects test. Results of this test show whether the fixed-effects dummy variables should be employed in the regressions. The table below provides the summary of the obtained test results.

Table 4. **Redundant Fixed Effects test results for Model 3**

Fixed Effects		***Pre-Crisis***	***Acute Crisis***	***Less Acute Crisis***	***Eurozone Crisis***	***All***
Cross-section fixed	Statistic F	0,07	0,75	2,70	0,07	0,22
	Df	(20, 635)	(27, 468)	(31, 813)	(321, 322)	(322, 834)
	Prob.	1,00	0,81	0,00	1,00	1,00
	Statistic Chi-sqr.	1,42	21,35	83,34	2,31	7,23
	Df	20	27	31	32	32
	Prob.	1,00	0,77	0,00	1,00	1,00
Period fixed	Statistic F	34,70	14,15	13,94	12,84	10,7
	Df	(36, 619)	(20, 475)	(31, 812)	(42, 1312)	(112, 2754)
	Prob.	0,00	0,00	0,00	0,00	0,00
	Statistic Chi-sqr.	731,24	234,13	372,20	468,64	1038,14
	Df	36	20	32	42	112
	Prob.	0,00	0,00	0,00	0,00	0,00
Fixed-Fixed	Statistic F	21,88	6,70	9,86	7,22	8,39
	Df	(56, 599)	(47, 448)	(63, 781)	(74, 1280)	(144, 2722)
	Prob.	0,00	0,00	0,00	0,00	0,00
	Statistic Chi-sqr.	737,35	266,79	497,26	474,7	1055,29
	Df	56	47	63	74	144
	Prob.	0,00	0,00	0,00	0,00	0,00

This table presents the results of the Redundant Fixed Effects – Likelihood Ratio Test run on Model 3 which incorporates accounting leverage. The three versions of the fixed effects are investigated, namely the entity-fixed effects model (cross-section fixed), the time-fixed effects model (period fixed), and the two-way error component model (fixed-fixed). For each version of the fixed effects model, the table reports two statistics (the F-statistic and the Chi-square statistic) together with the corresponding degrees of freedom (Df) and p-values (Prob.). The redundant test for fixed effects is conducted over the four sub-periods and also during the whole sample period. The statistical level of significance is assumed to be 5 %. The null hypothesis of the LSDV model states that the fixed effects dummies are jointly equal to zero. A p-value of the F-statistic or Chi-square statistic that is less than 0,05 suggests that the null hypothesis should be rejected and that the fixed effects model should be utilized.

It can be seen that there is no heterogeneity in the cross-sectional dimension in the regressions run over the pre-crisis, acute phase of the financial crisis, Eurozone crisis sub-period as well as throughout the whole sample period. Nonetheless, the obtained results posit that it is necessary to include cross-sectional fixed effects in the less acute crisis regression. With regard to the time-specificity, it can be concluded that there is heterogeneity in the period dimension and it is necessary to account for it in all the regressions. Fixed effects in both dimensions should be applied to the regression run over the less acute phase of the financial crisis as the three versions of the Redundant Fixed Effects test show the necessity to account for heterogeneity in both dimensions.

In the next step, in order to determine whether the random effects model can be employed, the Correlated Random Effects-Hausman test is used. As mentioned before, the random effects model is based on more assumptions than the classical OLS, therefore, this test helps to indicate the viability of employing the random effects model. Table 5 depicts the Correlated Random Effects-Hausman test results.

Table 5. **Correlated Random Effects-Hausman test results for Model 3**

Random Effects		***Pre-Crisis***	***Acute Crisis***	***Less Acute Crisis***	***Eurozone Crisis***	***All***
Period Random	Statistic Chi-sqr.	12,90	5,91	13,59	28,34	33,52
	Df	6	5	5	6	6
	Prob.	0,04	0,32	0,02	0,00	0,00
Cross-Section Random	Statistic Chi-sqr.	0,85	11,20	57,51	1,75	5,56
	Df	6	5	5	6	6
	Prob.	0,99	0,04	0,00	0,94	0,47

This table shows the outcome of the Correlated Random Effects-Hausman test run on Model 3 which incorporates Total Equity/Total Assets ratio as a proxy for leverage. The two alternatives of the random effects model are investigated, namely the time (period random) and cross-sectional dimension (cross-section random). The Chi-square statistic (Statistic Chi-sqr.), the degrees of freedom (Df) and the p-values (Prob.) are reported for each version of the test. The Correlated Random Effects-Hausman test for random effects is reported over all sub-periods as well as over the whole sample period. The assumed statistical level of significance is 5 %. If the p-value of the Chi-square statistic is less than 0,05, we reject the null hypothesis that the random effects model is well-specified. Due to the unbalanced panel of data a two-way random effects specification cannot be run.

The test results suggest that the period random effects model should be implemented in the acute phase of the financial crisis. Even though the Correlated Random Effects-Hausman test indicates that, except the regressions run over the two phases of the financial crisis, the cross-section random effects should be used in all other specifications, we do not employ them in the study. If the cross-sectional fixed effects dummy variables are insignificant, this already posits that there is lack of cross-sectional heterogeneity to be accounted for.

Overall, the conclusions with regard to the correct model specification can be drawn from both the Redundant Fixed Effects test and the Correlated Random Effects-Hausman test. The choice for the pre-crisis, the Eurozone crisis and whole sample period regressions is period-fixed effects, whereas for the regression run over the acute phase of the financial crisis is the period random effects model. The period random effects model is chosen instead of the period fixed effects model for the acute phase due to the fact that the former model, as mentioned before, is considered to be more efficient. As the presence of two-dimension heterogeneity is uncovered in the less acute crisis regression, the chosen specification for it is period and cross-sectional fixed effects (fixed-fixed).

Similarly, a Redundant Fixed Effects test is undertaken for Model 4, which differs from Model 3 by employing banks' stock returns as a proxy for leverage. The obtained results are presented in the following table.

Table 6. **Redundant Fixed Effects test results for Model 4**

Fixed Effects		***Pre-Crisis***	***Acute Crisis***	***Less Acute Crisis***	***Eurozone Crisis***	***All***
Cross-section fixed	Statistic F	0,07	0,58	2,59	0,07	0,19
	Df	(20, 635)	(27, 468)	(31, 813)	(32, 1337)	(32, 2849)
	Prob.	1,00	0,95	0,00	1,00	1,00
	Statistic Chi-sqr.	1,47	16,59	80,18	2,4	6,32
	Df	20	27	31	32	32
	Prob.	1,00	0,94	0,00	1,00	1,00
Period fixed	Statistic F	33,92	15,44	12,77	10,3	8,93
	Df	(36, 619)	(20, 475)	(31,812)	(42, 1327)	(122,2769)
	Prob.	0,00	0,00	0,00	0,00	0,00
	Statistic Chi-sqr.	721,21	250,96	346,44	388,38	890,63
	Df	36	20	32	42	122
	Prob.	0,00	0,00	0,00	0,00	0,00
Fixed-Fixed	Statistic F	21,37	6,92	8,99	5,8	7
	Df	(56, 599)	(47, 448)	(63, 781)	(74, 1295)	(144, 2737)
	Prob.	0,00	0,00	0,00	0,00	0,00
	Statistic Chi-sqr.	726,88	273,57	463,42	393,82	905,45
	Df	56	47	63	74	144
	Prob.	0,00	0,00	0,00	0,00	0,00

This table presents the results of the Redundant Fixed Effects – Likelihood Ratio test run on Model 4 that incorporates banks' stock returns. The three versions of fixed effects are investigated, namely the entity-fixed effects model (cross-section fixed), the time-fixed effects model (period fixed), and the two-way error component model (fixed-fixed). The statistical level of significance is assumed to be 5 %. The null hypothesis of the LSDV model states that the fixed effects dummies are jointly equal to zero. A p-value of the F-statistic or Chi-square statistic that is less than 0,05 suggests that the null hypothesis should be rejected and that the fixed effects model should be utilized.

The results in Table 6 show that there is no need to account for cross-sectional heterogeneity in almost all the sub-periods as well as the whole period in the current model. The notable exception is the regression run over the less acute phase of the financial crisis. As far as the period effects are concerned, the associated probabilities of the Redundant Fixed Effects test are equal to 0,00 indicating that the null hypothesis can be rejected and the period fixed effects model should be employed in all the sub-samples. Both cross-sectional and period fixed effects should be used in the regression run over the less acute phase of the financial crisis as there is a strong evidence of heterogeneity in the time as well as cross-sectional dimensions.

