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UNIVERSITÉ DE **STRASBOURG**

MASTER THESIS

Pricing of bonds and credit default swaps:
Evidence from a panel of European companies

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Academic Year: **2015/2016**

Declaration of Authorship

I hereby declare that I compiled this thesis independently, using only the listed resources and literature.

I also declare that this thesis was not used for obtaining another degree.

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Prague, May 12, 2016

Eva Smotlachová

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Bibliography record

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Abstract

The aim of the thesis is to investigate determinants of corporate bond and CDS contract pricing using a sample of 34 European companies over the period 2008-2014. This work extends existing literature by studying differences in determinants of bond and CDS spreads not only for different time periods, but also for different sets of companies grouped by geography, industry, and profitability. The results reveal that bond and CDS spreads are generally influenced by similar factors, with a company's credit rating being the most influential factor. Nevertheless, the investigation of time-specific estimations suggests that firm-specific factors play a more significant role in pricing bonds, whereas market factors have a higher impact on CDS spreads. The analysis of the subsamples reveals substantial differences in regression results for individual groups of companies, which suggests a presence of idiosyncratic factors. Our conclusion is that the pricing of bonds and CDS contracts is not only time-dependent, but also unique for different groups of companies, which implies a necessity to use different pricing models for individual contracts.

JEL Classification	C23, C52, G01, G15
Keywords	Bonds, Credit Default Swaps, Europe, Panel Regression, Subsampling

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Abstrakt

Cílem této práce je prozkoumat determinanty oceňování korporátních dluhopisů a kontraktů CDS na vzorku 34 evropských společností za období 2008-2014. Tato práce přispívá k rozšíření existujícího výzkumu tím, že odhaluje rozdíly determinantů dluhopisů a CDS nejen pro různá časová období, ale také pro různé skupiny firem, rozdělených podle zeměpisné polohy, průmyslového sektoru, a ziskovosti. Výsledky ukazují, že oceňování dluhopisů a CDS je ovlivněno podobnými faktory s tím, že rating se ukazuje jako nejdůležitější faktor. Nicméně, odhadování parametrů oceňování pro různá časová období naznačuje, že faktory specifické pro jednotlivé společnosti hrají významnější roli pro oceňování korporátních dluhopisů, kdežto tržní faktory více ovlivňují kontrakty CDS. Odhadování dle podskupin společností odhaluje značné rozdíly ve výsledcích regresí pro jednotlivé skupiny společností, což značí přítomnost idiosynkratických faktorů. Ze závěrů našeho výzkumu vyplývá, že oceňování dluhopisů a kontraktů CDS je nejen závislé na daném časovém období, ale také se liší pro různé skupiny společností, z čehož vyplývá nutnost využívání různých modelů oceňování pro jednotlivé finanční instrumenty.

Klíčová slova	Dluhopisy, Swapy úvěrového selhání (CDS), Evropa, Panelová regrese, Podskupiny

Rozsah práce: 71 stran, 129 227 znaků

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LIST OF ACRONYMS

CDS Credit Default Swap

CR Current Ratio

CHF Swiss Franc

DR Debt Ratio

EUR Euro

FE Fixed effects

GLS Generalized least squares

NOK Norwegian Krona

OLS Ordinary least squares

OM Operating Margin

SEK Swedish Krona

TMT Technology, Media & Telecommunications

MASTER THESIS PROPOSAL

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Proposed Topic:

Relationship between credit default swap and bond spreads

Motivation:

The CDS market, as well as its link to bond market, has recently been in the center of attention by researchers, especially in connection with the recent European sovereign debt crisis. For instance, Fontana & Scheicher (2010) studied the relative pricing of euro area sovereign CDS (CDS of euro area banks) and the underlying government bonds over the period 2006-2010. Carboni (2011) examines the relation of the CDS and bonds market over the crisis period, focusing on the price discovery process. Blanco et al. (2005) studies determinants of CDS and credit spreads, employing macroeconomic and firm-specific variables in their models. Longstaff et al. (2011) analyses the nature of sovereign credit risk using CDS data for a set of developed and less developed countries. Finally, Man et al. (2014) investigated the role of non-default factors on the CDS basis.

The previous literature focused mainly on the pre-crisis and crisis period and on estimating the CDS basis, i.e. the difference between CDS and bond spreads. I would like to contribute to the previous research by concentrating on the most recent period to examine how the bond and CDS markets are influenced by economic occurrences of recent years, such as the Greek or Euro Zone crisis.

I would first compare the determinants of CDS spreads and bond spreads in the European market and study their differences. Subsequently, I will investigate the no-arbitrage condition, which arises from the theoretical CDS-bond spreads pricing relationship. The analysis will consist of a determination of factors that drive pricing differences between the two markets.

In addition, I will examine the extent to which the pricing differs for different groups of companies. These groups will be created based on various criteria, such as financial indicators, geographic location or type of industry.

Finally, I would like to compare post-crisis development of the two markets relative to crisis and pre-crisis period, elaborating on results from previous research.

Hypotheses:

1. Hypothesis #1: CDS and bond markets are driven by similar factors.
2. Hypothesis #2: The no-arbitrage condition diverges from zero in the post-crisis period.
3. Hypothesis #3: Determinants of the CDS spreads differ across industries.
4. Hypothesis #4: A company's financial performance plays a key role in the CDS/bond pricing.

Methodology:

To study the determinants of the CDS and bond spreads I will run panel regressions using daily data obtained from Bloomberg database over the period 2008 – 2014 for selected European companies. I will run one panel regression with CDS spreads as a dependent variable and a second one with the bond spreads as a dependent variable. With this approach, I will be able to compare the determinants of the two markets, i.e. which factors are essential for which market and what the level of their influence is on development of the two dependent variables. Then, I will create homogenous groups of companies based on several criteria, which will include geographic location, type of industry and financial performance. Consequently, I will run the same panel regressions for each of the subsamples and study their different behaviors.

Expected Contribution:

I will propose a comparative analysis of determinants of CDS spreads and the underlying bond spreads, focusing on the recent period, which has rarely been at the centre of researchers' attention. The contribution of my work, with respect to the works considering the same topic (such as Carboni (2011) or Fontana & Scheicher (2010)), will consist in comparing the determinants for different groups of companies based on various specifications. These specifications include financial performance of a company, geographic location and type of industry. Another contribution of the work represents the thorough study of the CDS basis in the post-crisis period, which would deliver important information for currently operating agents. The composition of factors driving the basis deviation from zero may contribute to the debate about the functioning of sovereign credit markets and their reactions to current economic developments. The estimated relationship between CDS and bond prices with respect to specific group of companies may advise researchers on setting a CDS price (accounting for the company's specifications) or testing for the appropriateness of the stated price.