In addition to this, in order to determine whether the assumptions behind the random effects model are satisfied, the Correlated Random Effects-Hausman test is run. The outcomes of the test are shown in the table 7.

Table 7. **Correlated Random Effects-Hausman test results for Model 4**

Random Effects		***Pre-Crisis***	***Acute Crisis***	***Less Acute Crisis***	***Eurozone Crisis***	***All***
Period Random	Statistic Chi-sqr.	10,69	6,59	8,19	36,96	44,19
	Df	6	5	5	6	6
	Prob.	0,10	0,25	0,15	0,00	0,00
Cross-Section Random	Statistic Chi-sqr.	0,76	6,94	54,86	1,69	4,66
	Df	6	5	5	6	6
	Prob.	0,99	0,23	0,00	0,95	0,59

This table depicts the outcome of the Correlated Random Effects-Hausman test run on Model 4 which incorporates stock returns as a proxy for leverage. The two alternatives of the random effects model are investigated, namely the time (period random) and cross-sectional dimension (cross-section random). The Chi-square statistic (Statistic Chi-sqr.), the degrees of freedom (Df) and the p-values (Prob.) are reported for each version of the test. The Correlated Random Effects-Hausman test for random effects is reported over all sub-periods as well as over the whole sample period. The assumed statistical level of significance is 5 %. If the p-value of the Chi-square statistic is less than 0,05, we reject the null hypothesis that the random effects model is well-specified.

The probabilities of the Correlated Random Effects-Hausman test for the period dimension exceed 5 % in the regressions for pre-crisis and the two phases of the financial crisis, thus indicating that the period random effects model is well-specified and should be used in these sub-periods. For the cross-sectional dimension, the random effects model should be employed for all regressions with the exception of the less acute phase of the financial crisis. However, the two-ways random effects model cannot be run when the associated panel data is unbalanced.

To conclude, based on the obtained results, we choose the period-random effects specification when estimating the regressions for the pre-crisis and acute crisis. Both period and cross-section fixed effects are chosen to be applied to the regression for the less acute crisis as the Redundant Fixed Effects test proves the existence of heterogeneity in the two dimensions. Lastly, we select the period fixed effects for the Eurozone crisis and the whole sample period instead of the cross-section random effects. This is motivated by the fact that the Redundant Fixed Effects test shows no heterogeneity in the cross-sectional dimension, thus indicating that it is not necessary to account for it.

Finally, we report the results of the Breusch-Pagan-Godfrey test for heteroscedasticity in both models. This test is run for all possible fixed and random effects model specifications (not reported). The following table presents the outcomes of the tests for the models chosen according to the Redundant Fixed Effects or the Correlated Random Effects-Hausman tests.

Table 8. BPG test results for Models 3– 4

	Pre-Crisis	**Acute Crisis**	**Less Acute Crisis**	**Eurozone Crisis**	**All**
Model 3	***Period Fixed***	***Period Random***	***Fixed Fixed***	***Period Fixed***	***Period Fixed***
F-statistic	0,33	3,76	3,00	8,41	9,47
Prob.	0,92	0,00	0,01	0,00	0,00
Model 4	***Period Random***	***Period Random***	***Fixed Fixed***	***Period Fixed***	***Period Fixed***
F-statistic	0,87	20,99	12,56	8,16	9,20
Prob.	0,52	0,00	0,00	0,00	0,00

The table shows the F-statistics and associated p-values (Prob.) obtained in the BPG tests. The null hypothesis of this test posits that the errors are homoscedastic. The employed statistical significance level is 5 %. The heteroscedasticity test is run for the two pooled models in all the sub-periods as well as during the whole sample period. Model 3 utilizes accounting leverage, whereas Model 4 incorporates stock returns.

It can be seen that in the pre-crisis sub-sample both models appear to have homoscedastic errors. The remaining regressions have non-constant variance of the errors and are corrected using the appropriate White‘s robust standard errors.

4. Empirical Analysis

Our empirical analysis seeks to investigate the impact of not only credit risk, but a plethora of other important determinants such as liquidity components, market factors, and sector specific factors on the CDS spread changes. We conduct this analysis by examining the importance of the explanatory variables over the different periods and models.

First, we start with the two pooled models (Model 1 and Model 2), which differ with respect to the proxy for leverage. Each model contains regressions over the four sub-periods (pre-crisis, acute and less acute phase of the financial crisis, Eurozone crisis) as well throughout the whole period. The two models are compared relatively to each other.

In the next step, we examine the other two models (Model 3 and Model 4) that incorporate only components that vary both cross-sectionally and over time. Panel data estimators are employed in estimating these models. Similarly to the pooled regressions, these two models have different measures for leverage. We assess the relative differences of these models as compared with the pooled ones. This enables us to draw additional insights into the determinants of banks' CDS spread changes.

The regression outputs for the first model over the sub-samples as well as throughout the whole sample are summarized in the table below.

Table 9. **Regressions results for Model 1**

	Pre-Crisis	**Acute Crisis**	**Less Acute Crisis**	**Eurozone Crisis**	**All**
Coefficients					
C	0,07	1,24	2,48**	13,10***	5,04***
	(0,71)	(0,79)	(2,18)	(4,05)	(3,26)
Structural Model Variables					
Δ Equity/Total Assets	-0,26	7,57	-0,77	-50,94*	-30,70*
	(-0,81)	(0,76)	(-0,10)	(-1,83)	(-1,93)
Δ Equity Volatility	-0,19	-1,19	-3,57***	-1,47	-1,96
	(-1,03)	(-0,62)	(-4,76)	(-0,79)	(-1,37)
Δ Interest Rate Swap	-1,27***	5,51	1,00	99,83***	35,71***
	(-3,02)	(0,73)	(0,17)	(5,77)	(4,61)
Ratings					
Downgrade	-0,67**	19,87*	17,13***	-38,73**	-9,23
	(-2,27)	(1,65)	(2,69)	(-2,43)	(-0,83)
Upgrade	-1,07	NA	NA	-75,95***	-31,31**
	(-1,58)	NA	NA	(-5,47)	(-2,42)
Liquidity					
Δ CDS Bid-Ask Spread	-1,44**	-160,02***	-194,16***	-455,37***	-33,72***
	(-1,99)	(-4,21)	(-5,63)	(-2,90)	(-2,81)
Equity Liquidity					
Δ Equity Bid-Ask Spread	4,26**	450,73	332,16	-430,78	-218,35
	(2,05)	(1,30)	(1,27)	(-0,95)	(-0,94)
Market Factors					
Δ Term Structure Slope	6,15**	20,01	11,42	-17,67**	-25,60***
	(2,42)	(1,15)	(0,82)	(-2,22)	(-3,53)
Δ Market Return	-0,08***	-1,10***	-0,99***	-8,85***	-4,16***
	(-2,82)	(-3,94)	(-4,65)	(-10,58)	(-11,84)
Δ Market Volatility	-0,01	-0,11	-0,03	0,07	-0,03
	(-0,29)	(-0,71)	(-0,22)	(0,14)	(-0,11)
Δ Swap Spread	-44,67***	26,23***	23,62***	161,14***	30,82***
	(-5,98)	(4,61)	(4,32)	(4,12)	(3,30)
Adj. R-squared	0,12	0,15	0,21	0,18	0,09
Nobs.	662	501	850	1361	2873

The table presents the coefficient estimates using the pooled regression. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis), and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. In order to account for the credit ratings change, the linear transformation of the credit ratings into numerical equivalents: Aaa (20) to C (0), is also examined. Nonetheless, this transformation might lead to biased results as it treats upgrade and downgrade events as equally important. Therefore, the results of this alternative approach are not reported. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.