Outline:

Core Bibliography:

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Author

Supervisor

1 INTRODUCTION

The European corporate bond and credit default swap (CDS) markets have received significant attention from market analysts in recent years. Corporate bond issuances have substantially increased since the global financial crisis in 2007. Due to economic uncertainties, corporate bonds became an alternative to squeezed bank lending and government bonds that offered very low yields. CDS contracts are the most widely traded credit derivative, serving as a form of insurance for a creditor against a debtor's failure to fulfil its payment obligations. Due to its unregulated nature and an enormous expansion through 2007, many analysts estimate that the CDS market was a primary cause of the financial crisis (Mirochnik (2010), Stulz (2009)). Nevertheless, CDS contracts constitute a powerful tool in risk management, and a well-functioning CDS market can play a significant role in economic growth.

A considerable number of works have focused on estimating the factors that determine the pricing of bonds and CDS contracts, with the aim to evaluate credit risk. Early researchers considered bond spreads as a proxy for credit risk. Merton (1974) initiated the modern analysis of corporate debt and suggested a theory for pricing bonds. Gradually, the attention of researchers moved towards CDS contracts, replacing bonds as a measure of credit risk. Aunon-Nerin et al. (2002) was one of the first works that evaluated CDS spreads and studied the impact of theoretical determinants of credit risk on pricing CDS contracts. Moreover, a number of related studies have evaluated the link between the bond and CDS markets. One of the most cited papers in the area of bond-CDS relationship is Blanco et al. (2005) that studied the relative pricing of corporate bonds and CDSs and compared the influence of firm-specific and macroeconomic factors.

This thesis expands on the existing literature, focusing on estimating determinants of pricing corporate bond and CDS contracts. We run separate regressions for bond and CDS spreads including firm-specific and market variables in order to reveal potential differences in pricing the two financial instruments. Our data covers information on 34

European companies over the period 2008-2014. To control for the presence of strong autocorrelation in the dataset, which would bias the results, we employ the Prais-Winsten estimator with panel specific errors.

Our work further contributes to the existing literature by employing recent data, which allows for evaluation of the most recent economic events in European Union. Unlike several authors that compared pricing of the financial instruments before and during the crisis, we compare the crisis and post-crisis periods. A key contribution of this work lies in comparing the determinants of bond and CDS spreads for different groups of companies. We split the sample companies into groups based on three criteria – geographical location, industry sector, and financial position.

To understand the role of bonds and CDSs in the economy, Chapter 2 provides a description of recent economic events in Europe and also describes the development of the bond and CDS markets. Chapter 3 provides an overview of the previous works focusing on estimating bonds and CDS contracts. Chapter 4 describes the dataset and characteristics of variables included in the model. In Chapter 5 we describe the methodology, where we first analyze the data with the help of explicit graphs and figures. We then test for fulfilment of standard conditions, and finally, we specify the estimation equations and determine the suitable estimator for our model. Chapter 6 is divided into three sections in order to present the acquired results in a coherent way. The first section summarizes the estimated results from the overall models; the second section describes the predicted differences of coefficients for different time periods; and the last section shows the importance of pricing bonds and CDSs for individual groups of companies, as the acquired results reveal substantial differences. Finally, Chapter 7 provides a summary of our findings and conclusions and suggests potential extensions of the research.

2 ECONOMIC BACKGROUND

This work studies the behavior of financial derivative instruments in Europe over the period 2008-2014. The motivation for the study lies in the increasing importance of financial derivatives in the global economy. The performance of the financial derivatives market plays a significant role in overall economic development as it may substantially contribute to recovery after a period of economic distress.

The first chapter presents a review of economic developments in the overall European market and the development of the financial derivatives markets to assess the influence of financial derivatives on economic growth. The chapter is structured as follows: we first review recent overall economic developments in Europe; we then introduce the bond and credit default swap (CDS) markets and describe their recent developments.

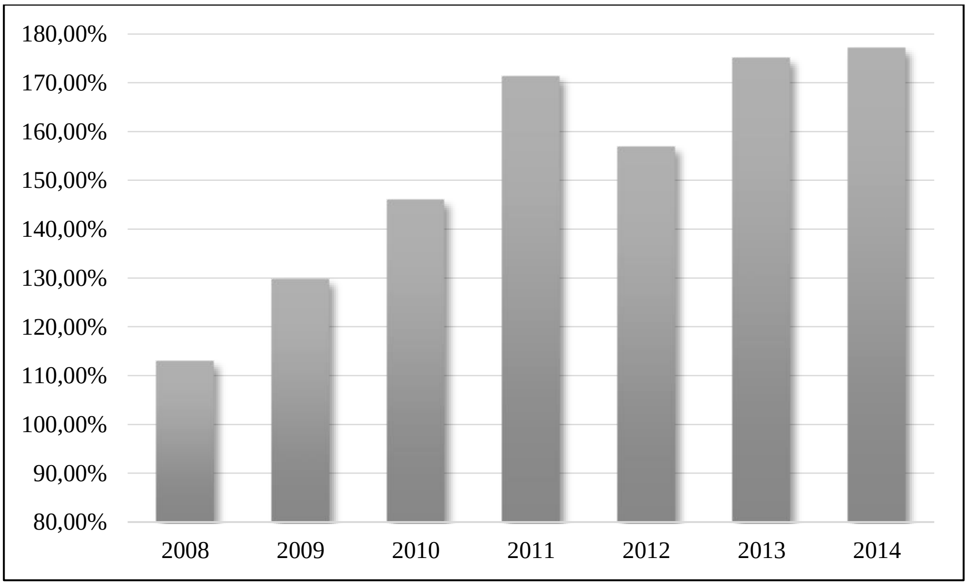
2.1 Recent economic developments in Europe

Despite the continuing recovery, the European economy still struggles from the negative impacts of the recent global financial crisis. The crisis has left the economic and financial environment in Europe vulnerable and raised questions about the uncertain future prospects of European fiscal and monetary policy. As the financial distress spread across countries all over the world, Europe has been particularly affected by several economic events stemmed from the financial crisis. One of the most disputable issue, playing a significant role in the recent economic development in Europe, was the Greek crisis.

At the end of 2009 Greece announced that it had not been truthfully reporting the level of deficit over previous years. The announcement has implied a sharp decline in confidence in Greek financial system and Greece has been since then unable to get sufficient amount of borrowing to finance its expenses. Greece has been accumulating an enormous sovereign debt for many years caused by a combination of substantial expenses and weak fiscal fundamentals. The situation aggravated in spring 2010 when Greece got close to bankruptcy and needed an urgent support from abroad.