It can be observed that the Merton model derived variables have a lack of explanatory power in some of the sub-periods. This finding is in line with the study of Collin-Dufresne et al. (2001) that emphasizes the deficiency of structural models variables in explaining CDS spread changes. However, leverage proxied by Total Equity/Total Assets becomes significant at the 10 % level in the Eurozone crisis and also during the whole sample period. As expected, the Total Equity/Total Assets coefficient is negative. This follows due to the fact that diminishing equity, while holding assets constant, leads to a rise in the Debt/Total Assets ratio, which increases the probability of default and respectively the CDS spread. The other structural model variable is equity volatility that becomes significant at the 1 % level in less acute phase of the financial crisis. The coefficient estimate of this variable is in absolute terms largest in this sub-period as compared with the others. Interestingly, the large fluctuations in the volatility of the entity-specific stock returns during the less acute phase (Appendix C) caused this proxy to reflect better asset volatility. However, consistently with the study of Annaert et al. (2013), the corresponding coefficient does not carry the expected sign during the financial turmoil. Nevertheless, in their empirical research, Annaert et al. (2013) do not observe any influence of this variable. The riskless rate proxied by the interest rate swap becomes significant at the 1 % level in pre-crisis, Eurozone crisis and during the whole period. This indicates that during the financial crisis banks' credit spreads are driven by other factors than the riskless rate. Nonetheless, in the last two periods the coefficients are positive, implying that the increase in the risk-free rate causes a rise in the CDS spread. The research of Raunig and Scheicher (2009) also attest the inconsistency related to the sign of the risk- free rate in various periods.

Another variable that is associated with default risk is given by credit ratings. Both downgrades and upgrades effects on the CDS spread changes are tested. The coefficient estimates of the downgrade variable are statistically significant in all the sub-periods. This confirms the existence of a link between the probabilities of default and ratings which is also observed by Naifar and Abid (2005). On one hand, downgrades are significant in the acute and less acute phases, and exhibit the expected positive relationship with the CDS spread changes. On the other hand, downgrades do not have the predicted sign in the pre-crisis and Eurozone crisis periods, in which they are also significant. This implies that a downgrade induces a lower CDS spread change. However, the coefficient estimates of the downgrade variable are statistically significant in all the sub-periods, thus proving the findings of Hull et al. (2004) that the CDS spreads anticipate credit events, and this is more pronounced for downgrades. As far as upgrades are concerned, the coefficient estimates of upgrade variable in both phases of the financial crisis are not reported as none of the banks were upgraded during this interval. The upgrade variable has explanatory power during the Eurozone crisis and the whole sample period, respectively 1% and 10% significance levels. This result posits that the increase in the creditworthiness of the financial institutions becomes important and leads to a lower change of the credit spread in the Eurozone crisis. The reasoning behind this is that during this period, the debt markets face a loss of confidence (Calice et al., 2013) and the credit ratings upgrade may raise the confidence of the credit derivatives market participants.

The regressions results show that a number of explanatory variables beyond the Merton model and credit ratings are statistically significant, thus confirming the belief that an increase in the CDS spread is not entirely driven by changes in credit risk. In this respect, the liquidity component, given by the change in the CDS bid-ask spread, exhibits strong explanatory power in the whole period as well as throughout the sub-periods. Coro et al. (2013) also ascertain that the CDS spreads are affected by the CDS liquidity. The coefficients are significant at the 1 % level in almost all regressions. Moreover, the negative sign of the bid-ask spread coefficients suggest that an increase in the bid-ask spread, which indicates lower liquidity, generates a decrease in the CDS spread. This result is consistent with the study of Chen et al. (2007) who find a positive relationship between the CDS liquidity and the CDS spread. Another observation is the dramatic increase in the bid-ask spread coefficient after the start of the financial crisis. This reveals that 1 basis point increase in CDS bid-ask spread (decrease in liquidity) leads to 160,02 basis points decrease in CDS spread during the acute phase. This trend is even more persistent during the Eurozone crisis, where a 1 basis point rise in CDS bid-ask spread is associated with 455,37 basis points contraction in the CDS spread. This suggests that liquidity is non-trivial, especially in more stressed times, which is also consistent with the study of Beber et al. (2009).

Regarding equity liquidity, this determinant is statistically significant at the 5 % level only prior to the financial crisis. This result is consistent with the findings of Das and Hanouna (2009) which imply that an increase in the bid-ask spread, which indicates lower liquidity, causes a rise in the CDS spread in the pre-crisis period. Their study shows that growing illiquidity in the equity markets, which entails higher bid-ask spreads, causes hedging activities to be more expensive, and thus leads to an increase in CDS spreads.

However, we find no evidence of the relationship between CDS and equity market liquidity since the start of the financial crisis.

The results also show that the market wide factors are prominent determinants of the CDS spread changes, some of them being significant in all periods. The changes in the slope of the term structure, which proxy the changes in business cycle, are significant at the 5 % level during pre-crisis and the Eurozone crisis, and at the 1 % level during the whole period. As expected, this determinant has a negative impact on the last two periods taken into consideration. However, the discrepancy is observed with regard to the signs of the coefficient estimates, which become positive in the pre-crisis. Nonetheless, according to Avramov et al. (2007: 92), “the realized effect of changes in the term structure slope on credit-spread changes is an empirical question”.

Another explanatory variable is given by the market returns, which are highly significant at the 1% level in all regressions, and in line with the study of Ericsson et al. (2009), have a negative relationship with the CDS spread changes. This shows that the decrease in the CDS spread can also be triggered by improved general business conditions that respectively lower the probability of default.

With regard to the changes in market volatility, which are an indicator of the uncertainty in the business climate, this determinant does not influence the CDS spread changes. Finally, the swap spread changes, which represent a rise or reduction in the banking sector risk, are almost in each occasion significant at the 1% level and consistently with the study of Dullmann and Sosinska (2007) have a positive relationship with the CDS spread changes. This relationship suggests that higher banking sector risk leads to a higher CDS spread. The notable exception is the pre-crisis period, during which the change in the swap rate exhibits a negative relationship with the dependent variable. This implies that an increase in credit risk premium of banks is associated with a decrease in CDS spread. This irregularity can be presumably attributable to the demand and supply imbalances in the CDS market prior to the financial crisis as addressed by Blanco et al. (2005).

The studies of Ericsson et al. (2013) and Coro et al. (2013) show that the models on credit spread changes explain less than one third of the variation in the credit spread changes. This is consistent with the obtained results. Compared with the other sub-periods regressions, the one run over the pre-crisis period has the lowest fit. As measured by the adjusted R-squared, only 11% of the variation in the CDS spread changes is explained by the included independent variables prior to the financial crisis. This is indicative of the lower sensitivity of the CDS spreads during calm periods. However, the overall fit of the model improves in the subsequent intervals, especially during the less acute phase, in which the adjusted R-squared reaches 22 %.

Relatively to the first regressions, the second model is altered by incorporating banks' stock returns as a leverage proxy. The regressions results can be seen below.

Table 10. Regressions results for Model 2

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Coefficients					
C	0,07	0,08	2,00*	11,67***	3,95***
	(0,70)	(0,05)	(1,83)	(3,73)	(2,72)
Structural Model Variables					
Bank Stock Returns	-0,01	-0,54	-0,43***	-0,95***	-0,96***
	(-0,79)	(-1,45)	(-2,90)	(-3,82)	(-5,34)
Δ Equity Volatility	-0,20	-1,30	-3,12***	-1,18	-1,72
	(-1,13)	(-0,67)	(-3,63)	(-0,59)	(-1,12)
Δ Interest Rate Swap	-1,25***	5,73	-0,14	92,63***	35,03***
	(-2,99)	(0,77)	(-0,02)	(5,38)	(4,62)
Ratings					
Downgrade	-0,56*	15,36	15,84**	-39,04**	-11,86
	(-1,93)	(1,23)	(2,56)	(-2,50)	(-1,07)
Upgrade	-1,05	NA	NA	-75,73***	-28,34**
	(-1,56)	NA	NA	(-6,59)	(-2,17)
Liquidity					
Δ CDS Bid-Ask Spread	-1,42**	-165,66***	-193,82***	-431,06***	-31,41***
	(-1,97)	(-4,48)	(-5,86)	(-2,75)	(-2,69)
Equity liquidity					
Δ Equity Bid-Ask Spread	4,37**	507,67	273,99	-353,37	-182,69
	(2,07)	(1,50)	(1,13)	(-0,78)	(-0,80)
Market Factors					
Δ Term Structure Slope	6,02**	18,16	10,13	-19,44**	-24,23***
	(2,36)	(1,03)	(0,74)	(-2,40)	(-3,22)
Market Return	-0,06*	-0,40	-0,32	-7,53***	-2,80***
	(-1,85)	(-0,95)	(-1,32)	(-8,97)	(-7,51)
Δ Market Volatility	-0,01	-0,10	-0,05	0,30	0,05
	(-0,34)	(-0,61)	(-0,38)	(0,62)	(0,22)
ΔSwap Spread	-44,67***	30,66***	27,51***	130,03***	30,55***
	(-6,02)	(5,17)	(5,02)	(3,21)	(3,45)
Adj. R-squared	0,12	0,17	0,24	0,18	0,11
Nobs.	662	501	850	1361	2873

The table presents the coefficient estimates using the pooled regression. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis) and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.

In the current regression specification, the leverage proxy, namely banks' stock returns are highly significant in the less acute phase, the Eurozone crisis and the whole sample period, whereas in the first model, the changes in the Total Equity/Total Assets ratio are only significant in the Eurozone crisis and the whole sample period at a lower confidence level. These observations entail that the market proxy for leverage given by the entity-specific stock returns has more influence over the CDS spread changes. Contrary to Das et al. (2006), the accounting proxy for leverage does not perform better than the market measure. However, both proxies for leverage are not significant in the acute phase of the financial crisis. This contradicts the theory behind the structural credit risk models, which implies that "the default option is less out-of-the-money in the crisis period implying that changes in leverage should have a higher impact on default risk" (Annaert et al., 2013: 14).

Furthermore, banks' stock returns exhibit the expected negative relationship with the credit spread changes. This means that negative stock returns, which entail higher leverage, lead to an increase in the CDS spread.

With respect to the other Merton-derived variables, the two models display similar patterns. In the current model, the structural model variables are also insignificant in the acute phase of the crisis. Moreover, the two models are consistent regarding the significance of the changes in equity volatility and the interest rate swap.

Contrary to the results in Model 1, the downgrade explanatory variable becomes insignificant in the acute phase of the financial crisis. Another difference between the two models is that the market return changes lose their explanatory power during the two phases of the financial crisis. This is attributable to the exact regression specification and inclusion of banks' stock returns.

The other independent variables exhibit a similar significance, magnitude and sign with the previous model. Relatively to the results of the first regression specification, this model's overall fit, prior to crisis, is only 12 % as measured by the adjusted R-squared. In the subsequent sub-periods, the overall fit of the model continues to increase, with a peak of 24% in the less acute phase.

In the next step, we address the results obtained in the models that include regressors that vary in both the time and cross-sectional dimensions and employ fixed or random effects. We start with providing the summary of the regressions results for Model 3 over the considered four sub-periods and the whole period. The outcomes of the Model 3 can be seen in Table 11.

Table 11. **Regressions results for Model 3**

	Pre-Crisis	**Acute Crisis**	**Less Acute Crisis**	**Eurozone Crisis**	**All**
	Period fixed	***Period random***	***Fixed-Fixed***	***Period fixed***	***Period fixed***
Coefficients					
Structural Model Variables					
Δ Equity/Total Assets	0,09	9,24	10,11	-36,10	-19,87
	(0,50)	(1,51)	(1,47)	(-1,19)	(-1,09)
Δ Equity Volatility	-0,07	-1,29	-3,18***	-2,01**	-1,66***
	(-0,65)	(-0,99)	(-3,52)	(-2,05)	(-2,99)
Ratings					
Downgrade	-1,05	17,28	3,25	-57,32***	-34,31**
	(-0,82)	(1,50)	(0,53)	(-2,80)	(-2,30)
Upgrade	-0,61	NA	NA	-35,29**	-15,41**
	(-1,05)	NA	NA	(-2,36)	(-2,44)
Liquidity					
Δ CDS Bid-Ask Spread	-0,48	-84,09	-105,26***	-357,09*	-21,36*
	(-1,60)	(-1,62)	(-3,61)	(-1,69)	(-1,68)
Equity liquidity					
Δ Equity Bid-Ask Spread	1,40	290,32	140,47	-396,15	-162,04
	(0,77)	(0,78)	(0,59)	(-0,88)	(-0,69)
Adj. R-squared	0,66	0,03	0,48	0,30	0,29
Nobs.	662	501	850	1361	2888

The table presents the coefficient estimates using fixed or random effects panel data estimators. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis), and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.

We aim to analyse and address the main differences of Model 3 as compared with the pooled regressions of Model 1 as they employ the same proxy for leverage, namely Equity/Total Assets.

Some explanatory variables become statistically significant as compared to the pooled regression (I), when fixed or random effects are used. The reasoning behind this is that these effects may diminish the variance of the error terms, thus improving the accuracy of the coefficient estimates. The other situation is when an independent variable is statistically significant in the pooled regression, but loses its explanatory power when employing panel estimator approaches (fixed or random effects). This happens as the effects may better capture the part of CDS spread changes that are supposed to be explained by another variable in the pooled regression.

Contrary to the regression results obtained in the mentioned pooled regressions, in this model, the Total Equity/Total Assets proxy for leverage becomes insignificant during the Eurozone crisis as well as during the whole period. This occurs due to the fact that the period random effects may pick what is explained by the Total Equity/Total Assets ratio in the pooled Model 1. This shows that the change in accounting leverage has no influence on the CDS spread changes.

Moreover, during the Eurozone crisis as well as over the whole sample period, the changes in equity volatility are statistically significant, as compared to the corresponding pooled Model 1. The accuracy of the associated coefficient estimates may have improved due to the applied period random effects that have presumably reduced the variance of the error terms. This determinant negatively affects the CDS spread changes, thus contradicting the expectation that an increase in equity volatility will lead to a higher probability of default and, respectively to a rise in the CDS spread.

As far as ratings are concerned, one of the main findings is that the downgrade variable loses its explanatory power in the pre-crisis as well as the two phases of the financial crisis, whereas it is highly significant in Model 1. The opposite tendency is observed when analysing the whole period as this determinant becomes statistically significant at the 5 % level. The coefficient estimates of the upgrade variable exhibit the same signs and similar significance but the magnitude of the associated coefficients, during the Eurozone crisis, decreases relatively to the outcomes of the regressions (I).

Furthermore, the changes in the CDS bid-ask spread become insignificant in the pre-crisis and acute phase of financial crisis. This outcome suggests that the use of period fixed effects prior to crisis as well as period random effects during the acute phase may substitute this explanatory variable in these sub-periods. The mentioned effects presumably capture, to a greater extent, something common to what is explained by the CDS bid-ask spread changes in the pooled regressions. Furthermore, during the Eurozone crisis and the whole sample period, the liquidity proxy manifests a decrease in significance from the 1 % level in the pooled regressions to the 10 % level in the current model.

Lastly, although pooled Model 1 displays that the change in equity liquidity appears to be a statistically significant determinant of the CDS spread changes prior to the crisis, in the current model the change in equity liquidity entails no influence over the analysed dependent variable in all the sub-samples considered.

Next, we present the results for the fourth model which differs from the third one with respect to the leverage proxy. The regression outputs in all the intervals considered are shown in the table below.

Table 12. **Regressions results for Model 4**

	Pre-Crisis	**Acute Crisis**	**Less Acute Crisis**	**Eurozone Crisis**	**All**
	Period random	***Period random***	***Fixed-Fixed***	***Period fixed***	***Period fixed***
Coefficients					
Structural Model Variables					
Bank Stock Returns	-0,01	-0,71**	-0,38***	-0,55***	-0,52***
	(-0,85)	(-2,20)	(-3,06)	(-2,72)	(-4,21)
Δ Equity Volatility	-0,08	-1,59	-3,03***	-1,78**	-1,60***
	(-0,77)	(-1,00)	(-3,08)	(-1,99)	(-2,90)
Ratings					
Downgrade	-1,03	10,84	1,27	-56,64***	-35,14**
	(-0,81)	(1,04)	(0,83)	(-2,79)	(-2,41)
Upgrade	-0,63	NA	NA	-40,44***	-15,76**
	(-1,09)	NA	NA	(-4,66)	(-2,28)
Liquidity					
Δ CDS Bid-Ask Spread	-0,51*	-83,01	-107,53***	-347,11*	-20,58*
	(-1,70)	(-1,61)	(-3,77)	(-1,69)	(-1,66)
Equity Liquidity					
Δ Equity Bid-Ask Spread	1,60	334,87	96,59	-351,99	-146,93
	(0,88)	(1,00)	(0,49)	(-0,77)	(-0,63)
Adj. R-squared	0,00	0,09	0,50	0,30	0,29
Nobs.	662	501	850	1361	2888

The table presents the coefficient estimates using fixed or random effects panel data estimators. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis) and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.