The grievous situation of Greek economy represented an immediate threat for the financial stability of the euro area and consequently for the global economy. The threat forced the European countries to subsidize Greek economy with the intention to support Greece in their efforts to stabilize their financial system. The bailouts, however, did not have the expected effect as Greece has been deepening its debt since the outset of the crisis. As the following graph shows, from the end of 2009 until 2014 the Greek debt increased from 129.7% to 177.1% of GDP and the country has plunged into further economic recession.

Figure 1: Debt to GDP ratio in Greece



Source: Eurostat, own estimation

The Greek development affected already deteriorated economic sentiment in Europe caused by the financial crisis and contributed to the current European debt crisis. The sovereign debt crisis first spread to countries with weaker fiscal fundamentals, i.e. to Italy, Spain, Portugal and Ireland, as they were downgraded by rating agencies and consequently unable to meet their obligations towards international creditors. The spread of financial contagion from the affected peripheral Eurozone countries has caused the overall European economy instable and vulnerable.

In addition, the European countries have been further affected by the recent developments in Russia. The Ukraine conflict and subsequent sanctions imposed on Russian economy have raised geopolitical tensions between the regions. The geopolitical tensions, sanctions and falling oil prices have seriously deteriorated Russian economy by increasing risk premiums and capital outflows, which have consequently implied an extreme depreciation of Russian currency. The Russian economic downturn primarily affects the Commonwealth of Independent States and Baltic countries but implies negative spillovers on European countries as well, notably on the European eastern countries, as they have stronger trade and financial links with Russia and are highly dependent on Russian energy imports (Stepanyan et al., 2015).

To mitigate the negative effects of the financial crisis central banks have undertaken numerous monetary policy measures to stimulate the economy. The expansionary monetary policy ongoing since the beginning of the financial crisis pushed the interest rates towards zero bound and created a favorable environment for investment. The prevailing deflationary threat in European economies forced the European Central Bank to adopt additional measures using unconventional monetary policy tools to inject money into economy and mitigate concerns about debt sustainability.

The low interest rate environment on one hand boosted the investment and thus economic recovery, but on the other hand caused deeper indebtedness especially in emerging economies. The extremely low interest rates encouraged imprudent financial behavior as the investors were motivated by the low cost of financing and did not hesitate to undertake riskier projects. Additionally, the increasing portion of risky projects in investment portfolios was fueled by the overall search for higher yields in the low yield environment (Financial Stability Review, 2014).

Overall, due to additional monetary policy supply and still low oil prices the macroeconomic conditions in Europe improved slightly, but are exposed to prevailing financial and political risks that may deteriorate future economic growth. Among others, the risks that may slowdown economic recovery in Europe include the contagion risk from the indebted emerging countries, the increasing concerns about recent Greek developments, Chinese downturn or the current refugee crisis in Europe.

2.2 Bond markets

In this work, we examine the corporate bond yields and thus understanding the functioning of bond contracts and development of the corporate bond markets are crucial factors for our study. Therefore, we firstly describe basic characteristics of bonds and bond markets and consequently summarize their recent development in the second part of this section.

A bond is a loan agreement requiring the bond issuer to repay the principle to an investor (a buyer of the bond) at the maturity date and in most cases the investor receive regular interest payments over the defined period. Corporate bonds are transferable debt securities issued by corporations for the purpose of receiving financing for their business activities.

The corporate bond market is divided into primary and secondary market based on the time delay since the bond issuance. The bonds are initially sold to investors in the primary market, usually with the help of an investment bank, which provides the issuer with necessary information about market trends and suggests appropriate characteristics of the issue. In the primary market, the trade takes place at the issuance of bonds or shortly thereafter, whereas the secondary market is available for trading of bonds since their issuance until their maturity or redemption.

The secondary market trading takes place mostly over-the-counter (OTC). The reason for the OTC trading lies mainly in the limited comparability of bonds as they are characterized by various quality levels, yields or maturities. Moreover, the market pricing of previously issued bonds depends on interest rates and issuer’s credit ratings, which implies difficulties in setting current bond prices and thus trading bonds via exchanges.

Comparing to government bonds, the corporate bonds offer investors a higher return in exchange for a higher implied risk. The most significant risk associated with corporate bonds is credit risk, also known as default risk. The credit risk assesses the probability of a company to default on its obligations towards an investor, i.e. paying the interest payments or the principal. As the level of credit risk is the critical factor for an investor, most corporate bond issuers are evaluated for the credit quality by rating agencies, such as Moody's, Standard & Poor's, and Fitch. The evaluation process is derived from the company's ability to pay its debts.

Based on the ratings we can distinguish two types of bonds - investment grade bonds and high-yield, or junk bonds. Investment grade bonds are issued by companies with relatively strong balance sheets. They are perceived as relatively safe and are seen as trustworthy by the investors. Credit ratings of investment grade bonds exceed BBB-rating according to S&P and Fitch or Baa3 according to Moody's.[1] Junk bonds are low quality bonds with credit ratings below the thresholds (BBB- or Baa3. They are characterized by higher yields than investment grade bonds but it is generally not recommendable to invest in them as they are associated with a higher probability of default.

Bond markets were recently in the center of attention by researchers due to their increasing importance in current economic development. Corporate bonds serve as a stable and reliable source of corporate funding, which is especially appreciable during periods of economic troubles when the possibility of bank funding is limited. The bonds offer stable and predictable income, encouraging private investment and thus, enhance economic growth (ICMA, 2013).

The corporate bond market has grown significantly since the onset of the recent financial crisis, which was caused by several reasons. Companies have been increasingly funding their businesses through bond issuing as bank lending has been squeezed in response to economic uncertainty. Kaya & Meyer I. (2013) applied in their

[1] See Table 18 in Appendix for credit ratings scale of respective rating agencies.

work a method of hypotheses testing to examine the changing structure of funding sources for corporations after the crisis. They confirm the evidence of increasing portion of financing through debt securities to the detriment of bank lending. Overall, corporate bonds represent a meaningful alternative to bank loans in the long run as a source of financing for corporations.

The increasing corporate bond issuance is highly correlated with the quantitative easing policies that have been undertaking since the onset of the financial crisis. As all countries have experienced the increasing bond issuance, the common factors seem to be more crucial than country-specific factors regarding the bond market activity. European Central Bank researchers have confirmed the evidence in the Financial Stability Review (2014) with the help of a panel regression analysis. The results of the regression suggest that the large-scale asset purchases of the US Federal Reserve System in late 2008 had substantially contribute to the rise in the corporate bond issuance, notably in the emerging economies where the rise in bond issuance has been more pronounced than in advanced economies.