Relatively to the pooled Model 2, which also incorporates a market proxy for leverage, the stock returns become statistically significant at the 5 % level in the acute phase of the financial crisis. The coefficient of this variable is negative, in line with the theoretical assumption that negative stock returns lead to a higher leverage, and thus increase the credit risk. Also, the other structural model variable, given by the change in equity volatility, turns out to be significant in the Eurozone crisis sub-period and during the full period. This is due to the use of period random effects that contribute to an increase in the accuracy of the coefficient estimates.

Ratings downgrades loss their explanatory power in the regression for pre-crisis and the less acute phase. However, they become statistically significant at the 5% level throughout the full period. This variable maintains the same puzzling results as in the pooled models as the coefficient sign is negative during the last two periods analysed. This indicates that a downgrade is associated with a decrease in the CDS spread. Results with regard to the upgrade variable are similar to the ones obtained in pooled Model 2.

Another difference is observed in the behavior of the CDS liquidity component that by comparison with Model 2 loses its significance in the acute phase. This happens as the period random effects may capture what is explained by the CDS bid-ask spread changes in the pooled models.

Lastly, the equity liquidity changes appear to be insignificant in all sub-periods and the whole sample period. This result differs from Model 2 which shows that this variable impacts the CDS spread changes in the pre-crisis.

5. Conclusions

In this study, we analyse the determinants of the credit default swaps changes of 34 European banks. Our study extends the related body of empirical works by taking into consideration the financial institutions that are insufficiently examined due to their specific features such as asset opacity and regulatory requirements, and by employing a rich set of explanatory variables beyond those used in previous studies. This paper further contributes to past research works by investigating the changes in CDS drivers during four sub-periods covering both calm and turbulent times (pre-crisis, acute phase and less acute phase of the financial crisis, and the most recent European sovereign debt crisis) as well as during the 10-year sample period between January 2004 and December 2013.

In order to assess the determinants of CDS in more detail, we include credit ratings upgrades and downgrades in addition to the theoretical determinants of default risk based on the Merton (1974) model (leverage, volatility and risk-free rate). We further extend our analysis by incorporating two liquidity components related to the CDS market and the equity market, as well as several variables that should capture sector specificity, market and general economic conditions. The obtained results ensue after employing several different model specifications: pooled models and models with fixed or random effects.

Our findings from the pooled models appear to highlight that the credit risk variables implied by the structural models cannot be perceived as prominent drivers of banks' CDS spreads. In particular, leverage, risk-free rate and equity volatility have no explanatory power in some of the sub-periods. Both proxies for leverage, namely balance sheet leverage and stock returns, manifest their explanatory power after the start of the financial crisis. This shows that in turbulent times, the default risk is more strongly influenced by the increase in leverage. Moreover, it is uncovered that the market proxy for leverage, namely banks' stock returns, is a more influential determinant of the CDS spread changes than the other measure of leverage represented by Equity/Total Assets. Furthermore, it is observed that the balance sheet proxy for leverage has no impact on the dependent variable in the models with fixed or random effects. This indicates that the employed effects can better capture the variation in the CDS spread changes that was previously explained by the accounting leverage.

Another finding is that the performance of ratings downgrades as an explanatory variable greatly fluctuates over the various periods, whereas the ratings upgrades show a steady pattern throughout all models and sub-periods considered. As such, downgrades exhibit explanatory power mainly during the less acute phase of the financial crisis and the European sovereign debt crisis in the pooled models, while the upgrades are always influential after the financial crisis as well as throughout the entire period. This dynamics emphasizes that credit ratings changes become important drivers of the CDS spread fluctuations in more turbulent times during which the market expresses a higher interest towards probabilities of default. The reason behind this is that credit ratings may contain relevant information for the probabilities of default.

In addition, the obtained results posit that the increase in banks' CDS spread is not entirely driven by credit risk. More specifically, the CDS liquidity is embedded in CDS spreads. In the pooled models, CDS liquidity appears to be a highly significant factor throughout all the sub-samples, whereas when using panel data estimators (fixed or random effects models), the CDS liquidity becomes an influential determinant mainly since the financial crisis. The opposite finding is obtained when taking into account equity liquidity. The pooled models suggest that banks' CDS spread changes are influenced by the fluctuations in equity liquidity only before the onset of the financial crisis. However, equity liquidity loses its statistical significance when fixed or random effects are introduced, thus proving that there is a lack of equity liquidity impact on the European banks' CDS.

Furthermore, the sector specific, market factors, and business climate proxies, prevail in explaining the CDS spread changes as compared to the variables inspired by the Merton (1974) model. In this respect, the changes in the swap spread manifest an influence on the changes in the CDS spread in all the analysed pooled models and over all the sub-periods included. This finding suggests that the banking sector intrinsic credit risk is a prominent source of influence. The market return and changes in the slope of the term structure also appear to be important drivers of the CDS premium changes. However, the market wide volatility changes do not seem to play any role in explaining the variation in the dependent variable regardless of the period and model specification, indicating that uncertainty about future economic prospects does not affect financial institutions' CDS.

All in all, our results provide strong evidence that banks' CDS spread changes are greatly affected by liquidity and market wide factors. Moreover, these factors are found to fluctuate over the different periods analysed. The overall findings have implications for the financial regulators who take into consideration the banks' CDS spreads when monitoring the banking industry’s stability. More specifically, banks’ supervisors should alter their decisions based on the different signals that are generated if the credit spread change is driven by either market, credit or liquidity risk. Furthermore, they should undertake a timely assessment of the banks’ CDS spreads in order to account for their variation over time.

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7. Appendix

A: Sample of the banks

Country	Banks
Austria	Erste Group Bank AG Raiffeisen Bank International AG
Belgium	KBC Group N.V.
Denmark	Danske Bank A/S
France	BNP Paribas S.A. Credit Agricole S.A. Natixis Societe Generale Group
Germany	Commerzbank AG
Greece	Alpha Bank A.E. Eurobank Ergasias S.A. National Bank of Greece S.A. Piraeus Bank Societe Anonyme
Ireland	The Governor and Company of the Bank of Ireland
Italy	Banca Monte dei Paschi S.p.A. Banca Popolare di Milano Scarl Banco Popolare Societa Cooperativa Scarl Intesa Sanpaolo S.p.A. UniCredit S.p.A Unione di Banche Italiane Scpa UniCredit S.p.A. Unione di Banche Italiane Scpa
Portugal	Banco BPI S.A. Banco Comercial Portugues S.A. Banco Espirito Santo S.A.
Spain	Bankinter S.A. Banco Bilbao Vizcaya Argentaria S.A. Banco de Sabadell S.A. Banco Popular Espanol S.A. Banco Santander S.A.
Sweden	Nordea Bank AB Skandinaviska Enskilda Banken AB Swedbank AB Svenska Handelsbanken AB
United Kingdom	HSBC Holdings PLC Standard Chartered PLC The Royal Bank Of Scotland PLC

B: Augumented-Dickey Fuller Unit Root Test

Banks	Ho: series has unit root	
	ADF test statistic	p-value
Alpha Bank A.E.	-0,58	0,46
Banca Monte dei Paschi di Siena S.p.A.	-0,84	0,35
Banca Popolare di Milano Scarl	-0,92	0,32
Banco Bilbao Vizcaya Argentaria S.A.	-0,72	0,40
Banco BPI S.A.	-0,57	0,47
Banco Comercial Português S.A.	-1,39	0,15
Banco de Sabadell S.A.	-1,06	0,26
Banco Espírito Santo S.A.	-0,81	0,37
Banco Popolare Societa Cooperativa Scarl	-0,86	0,34
Banco Popular Espanol S.A.	-0,91	0,32
Banco Santander, S.A.	-0,66	0,43
Bankinter S.A.	-0,93	0,31
BNP Paribas S.A.	-0,78	0,38
Commerzbank AG	-0,33	0,57
Credit Agricole S.A.	-1,58	0,49
Danske Bank A/S	-1,39	0,58
Erste Group Bank AG	-2,97	0,04
Eurobank Ergasias S.A.	-2,24	0,20
HSBC Holdings plc	-0,65	0,44
Intesa Sanpaolo S.p.A.	-1,48	0,54
KBC Group N.V.	-1,65	0,46
National Bank of Greece S.A.	-1,99	0,29
Natixis	-1,89	0,34
Nordea Bank AB	-1,94	0,31
Piraeus Bank Société Anonyme	-0,45	0,52
Raiffeisen Bank International AG	-0,76	0,38
Skandinaviska Enskilda Banken AB	-2,03	0,27
Societe Generale Group	-1,50	0,53
Swedbank AB	-2,00	0,29
Svenska Handelsbanken AB	-2,36	0,16
The Governor and Company of the Bank of Ireland	-1,69	0,43
The Royal Bank Of Scotland PLC	-1,63	0,46
UniCredit S.p.A.	-1,62	0,47
Unione di Banche Italiane Scpa	-1,74	0,41

The table shows the results of the univariate ADF test for stationarity. The associated ADF test statistics and p-values are presented. The chosen level of significance is 5 %. The null hypothesis is that the series contain a unit root. The null hypothesis is rejected if the p-value is less than 0,05. All the banks' CDS series, except the one for Erste Group Bank AG, are non-stationary.

C: Descriptive Statistics of Explanatory Variables

Descriptive statistics of changes in the CDS bid-ask spread:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,00	-0,01	-0,01	0,00	0,00
Max.	1,72	0,21	0,21	0,17	1,72
Min.	-1,77	-0,36	-0,36	-0,13	-1,77
Std. Dev.	0,16	0,05	0,05	0,02	0,09

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of CDS bid-ask spread changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in Total Equity/Total Assets ratio:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	-0,01	-0,01	0,02	0,00	0,00
Max.	1,51	1,24	1,24	3,01	3,01
Min.	-1,83	-0,75	-0,75	-1,88	-1,88
Std. Dev.	0,26	0,18	0,17	0,26	0,24

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of Total Equity/Total Assetschanges during the four sub-periods as well as the whole period.

Descriptive statistics of changes in equity bid-ask spread:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,00	0,00	0,00	0,00	0,00
Max.	0,36	0,06	0,06	0,40	0,40
Min.	-0,36	-0,07	-0,07	-0,31	-0,36
Std. Dev.	0,02	0,01	0,01	0,02	0,02

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the equity bid-ask spread changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in equity volatility:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	-0,05	0,38	0,39	-0,13	0,04
Max.	4,48	7,96	45,81	47,05	47,05
Min.	-6,22	-4,73	-5,55	-38,77	-38,77
Std. Dev.	0,61	1,08	2,03	2,78	2,06

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the equity volatility changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in the benchmark government bond yield:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,01	-0,02	-0,02	-0,02	-0,01
Max.	0,29	0,39	0,39	0,54	0,54
Min.	-0,19	-0,32	-0,32	-0,59	-0,59
Std. Dev.	0,14	0,17	0,16	0,26	0,20

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the benchmark government bond yield changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in the interest rate swap:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,03	-0,11	-0,08	-0,03	-0,02
Max.	0,35	0,81	0,81	0,47	0,81
Min.	-0,31	-0,56	-0,56	-0,55	-0,56
Std. Dev.	0,17	0,28	0,25	0,19	0,21

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the interest rate swap changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in market volatility:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	-0,03	1,17	0,08	-0,09	-0,02
Max.	10,72	32,14	32,14	22,17	32,14
Min.	-10,6	-33,84	-33,84	-17,5	-33,84
Std. Dev.	3,39	12,74	10,43	6,89	7,22

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of market volatility changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in the swap spread:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,00	0,05	0,01	0,00	0,00
Max.	0,03	1,15	1,15	0,37	1,15
Min.	-0,03	-0,34	-0,34	-0,21	-0,34
Std. Dev.	0,01	0,32	0,26	0,10	0,15

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the swap spread changes during the four sub-periods as well as the whole period.

Descriptive statistics of changes in the slope of the term structure:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	-0,02	0,05	0,04	0,00	0,01
Max.	0,06	0,35	0,35	1,91	1,91
Min.	-0,09	-0,17	-0,17	-1,29	-1,29
Std. Dev.	0,04	0,14	0,12	0,42	0,26

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the slope of term structure changes during the four sub-periods as well as the whole period.

Descriptive statistics of credit ratings downgrades:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,00	0,02	0,03	0,06	0,04
Max.	1,00	1,00	1,00	1,00	1,00
Min.	0,00	0,00	0,00	0,00	0,00
Std. Dev.	0,06	0,15	0,18	0,25	0,19

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the credit ratings downgrades during the four sub-periods as well as the whole period.

Descriptive statistics of credit rating upgrades:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	0,03	0,00	0,00	0,00	0,01
Max.	1,00	0,00	0,00	1,00	1,00
Min.	0,00	0,00	0,00	0,00	0,00
Std. Dev.	0,16	0,00	0,00	0,05	0,10

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the credit ratings upgrades during the four sub-periods as well as the whole period.

Descriptive statistics of the market return:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	1,38	-3,99	-1,19	0,65	0,39
Max.	5,88	3,68	14,49	10,46	14,49
Min.	-5,57	-12,35	-12,35	-9,29	-12,35
Std. Dev.	2,60	5,53	6,57	4,01	4,63

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the market return during the four sub-periods as well as the whole period.

Descriptive statistics of the banks' stock returns:

Statistic	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Mean	1,76	-6,83	-2,21	-0,48	-0,19
Max.	29,8	43,56	200,52	208,55	208,55
Min.	-20,27	-62,29	-70,31	-77,96	-77,96
Std. Dev.	5,39	12,24	16,79	16,87	14,10

The table shows the mean, maximum (max.) and minimum (min.) values as well as standard deviation (std. dev.) of the bank stock returns during the four sub-periods as well as the whole period.

D: Collinearity matrices

Correlation matrix for the pre-crisis period:

CORR.	CBA	CEA	CEQL	CEQV	CGLD	CIRS	CMVL	CSWP	CTSR	DGRD	MRET	SRET	UGRD
CBA	1,00	0,01	-0,02	-0,05	-0,02	-0,04	0,02	0,08	-0,07	-0,02	0,02	0,07	0,03
CEA	0,01	1,00	0,00	0,09	-0,02	-0,01	-0,04	0,04	-0,03	-0,04	-0,01	0,02	-0,02
CEQL	-0,02	0,00	1,00	0,03	0,07	0,05	0,04	-0,04	0,06	0,00	-0,02	0,03	0,01
CEQV	-0,05	0,09	0,03	1,00	0,21	0,20	0,05	-0,03	-0,03	0,00	0,10	0,04	-0,02
CGLD	-0,02	-0,02	0,07	0,21	1,00	0,86	0,01	0,07	0,14	0,06	0,16	0,09	-0,01
CIRS	-0,04	-0,01	0,05	0,20	0,86	1,00	0,01	0,12	-0,02	0,07	0,17	0,11	0,01
CMVL	0,02	-0,04	0,04	0,05	0,01	0,01	1,00	-0,12	0,35	-0,07	0,20	-0,02	-0,05
CSWP	0,08	0,04	-0,04	-0,03	0,07	0,12	-0,12	1,00	-0,19	-0,07	0,21	0,18	0,02
CTSR	-0,07	-0,03	0,06	-0,03	0,14	-0,02	0,35	-0,19	1,00	-0,03	0,08	-0,08	-0,01
DGRD	-0,02	-0,04	0,00	0,00	0,06	0,07	-0,07	-0,07	-0,03	1,00	-0,06	0,00	0,00
MRET	0,02	-0,01	-0,02	0,10	0,16	0,17	0,20	0,21	0,08	-0,06	1,00	0,51	-0,02
SRET	0,07	0,02	0,03	0,04	0,09	0,11	-0,02	0,18	-0,08	0,00	0,51	1,00	0,00
UGRD	0,03	-0,02	0,01	-0,02	-0,01	0,01	-0,05	0,02	-0,01	0,00	-0,02	0,00	1,00