The quantitative easing has implied an increasing demand of investors for corporate bonds. The current expansionary monetary policy regime has created extremely low interest rate environment implying low yields on government bonds. The corporate bonds thus represent a meaningful alternative for investors searching for higher return on their investments and serve as a mean to diversify their investment portfolios.

Kaya & Meyer II. (2013) focus on an issuer's point of view while evaluating the market of corporate bonds. In their opinion, the market is currently in a state of an ideal combination of market conditions for the bond issuance. The optimal conditions include low benchmark yields and moderate spreads, which favors corporate bonds as a source of financing. The further evolution of the corporate bond market will depend mainly on market liquidity and interest rates that will determine both the issuers' willingness to issue bonds and investors' willingness to invest in them.

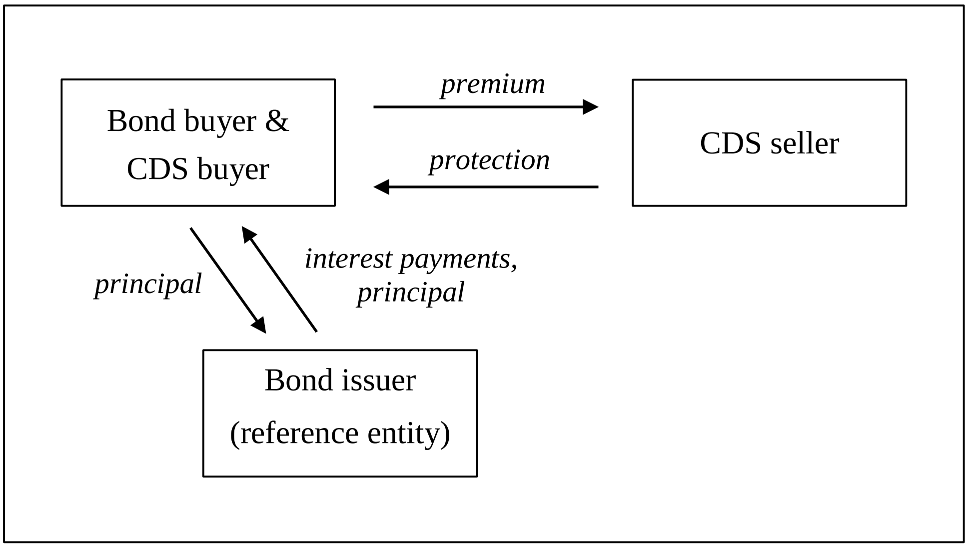
The substantial growth has risen questions about sustainability as it has deteriorated for instance liquidity of the corporate bonds, especially in the secondary market. The steady growth in the market size was not accompanied by increasing trading capacity. On the contrary, the trading capacity has decreased due to tightening of banking sector. In response to the recent financial crisis, multiple efforts have been pursued since 2008 to strengthen and stabilize the financial system. The reforms have imposed higher capital and liquidity requirements on banks, which consequently reduced the banks' market-making activity in corporate bond market as they were forced to abandon risky capital market activities (BlackRock, 2014).

As the bond markets depend on banks willing to facilitate trading, their limited activity has implied lower and more volatile liquidity in the corporate bond market (Hannappal, 2015). The higher volatility on bond markets may be partly explained by increasing concerns about the Greek situation. Concerning the illiquidity, many recent works (for instance Bank for International Settlement (2014) or Papanyan (2015)) focus on that issue as illiquidity deteriorates the bond market by increasing transaction costs and reducing trade sizes, which may subsequently affect economic growth. BlackRock (2014) suggests a solution to that issue by emphasizing the need for standardization of corporate bond contracts to enhance market liquidity. The suggestion stems from the comparison with government bond markets as a higher standardization of government bonds may contribute to a higher liquidity in these markets.

2.3 Credit default swap markets

The idea of credit default swaps (CDS) originated in early 1990s as a way to protect banks against risks related to huge corporate loans they granted. Credit default swap is the most widely traded credit derivative serving as a form of insurance for a creditor against debtor's failure to fulfil its payment obligations. The following figure summarizes a CDS transaction. The transaction always involves minimum three parties – an issuer of a debt security (a bond), a buyer of the bond willing to buy a protection and a seller of the protection. The buyer of the CDS contract pays the seller a premium for a protection that is effectuated in the case of a default of the debt issuer or other credit event. The CDS seller is thus entitled to pay only in case of a credit event.

Figure 2: CDS transaction



Source: own estimation

Therefore, a CDS contract allows a creditor to transfer the credit risk associated with a bond to a third party. The CDS sellers are in most cases financial institutions, such as banks, hedge funds or insurance companies, willing to speculate on market assessment of credit risk of a reference entity. The financial institutions sell a CDS contract to a bond buyer if they believe that default probability of the reference entity is overvalued by the market. The banks thus benefit from the interest payments by taking relatively low risk. The interest payments, or swap rates, are the higher, the higher is the expected default probability of the reference entity, i.e. the lower is its credibility.

Additionally, the CDSs allow for a more efficient credit risk management than bond trading as they do not consider interest rate risk and focus only on credit risk. The CDS may thus serve as a proxy for default probabilities in the market, which has been recently widely exploited by researchers studying market credit risk. The CDS is thus not only an efficient hedging tool for credit risk exposure but it is widely used also as an indicator for the company's default risk.

The indisputable advantages of credit default swaps played a significant role in the enormous expansion of CDS market since its inception until the beginning of the financial crisis in 2007. The financial crisis proved the unsustainability of the CDS market and seriously deteriorated CDS market reputation, which slowed down their expansion.

The CDSs are traded over-the-counter on a bilateral basis, i.e. the two parties agree on the contractual terms without any limitation. The CDS market is thus subjected to less regulation and higher credit risk in comparison with other derivatives traded on exchange. The market thus involves a high degree of speculation about the default of debt issuers, which together with insufficient risk management eventually evolves in an unsustainable situation culminated at the onset of financial crisis.

The problem with CDS contracts is that they are not ordinary insurance because insurance companies are usually regulated by governments and thus they are exposed to regulatory requirements ensuring enough money within the institution to cover the potential claims. As the CDS contracts are negotiated bilaterally over-the-counter, the transparency is limited and it is thus challenging to identify the individual parties participating in the CDS trading and examine their creditworthiness.