CBA is the monthly change in the CDS bid-ask spread (in basis points). CDS bid-ask spread is calculated as the bid-ask quotes difference divided by the bid-ask midpoint. CEA is the monthly change in Total Equity/Total Assets ratio (percentage points). CEQL is the monthly change in equity liquidity proxied by the equity bid-ask spread. Equity bid-ask is computed as the bid-ask difference divided by the bid-ask midpoint. CEQV is the change in equity volatility, which is based on the monthly change in the historical standard deviation calculated based on a 12-month rolling window of the monthly stock returns of the corresponding entity (percentage points). CGLD is the monthly change in the 10-year benchmark government bond yield (percentage points). CIRS is the monthly change in the 5-year interest rate swap. CMVL is the monthly change in market volatility, where the VSTOXX index is used as a proxy for market volatility. CSWP is the monthly change in the LIBOR-OIS swap spread (percentage points). CTSR is the monthly change in the term structure slope (percentage points). DGRD is the credit rating downgrade. MRET is the market return, calculated as the return on the STOXX Europe 600 index. SRET is the monthly stock returns of the underlying bank. UGRD is the credit rating upgrade.

Correlation matrix for the acute phase of the financial crisis:

CORR.	CBA	CEA	CEQL	CEQV	CGLD	CIRS	CMVL	CSWP	CTSR	DGRD	MRET	SRET
CBA	1,00	-0,07	-0,06	-0,01	0,05	-0,07	0,23	0,19	0,18	-0,02	-0,02	-0,01
CEA	-0,07	1,00	0,01	0,03	0	-0,03	-0,02	0,03	0,02	-0,08	0,01	-0,01
CEQL	-0,06	0,01	1,00	0,09	-0,1	-0,02	-0,13	0,02	-0,11	0,01	-0,04	0,07
CEQV	-0,01	0,03	0,09	1,00	-0,25	-0,2	-0,2	-0,13	-0,08	-0,01	-0,08	-0,08
CGLD	0,05	0,00	-0,1	-0,25	1,00	0,73	0,13	0,06	-0,09	0,05	0,38	0,18
CIRS	-0,07	-0,03	-0,02	-0,2	0,73	1,00	0,11	0,14	-0,49	0,02	0,31	0,24
CMVL	0,23	-0,02	-0,13	-0,2	0,13	0,11	1,00	0,45	0,62	0,07	0,12	0,15
CSWP	0,19	0,03	0,02	-0,13	0,06	0,14	0,45	1,00	0,10	0,01	-0,09	0,16
CTSR	0,18	0,02	-0,11	-0,08	-0,09	-0,49	0,62	0,10	1,00	0,10	-0,04	-0,05
DGRD	-0,02	-0,08	0,01	-0,01	0,05	0,02	0,07	0,01	0,10	1,00	-0,05	-0,12
MRET	-0,02	0,01	-0,04	-0,08	0,38	0,31	0,12	-0,09	-0,04	-0,05	1,00	0,59
SRET	-0,01	-0,01	0,07	-0,08	0,18	0,24	0,15	0,16	-0,05	-0,12	0,59	1,00

Correlation matrix for the less acute phase of the financial crisis:

CORR.	CBA	CEA	CEQL	CEQV	CGLD	CIRS	CMVL	CSWP	CTSR	DGRD	MRET	SRET
CBA	1,00	-0,04	-0,02	0,01	0,05	0,01	0,20	0,14	0,12	0,00	0,06	0,05
CEA	-0,04	1,00	-0,01	0,09	0,00	0,07	-0,06	-0,06	-0,05	-0,04	0,23	0,17
CEQL	-0,02	-0,01	1,00	0,02	-0,05	-0,04	-0,07	0,03	-0,06	0,04	-0,08	-0,08
CEQV	0,01	0,09	0,02	1,00	-0,05	-0,03	-0,09	-0,10	-0,03	0,01	0,01	0,13
CGLD	0,05	0,00	-0,05	-0,05	1,00	0,64	0,16	0,02	0,05	0,01	0,27	0,09
CIRS	0,01	0,07	-0,04	-0,03	0,64	1,00	0,11	0,01	-0,45	0,00	0,45	0,23
CMVL	0,20	-0,06	-0,07	-0,09	0,16	0,11	1,00	0,44	0,58	0,01	0,02	0,01
CSWP	0,14	-0,06	0,03	-0,10	0,02	0,01	0,44	1,00	0,16	0,00	-0,25	-0,05
CTSR	0,12	-0,05	-0,06	-0,03	0,05	-0,45	0,58	0,16	1,00	0,07	-0,20	-0,12
DGRD	0,00	-0,04	0,04	0,01	0,01	0,00	0,01	0,00	0,07	1,00	-0,01	-0,04
MRET	0,06	0,23	-0,08	0,01	0,27	0,45	0,02	-0,25	-0,20	-0,01	1,00	0,56
SRET	0,05	0,17	-0,08	0,13	0,09	0,23	0,01	-0,05	-0,12	-0,04	0,56	1,00

Correlation matrix for the Eurozone crisis period:

CORR.	CBA	CEA	CEQL	CEQV	CGLD	CIRS	CMVL	CSWP	CTSR	DGRD	MRET	SRET	UGRD
CBA	1,00	0,01	0,00	-0,02	0,03	-0,03	0,10	0,05	0,03	-0,02	0,13	0,08	0,04
CEA	0,01	1,00	0,00	-0,08	0,01	0,07	0,01	-0,11	0,13	-0,07	0,12	0,12	0,02
CEQL	0,00	0,00	1,00	-0,24	0,02	-0,03	0,05	0,06	-0,09	-0,03	0,05	0,09	0,02
CEQV	-0,02	-0,08	-0,24	1,00	-0,08	0,03	-0,05	-0,11	0,18	0,00	0,09	0,01	0,04
CGLD	0,03	0,01	0,02	-0,08	1,00	0,65	-0,10	0,05	-0,07	-0,01	0,05	-0,03	0,03
CIRS	-0,03	0,07	-0,03	0,03	0,65	1,00	-0,36	-0,43	0,10	0,01	0,17	0,08	0,03
CMVL	0,10	0,01	0,05	-0,05	-0,10	-0,36	1,00	0,33	0,01	-0,10	-0,02	0,07	0,01
CSWP	0,05	-0,11	0,06	-0,11	0,05	-0,43	0,33	1,00	-0,31	0,01	-0,25	-0,28	0,00
CTSR	0,03	0,13	-0,09	0,18	-0,07	0,10	0,01	-0,31	1,00	-0,07	0,04	0,13	0,00
DGRD	-0,02	-0,07	-0,03	0,00	-0,01	0,01	-0,10	0,01	-0,07	1,00	-0,23	-0,15	-0,01
MRET	0,13	0,12	0,05	0,09	0,05	0,17	-0,02	-0,25	0,04	-0,23	1,00	0,45	0,00
SRET	0,08	0,12	0,09	0,01	-0,03	0,08	0,07	-0,28	0,13	-0,15	0,45	1,00	0,02
UGRD	0,04	0,02	0,02	0,04	0,03	0,03	0,01	0,00	0,00	-0,01	0,00	0,02	1,00

E: Pooled model with accounting leverage and the government bond yield

$$CSPR_{i,t} = \alpha_0 + \alpha_1 CEA_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_3 CGLD_{i,t} + \alpha_4 DGRD_{i,t} + \alpha_5 UGRD_{i,t} + \alpha_6 CBA_{i,t} + \alpha_7 CEQL_{i,t} + \alpha_8 CTSR_{i,t} + \alpha_9 MRET_{i,t} + \alpha_{10} CMVOL_{i,t} + \alpha_{11} CSWP_{i,t},$$

where we denote $CSPR_{i,t}$ as the change in CDS spread of bank *i* at time *t*; α_0 as the intercept; $CEA_{i,t}$ as the change in Total Equity/Total Assets ratio; $CEQV_{i,t}$ as the change in equity volatility; $CGLD_{i,t}$ as the change in the benchmark government bond yield; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in CDS bid-ask spread; $CEQL_{i,t}$ as the change in equity bid-ask spread; $CTSR_{i,t}$ as the change in the term structure slope; $MRET_{i,t}$ as the market return; $CMVOL_{i,t}$ as the change in market volatility; $CSWP_{i,t}$ as the change in the swap spread.