The banks and traders have been speculating on the future direction of the market by hedging and betting on the future performance of various mortgage securities, creating a huge trading volume of CDS sold on mortgaged-backed securities. Consequently, after the housing bubble burst, the value of mortgage securities decreased substantially causing serious problems to CDS sellers that underestimated risk management. The CDS sellers did not have enough money to cover the claims, as they were not forced to keep adequate capital reserves by regulatory bodies.

The collapse and subsequent bailout of the American insurance company AIG is a good example of a failure related to CDS business, having negative impacts on overall economic development. The AIG was before crisis largely involved in CDS activity, particularly in selling CDS on mortgage-backed securities. The mortgage crisis and the AIG’s huge exposure to CDS caused a drop in credit rating of AIG, implying increasing requirements on collateral. As the housing bubble burst and mortgage borrowers defaulted, the decreased value of mortgage-backed securities caused a liquidity crunch at AIG as it had not enough money to pay its obligations (Xinzi, 2013).

Although the expansionary path and the popularity of CDS trading slowed down after the crisis, which may be partly explained by increased regulatory requirements, the CDS still remain a popular way of hedging credit risk. By definition, the CDS contracts serve as a credit protection and the availability of the protection in the market encourage lending activity, which is the key driver of the economic prosperity. The good functioning of the market may thus significantly contribute to economic recovery.

3 LITERATURE REVIEW

This section will summarize the previous related literature focusing on estimating bond and CDS markets. Initially, bond yield spreads have been used as a way to measure credit risk. The bond yield spreads have been thus widely investigated by researchers, as credit risk is an important variable for financial analysts, traders, and economic policy makers. With the development of financial derivatives the attention has been moved towards credit default swaps (CDS) as they represent a better reference measure for credit risk. The section is structured in the following way. Firstly, we describe the related literature investigating pricing of bonds. Secondly, we provide a literature review concerning the CDS valuation and finally, we summarize the key works providing evidence about links between the two financial instruments.

3.1 Bond evaluation

A significant portion of works investigating bond yield spreads focus on European countries, particularly on euro area. Georgoutsos & Migiakis (2013) investigate the determinants of euro area sovereign bond yield spreads vis-à-vis the German Bund. They employed both country-specific factors and factors common across euro area. Their findings suggest a significant heterogeneity of influencing factors across countries with economic sentiment playing the most important role in sovereign bond yield evolution.

Similarly, Manganelli & Wolswijk (2007) study the determinants of euro area sovereign spreads after the introduction of the euro. With the use of a fixed-effects panel model the authors concluded for ratings and short-time interest rates to be the most significant drivers of bonds spreads.

Several studies reveal a significant impact of government debt and deficit on sovereign bond spreads. Using a dynamic panel approach Attinasi et al. (2009) predict the determinants of widening sovereign bond yield spreads in the euro area over the period 2007 to 2009. The results identify budget deficits and government debt ratios to play a significant role in the bond yield spreads divergence.

Bernoth et al. (2004) investigate sovereign bond yield spreads on a pool of 13 European Union countries between 1991 and 2002. The paper shows that bond yield spreads are affected by international risk factors and reflect default and liquidity risk premia. In addition, the analysis reveals a significant influence of fiscal fundamentals, such as budget deficit and government debt, on sovereign bond spreads. Similar results were obtained by Hallerberg & Wolff (2006). The authors use fixed effects panel estimations to assess the impact of good institutions on European sovereign bond markets. They argue that fiscal performance is a crucial determinant of sovereign bond yields but its influence is lower in countries with better budget institutions.

Consequently, several event study analyses have shown that macroeconomic announcements have a significant impact on sovereign bond spreads. Among others, Andersson et al. (2009) study this phenomenon while investigating the German bond market and its reactions on major macroeconomic and monetary announcements over the period 1999-2005. The authors found out that the announcements have a more significant impact on volatility than on the level of bond prices. Andersen et al. (2005) focus on a similar topic examining an impact of macro announcements on 30-year US Treasury bond futures contracts.

The modern analysis of corporate debt was initiated by Merton (1974). The paper presents a theory for pricing bonds in the presence of significant probability of default and provide a method for pricing any type of corporate liabilities. Consequently, many empirical works build on structural form models while describing variation on bond yield spreads. The structural models usually include variables, such as interest rates, the slope of the term structure, equity and market return and volatility, and company leverage and volatility (Avramov et al., 2007).

In paper Avramov et al. (2007), the authors test the ability of structural models to predict variation in corporate credit spreads. They conclude that structural models are efficient in explaining systemic variation in credit-spread changes. Beyond the traditional variables, the authors suggest considering idiosyncratic volatility and the price-to-book ratio for explaining variation in corporate bond yield spreads.

Campbell & Taksler (2003) also focus on estimating the drivers of variation in corporate bond yield spreads. Beyond the existing findings about corporate bond spreads, the authors provide an evidence that equity volatility explains as much variation in corporate credit spreads as do credit ratings. The importance of the aggregate idiosyncratic equity volatility in explaining bond spreads support the structural models as they consider volatility as a crucial determinant of default risk.

On the other hand, a number of works focusing on estimating bond yields indicate that especially corporate bond yield spreads cannot be fully explained by structural models, i.e. using only credit risk determinants. Therefore, they suggest incorporating liquidity risk in bond pricing as omitting the liquidity measure may be a reason for the inability of credit risk variables to capture a higher fraction of bond yields variation.

Collin-Dufresne et al. (2001) run a regression using proxies for default risk and recovery rate revealing low explanatory power of these variables on credit spread changes. The authors conclude for liquidity measures to be necessary for explaining bond yield variation. Nevertheless, even with the liquidity variables included in the regression the model is unable to explain the most of the common systemic factor suggesting that the spread changes in corporate bond market is driven by unpredictable local supply or demand shocks.

Similarly, Huang & Huang (2012) indicate that the corporate bond yield spreads cannot be fully explained by credit risk determinants. The evidence of insufficient explanatory power of credit risk determinants is particularly valid for investment grade bonds as the credit risk accounts for only around 20% of the yield variation. As one way to increase explanatory power of a model, the authors suggest incorporating liquidity risk variables.

The same view regarding liquidity measure is proposed by Longstaff et al. (2005). The authors benefit from the availability of CDS market information to decompose the corporate yield spreads into default and nondefault determinants. The work suggests that the default variables account for the majority of the corporate bond spreads, which is in contrast with most of previous studies but correspond to the findings of Avramov et al. (2007) and Campbell & Taksler (2003). The authors conclude, however, that the individual corporate bond illiquidity is an essential factor, which should be considered, as it is strongly related to the nondefault component in the corporate bond spreads.

Many other works appointed the liquidity risk to be a significant driver of bond yield spreads. Among others Elton et al. (2001), Chen et al. (2007) or Duffee (1999) suggest a high importance of liquidity factors for pricing corporate bond yield spreads as their analyses reveal a significant positive relationship between illiquidity and bond yield spreads. Gomez-Puig (2006) and Beber et al. (2009) examine sovereign bonds spreads and reach the same conclusion about the importance of considering liquidity risk while pricing bond yield spreads.

3.2 CDS evaluation

With the rapid development of the credit derivative market the researchers focusing on estimating credit risk have moved their attention towards CDS spreads, replacing bond spreads as a measure of credit risk. The reasons behind the move of interest towards the CDSs lie in their ability to measure credit risk more precisely. Bond markets are usually more illiquid than CDS markets and bond prices reflect interest rate risk beyond the credit risk, which contributes to the inefficiency of explaining bond prices by credit risk factors.

Aunon-Nerin et al. (2002) is one of the first studies investigating CDS spreads as a way to explain credit risk. By including fixed-income market data as well as equity-market data their model explains 82% of variation in CDS spreads. In addition the authors examine the differences in behavior between high rated and low rated underlyings, sovereign and corporate underlyings, and US and non-US underlyings. Their results indicate that determinants predicted by classical theoretical models play a significant role in modelling CDS prices. The authors argue that rating is the most important determinant of CDS spreads and that equity market information should be considered as well as it has substantial explanatory power.

Benkert (2004) represents another early empirical study on pricing CDS concentrating primarily on volatility measures. The volatility risk is also considered by Zhang et al. (2009) that investigate the relationship between equity return and CDS market. More specifically the authors explore the effect of stochastic volatility and jumps on CDS spreads

More recent empirical studies investigating determinants of CDS spreads distinguish the pricing behaviors between normal times and crisis times. For instance, Dieckmann & Plank (2011) suggest substantial pricing differences of CDS before and after the collapse of Lehman Brothers. The paper examines the determinants of CDS spreads in 18 European developed countries. Their principle component analysis reveals a high degree of commonality. Besides the theoretical determinants of CDS spreads used in the related literature, the authors reveal high explanatory power of domestic financial system as well as the state of the world financial system. The results of their econometric analysis suggest that CDS spread are on average lower for members of the European Economic and Monetary Union (EMU) but they are more sensitive to shocks to the global and local financial system. Using corporate bond spreads as a proxy for corporate credit spread the authors do not reveal a significant impact of the corporate credit spread on CDS spreads.

Another work investigating the differences in pricing CDSs before and during the recent crisis is Di Cesare & Guazzarotti (2010). On a sample of US non-financial companies over the period 2002-2009 the authors test the significance of variables that have been empirically proven to have explanatory power on CDS spreads. They found the level of leverage being more influential after the beginning of the crisis while volatility has lost some explanatory power on CDS spreads. In addition, their principle component analysis shows that CDS spreads changes are more substantially driven by a residual common factor since the outset of the crisis.

Next, Aizenman et al. (2013) examine pricing sovereign risk for 60 economies based on CDS spreads. Their analysis revealed evidence of mis-pricing in the euro area periphery relative to a set of macroeconomic fundamentals, such as fiscal space. They reveal unpredicted low CDS prices in tranquil period and unpredicted high CDS prices during crisis period, especially during sovereign debt crisis in 2010.

Longstaff et al. (2011) focus on the sources of commonality in emerging market CDS spreads, which are used to describe sovereign credit risk. The principal component analysis suggests that the most variation in sovereign credit risk can be explained by global factors and their importance is even higher during the crisis period 2007-2010. The regression analysis indicates the U.S. stock and high-yield markets, and the volatility risk premium to be the most significant determinants of CDS spreads. The country-specific fundamentals thus do not bear significant information for pricing CDS.

Several studies considering determinants of CDS spreads test significance of theoretical variables, which include credit rating, maturity, riskless interest rate, slope of the yield curve, and volatility of equities. Abid & Naifar (2006) confirm that theoretical determinants of credit risk explain the most variance in CDS level. With the help of a linear regression they conclude for credit rating to be the most significant determinant of CDS spreads. Ericsson et al. (2009) analyze the relationship between theoretical determinants and corporate CDS spreads employing a principal component analysis. The authors prove a substantial explanatory power of the theoretical determinants as the evidence for a residual common factor is limited.

Besides the traditional variables some researchers, such as Kapar & Olmo (2011), use iTraxx index as a determinant of CDS spreads. Bystrom (2005) and Alexander & Kaeck (2007) investigate iTraxx CDS index as a dependent variable to proxy individual CDS spreads. Bystrom (2005) examine the relationship between the iTraxx CDS index market and stock market. The results reveal a negative relationship between the CDS spreads and stock prices and a positive relationship between CDS spreads and stock price volatility. Moreover, the work suggests a high degree of autocorrelation in the iTraxx CDS indices. Alexander & Kaeck (2007) study the determinants of the iTraxx Europe indices with the help of a linear regression and a Markov switching models. The paper extends Bystrom (2005) by examining a wider set of potential determinants of CDS spreads and found that the theoretically variables contribute to the CDS spread changes but their influence depends on specific market conditions, such as volatility. They reveal that in tranquil periods the interest rates are significant determinants of CDS spreads, whereas during the high volatility periods the credit spreads are influenced rather by stock market variables.

Almost every work investigating CDS prices consider credit risk of a reference entity in their estimations. Nevertheless, after the financial crisis and subsequent failures of main CDS sellers, such as AIG or Bear Sterns, the need for the credit assessment of CDS sellers becomes evident. One of the few empirical studies considering the counterparty credit risk while investigating pricing of CDS contracts is Arora et al. (2012). The paper examines the counterparty credit risk on a pool of 14 CDS dealers selling protection on the same underlying entity and studies its effect on CDS prices. The authors find a significant relation between counterparty credit risk and the prices of credit protection but the level of the impact of dealer credit risk on CDS spreads is small. Moreover, they reveal that counterparty credit risk is priced in CDS contracts across all industries except financials.

Another work considering the counterparty risk when pricing CDS contracts is Kapar & Olmo (2011). By examining a set of European contracts over the period 2005-2010 the authors compare the influence of market and firm-specific variables on CDS spreads before and after the financial crisis. Besides the counterparty risk, they also consider the iTraxx Europe index, which they find to be the most significant determinant for pricing CDS spreads before crisis. They reveal that before the crisis general market conditions have a sufficient explanatory power whereas during the crisis the CDS spreads are influenced rather by firm-specific factors. Moreover, the results suggest that the counterparty risk is only considered in pricing CDS after the crisis for all contracts excluding those on financial companies. The findings correspond to Arora et al. (2012), except that Arora et al. (2012) show evidence of pricing counterparty risk into CDSs even before the crisis.