Table E1. BPG test results

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
F-statistic	1,73	3,33	1,76	5,73	5,34
Prob.	0,06	0,00	0,06	0,00	0,00

The table shows the F-statistics and associated p-values (prob.) obtained in the BPG tests. The null hypothesis of this test posits that the errors are homoscedastic. The employed statistical significance level is 5 %. The heteroscedasticity test is run for the pooled models in all the sub-periods as well as during the whole sample period. Homoscedastic errors can be observed in the pre-crisis as well as the less acute phase of the financial crisis. In the other periods errors are heteroscedastic and are corrected using White's robust standard errors.

Table E2. Regression results

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Coefficients					
C	0,06	0,79	2,58**	10,23***	3,97***
	(0,56)	(0,49)	(2,13)	(3,18)	(2,65)
Structural Model Variables					
Δ Equity/Total Assets	-0,25	7,50	-0,31	-49,12*	-30,24*
	(-0,85)	(0,75)	(-0,04)	(-1,78)	(-1,90)
Δ Equity Volatility	-0,23	-0,94	-3,55***	-1,48	-1,91
	(-1,50)	(-0,50)	(-7,29)	(-0,76)	(-1,32)
Δ Government bond yield	-0,76	13,07*	7,91	15,21	14,22*
	(-1.26)	(1,80)	(1,13)	(1,57)	(1,86)
Ratings					
Downgrade	-0,95	19,21	17,11***	-38,61**	-8,44
	(-0.47)	(1,60)	(3,06)	(-2,37)	(-0,75)
Upgrade	-1,11	NA	NA	-65,85***	-29,38**
	(-1,22)	NA	NA	(-4,70)	(-2,25)
Liquidity					
Δ CDS Bid-Ask Spread	-1,39***	-164,35***	-194,33***	-464,76***	-35,68***
	(-2.99)	(-4.22)	(-8.30)	(-2,97)	(-2,89)
Equity Liquidity					
Δ Equity Bid-Ask Spread	4,10	466,57	335,05*	-430,12	-221,32
	(1,44)	(1,33)	(1,85)	(-0,93)	(-0,94)
Market Factors					
Δ Term Structure Slope	6,59***	13,51	9,64	-17,76**	-25,46***
	(2,71)	(1,42)	(0,83)	(-2,22)	(-3,47)
Δ Market Return	-0,08***	-1,19***	-1,03***	-8,56***	-3,75***
	(-2.60)	(-3,86)	(-5,56)	(-10,17)	(-11,01)
Δ Market Volatility	-0,01	-0,06	-0,03	-0,53	-0,10
	(-0,33)	(-0,54)	(-0,23)	(-1,06)	(-0,40)
Δ Swap Spread	-46,11***	25,96***	23,45***	96,92**	29,45***
	(-5,91)	(4,65)	(4,78)	(2,51)	(3,20)
Adj. R-squared	0,11	0,15	0,22	0,16	0,09
Nobs.	662	501	850	1361	2873

The table presents the coefficient estimates using the pooled regressions. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis), and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.

F: Pooled model with banks' stock returns and the government bond yield

$$CSPR_{i,t} = \alpha_0 + \alpha_1 SRET_{i,t} + \alpha_2 CEQV_{i,t} + \alpha_3 CGLD_{i,t} + \alpha_4 DGRD_{i,t} + \alpha_5 UGRD_{i,t} + \alpha_6 CBA_{i,t} + \alpha_7 CEQL_{i,t} + \alpha_8 CTSR_{i,t} + \alpha_9 MRET_{i,t} + \alpha_{10} CMVOL_{i,t} + \alpha_{11} CSWP_{i,t}, \quad (2)$$

where we denote $CSPR_{i,t}$ as the change in CDS spread of bank *i* at time *t*; α_0 as the intercept; $SRET_{i,t}$ as the banks' stock returns; $CEQV_{i,t}$ as the change in equity volatility; $CGLD_{i,t}$ as the change in the benchmark government bond yield; $DGRD_{i,t}$ as the credit rating downgrade; $UGRD_{i,t}$ as the credit rating upgrade; $CBA_{i,t}$ as the change in CDS bid-ask spread; $CEQL_{i,t}$ as the change in equity bid-ask spread; $CTSR_{i,t}$ as the change in the term structure slope; $MRET_{i,t}$ as the market return; $CMVOL_{i,t}$ as the change in market volatility; $CSWP_{i,t}$ as the change in swap spread.

Table F1. BPG test results

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
F-statistic	1,70	12,47	4,68	5,83	5,62
Prob.	0,07	0,00	0,00	0,00	0,00

The table shows the F-statistics and associated p-values (prob.) obtained in the BPG tests. The null hypothesis of this test posits that the errors are homoscedastic. The employed statistical significance level is 5 %. The heteroscedasticity test is run for the pooled models in all the sub-periods as well as during the whole sample period. Homoscedastic errors can be observed in the pre-crisis period. In the other periods errors are heteroscedastic and are corrected using White's robust standard errors.

Table F2. Regressions results

	Pre-Crisis	Acute Crisis	Less Acute Crisis	Eurozone Crisis	All
Coefficients					
C	0,06	-0,20	2,08*	8,92***	2,86**
	(0,54)	(-0,12)	(1,89)	(2,86)	(2,02)
Structural Model Variables					
Bank Stock Returns	-0,01	-0,52	-0,42***	-0,99***	-0,96***
	(-0,79)	(-1,41)	(-2,88)	(-3,98)	(-5,24)
Δ Equity Volatility	-0,24	-1,15	-3,11***	-1,20	-1,69
	(-1,61)	(-0,60)	(-3,59)	(-0,57)	(-1,09)
Δ Government bond yield	-0,73	10,09	5,13	13,41	11,47
	(-1,22)	(1,35)	(0,81)	(1,37)	(1,49)
Ratings					
Downgrade	-0,84	15,21	15,79**	-38,89**	-11,02
	(-0,41)	(1,20)	(2,54)	(-2,44)	(-0,99)
Upgrade	-1,09	NA	NA	-65,80***	-26,31**
	(-1,20)	NA	NA	(-5,69)	(-2,01)
Liquidity					
Δ CDS Bid-Ask Spread	-1,37***	-169,21***	-193,81***	-439,96***	-33,38***
	(-2,95)	(-4,45)	(-5,86)	(-2,82)	(-2,78)
Equity Liquidity					
Δ Equity Bid-Ask Spread	4,22	516,14	277,27	-349,89	-185,52
	(1,48)	(1,52)	(1,14)	(-0,75)	(-0,80)
Market Factors					
Δ Term Structure Slope	6,44***	10,60	10,15	-19,39**	-24,15***
	(2,64)	(1,03)	(1,06)	(-2,38)	(-3,17)
Δ Market Return	-0,07*	-0,47	-0,37	-7,18***	-2,39***
	(-1,83)	(-1,11)	(-1,52)	(-8,46)	(-6,43)
Δ Market Volatility	-0,01	-0,04	-0,06	-0,23	-0,02
	(-0,38)	(-0,35)	(-0,59)	(-0,46)	(-0,08)
Δ Swap Spread	-46,08***	30,28***	27,39***	68,48*	29,37***
	(-5,90)	(5,11)	(5,02)	(1,75)	(3,34)
Adj. R-squared	0,11	0,17	0,24	0,16	0,10
Nobs.	662	501	850	1361	2873

The table presents the coefficient estimates using the pooled regression. Associated t-statistics are reported in brackets. The 1 % significance level is denoted by ***, the 5 % significance level by ** and respectively the 10 % significance level by *. The sample periods are January 2004 to June 2007 (pre-crisis), July 2007 to March 2009 (acute crisis), July 2007 to March 2010 (less acute crisis), April 2010 to December 2013 (Eurozone crisis), and January 2004 to December 2013 (All). The upgrade variable is not included in the regressions for acute and less acute phases as there were no upgrades during these sub-periods. Number of observations is denoted by Nobs and it differs in each sub-period as the panel data is unbalanced.