Blommestein et al. (2015) suggest inaccuracies of previous literature examining pricing of CDS contracts. The authors study the determinants of sovereign CDS spreads in five euro area countries (Greece, Ireland, Italy, Portugal and Spain) over the post-crisis period using regime-switching models. They investigate the endogeneity issue in modelling sovereign CDS spreads and found that it can produced bias estimates as some determinants of CDS spreads are not exogenous. The absence of treatment of the endogeneity issues in previous studies raises questions about the validity of their findings. Nevertheless, Blommestein et al. (2015) confirm findings of Longstaff et al. (2011) by detecting market conditions to be the most significant determinants of sovereign CDS spreads and their influence to be regime dependent.

3.3 Links between bond and CDS markets

A substantial number of previous works examined links between bond and CDS markets. A key common factor across most of the works is investigation of CDS basis, which is a spread difference between a CDS and a bond spread on the same underlying. Understanding the CDS basis is essential for correct interpretation of pricing of CDS and bond spreads and it was thus examined from many perspectives. The CDS basis should equal zero in normal times constituting a no-arbitrage condition. The basis divergence from zero thus violate the no-arbitrage condition and offer a possibility for arbitrage trading, which is one of the reasons for the researchers' interest in this topic.

One of the most widely cited paper considering the CDS-bond relationship is Blanco et al. (2005). The authors study the relative pricing of corporate bonds and CDSs using a set of 33 corporations from 2001 until mid-2002. They reveal a leadership of the CDS market in price discovery, suggesting the CDS market to be more convenient for trading credit risk. The results from their econometric analysis show that bond spreads react more to firm-specific variables, whereas CDS spreads to macroeconomic variables. Also, by studying the CDS basis they show that CDS and bond spreads converge to each other in the long run but the level of their sensitiveness to specific factors differ in the short run.

Zhu (2006) confirm the evidence for the CDS basis divergence in the short run. Using a sample of corporations over the period 1999-2002 the author explains the differences between CDS and bond spreads by a higher liquidity of the CDS market implying a faster reflection of changes in market conditions.

Palladini & Portes (2011) build on the work of Zhu (2006) by testing the no-arbitrage relationship between sovereign CDS and bond yield spreads on a pool of six euro area countries over more recent period 2004-2011. The cointegration analysis also predicts that the two prices should be equal in equilibrium but their relationship diverge from zero in the short run. By employing the VECM procedure the authors show that the CDS market leads the bond market in price discovery. In addition, the paper reveals the importance of considering CDS spreads while estimating bond yield spreads, which supports an early study of Longstaff et al. (2005).

Similarly, Ammer & Cai (2011) analyze the relationship between sovereign CDS and bond yield spreads but they focus on emerging countries unlike Palladini & Portes (2011) that investigate developed countries. Most precisely, Ammer & Cai (2011) examine the implication of a ‘cheapest to deliver’ (CTD) option on the CDS basis. The authors suggest the CTD option to be a crucial factor for pricing relationship between CDS and bonds as the basis is higher for entities where the value of the CTD option ex-post is higher. In addition, the basis is higher for entities with higher credit spreads and lower credit ratings. Finally, the analysis of price discovery process implies relative liquidity of the two markets to be a crucial determinant of which market leads the other one.

The CTD option was also referenced by Cossin & Lu (2005). By examining the different pricing of European corporate bonds and CDSs the authors reveal that the difference stems particularly from the liquidity premium, which can be explained by the CTD option.

The basis between corporate CDS and bond spreads has reached substantial negative figures after the collapse of Lehman Brothers. The recent literature thus examines the movements in the CDS basis during crisis by suggesting potential drivers for the divergence. Among others, Man et al. (2014) investigate the extreme negative CDS basis during the crisis and argue that misspecification of risk factors in the pricing models of CDS and bond markets may be an explanation for the basis divergence. The authors examine the possibility of different pricing of risk factors by the two markets and potential limits to arbitrage that may drive the CDS basis divergence. The paper indicates nondefault risk factors as well as impediments to arbitrage as contributors to the negative CDS basis.

Bai & Collin-Dufresne (2013) provide explanation for the negative basis during the crisis based on an analysis on a sample of 484 companies. The authors differentiate between investment-grade and high-yield bonds but reach the same conclusion related to the negative CDS basis during the crisis for both groups of bonds. Bai & Collin-Dufresne (2013) suggest limits to arbitrage as a reason for the divergence as they explain a significant portion of the CDS basis cross-sectional variation during the post-Lehman period. The significant determinants of cross-sectional variation in CDS basis during the crisis include liquidity risk, counterparty risk, funding risk, and collateral quality.

Another group of related works considers credit ratings for analyzing the CDS and bond spreads. Beirne & Fratzscher (2013) focus on drivers of sovereign risk on a sample of 31 advanced and emerging economies during the European sovereign debt crisis. The analysis consists in empirical modelling the link between long-term government spreads, CDS spreads and ratings of sovereigns. The results of their research show that a rise in the sovereign yield spreads and CDS spreads during the crisis can be mostly explained by deterioration in countries' fundamentals and by a rise in sensitivity of financial markets to fundamentals. Moreover, the pricing of sovereign debt differed in the pre-crisis and crisis period suggesting different attitude of market participants towards the sovereign risk.

Hull et al. (2004) investigate the relationship between CDS spreads, bond yields and credit rating announcements on a wide set of 1599 entities. They proved the theoretical relationship between CDS spreads to hold fairly well and they used it for estimating the benchmark risk-free rate in the CDS market. Regarding the credit rating announcements, the authors reveal a significant impact of CDS changes and levels on the probability of negative credit rating changes. Moreover, the CDS changes are influenced more significantly by negative rating events and Reviews for Downgrade are the main source of information.

Finally, many researchers focus on price discovery process while studying CDS and bond spreads. For instance, Coudert & Gex (2010) reveal that the CDS market is leading the bond market for corporates by examining CDS and bond yields on 18 governments and 17 financials. Furthermore, the CDS market's lead was intensified by the current crisis.

Beyond the CDS basis examination, Fontana & Scheicher (2010) also consider the price discovery process. The paper investigates determinants of sovereign CDS and bond spreads on a pool of 10 euro area countries over the period 2006-2010. By running panel regressions the authors first estimate CDS or bond spreads as dependent variables with the same comprehensive set of explanatory variables, including country-fixed effects. Consequently, the paper investigates the CDS basis to reveal pricing difference between the two markets. The findings suggest that since 2008 the basis is mostly positive (with exemption of Ireland, Greece and Portugal), which is in contrast with evidence observed in corporate debt markets. The explanation for the positive basis could be the 'flight to liquidity' effects as it lowers government spreads during periods of economic troubles. The price discovery process takes place in CDS market in half countries and in bond market in the other half according to the study, which does not correspond with the most of previous works as they suggest CDS market to lead price discovery process.

Carboni (2011) partly agree with Fontana & Scheicher (2010) as they reveal that both markets contribute to price discovery before Lehman Brothers collapse. Nevertheless, by employing vector error correction model and measuring the ratio of the speed of adjustment in bond and CDS markets the authors find evidence for the CDS market to lead the bond market in price discovery during 2010.

We build on Fontana & Scheider (2010) as they run individual regressions for bonds and CDSs. We estimate the same set of determinants for both bond and CDS spreads. Unlike the previous studies, we use recent daily data for our analysis covering the crisis and post-crisis period. The wide scale of the data allows us to assess the effect of the crisis as well as the recent economic development on pricing the influential factors of bonds and CDS spreads. The key novelty of our work lies in capturing the differences in pricing bond and CDS spreads across various groups of companies, created based on specific criteria.

4 DATA

In this section we present data used for our empirical analysis. The aim of our research is to determine factors influencing pricing of bonds and CDS contracts. We concentrate on the European market and select companies for our sample based on the availability of data for the two dependent variables – bond and CDS spreads.

In the first part of this section we describe the procedure of data collection and dataset creation. In the second part, we present characteristics of the independent variables used for our analysis.

4.1 Dataset creation

The first step in collecting the data for our analysis was to download data from the Bloomberg Database on CDS prices for the 125 most actively traded European companies in the Markit iTraxx Europe CDS index. We have chosen five-year maturity CDS contracts, which are considered to be the most liquid ones and thus the data are the most likely to be available. The time period was chosen in order to cover the crisis and post-crisis period, i.e. from 1 January 2008 to 31 December 2014, so that we could analyze also the effects of the crisis in Europe on bond and CDS pricing.

For each CDS contract we searched for bond data on the reference entity. We downloaded five-year daily bond yields from the Bloomberg database to match the five-year maturity of the CDS contracts. Certain bond data was not available for all of the 125 companies and we therefore eliminated companies with missing information to obtain a balanced dataset. For instance, we removed companies for which we did not identify a correspondent bond; this process eliminated 21 companies from the dataset. We also eliminated companies with missing bond yield information; this process eliminated 62 companies. Finally, we eliminated four companies with missing information on CDS prices. Ultimately, we ended up with 38 companies with sufficient information on CDS prices and corresponding bond yields. Note, however that in conducting the analysis we were forced to discard an additional four companies due to unavailable data on independent variables. Table 17 in Appendix offers a list of all 34 companies together with their characteristics.

Following Blanco et al. (2005) we used five-year vanilla interest rate swap rates in euro as a proxy for the risk-free rate. We calculated the bond spreads as a difference between bond yields and swap rates. Another possibility is the use of governments bonds as the reference rates, but as Blanco et al. (2005) pointed out, government bonds do no longer constitute risk-free securities due to different tax treatment, repo specialness, legal constraints, and other factors, such as the recent economic crisis which brought into question the credit-worthiness of governments (e.g. Greece). We are aware that even the applied swap rates are not perfectly risk-free and may thus contribute to a measurement error in our analysis.

Another step for creating a balanced dataset was to remove missing observations for non-trading days. We deleted weekends and holidays from our time series. Finally, we ended up with 1,781 observations per entity, implying a dataset of 65,554 observations over the period from 1 January 2008 to 31 December 2014 for 34 European companies.

One of the main contributions of our work is the comparison of factors influencing pricing of bonds and CDSs across various group of companies. The groups were created based on three criteria – geographic location, industrial sector, and financial performance. The companies in our sample are based in ten European countries, out of which we created four equivalent groups. The following table describes the geographical distribution together with number of companies per each group.

Table 1: Geographical distribution

Group	**Country**	**Number of companies**
Group 1	*Germany*	8
Group 2	*France*	7
Group 3	*United Kingdom*	8
Group 4	*Rest*	11

Source: own estimation

Similarly, we divided the companies into 5 industry sectors in accordance with the Markit iTraxx index's information. The following table shows the representation in the industry sectors.

Table 2: Industry distribution

Group	Sector	Number of companies
Group 1	*Autos & Industrials*	12
Group 2	*Consumers*	4
Group 3	*Energy*	10
Group 4	*Financials*	1
Group 5	*Technology, Media & Telecommunications*	7

Source: own estimation

The last criterion is the financial position of a company. In order to capture the overall company's performance, we have chosen three financial ratios: we use Operating Margin as a profitability ratio, Current Ratio as a liquidity ratio, and Debt Ratio as a leverage ratio. Operating Margin shows how much of the revenue is left in a company after paying for all variable and operational costs. The Current Ratio describes the company's ability to cover its short-term obligations with current assets, i.e. it measures the company's liquidity; a high ratio indicates a more liquid company, implying less risk for an investor. The Debt Ratio measures the company's indebtedness; a higher debt ratio indicates additional risk to an investor. By implication, we will be able to see if either profitability, liquidity, or leverage of a company play some role in determining bond and CDS pricing.

The formulas for the ratios are as follows:

$$Operating\ Margin\ Ratio = \frac{Operating\ Profit\ (EBIT)}{Net\ Sales}$$

$$Current\ Ratio = \frac{Current\ Assets}{Current\ Liabilities}$$

$$Debt\ Ratio = \frac{Total\ Liabilities}{Total\ Assets}$$

We calculated the ratios based on the companies' financial figures from the Amadeus and Compustat Global databases. A problem is that financial ratios are not comparable across industry sectors, as each sector involves different business models that lead to differences in operating and/or financing circumstances across industries. We therefore computed industry averages and compare the individual companies' values to the respective industry average. To obtain the averages we have chosen a set of NACE codes describing each industry sector (as depicted in the following table) and downloaded financial information for all European companies falling within the corresponding NACE codes. We then calculated the ratios for all of the downloaded companies and took averages for all three ratios within each of the five sectors.

Table 3: Industry NACE codes

Sector	**NACE codes***
Autos & Industrials	2000, 2900, 2930, 3000, 4200, 5220
Consumers	1000, 1101, 4711, 4719
Energy	3510
Financials	6510
Technology, Media & Telecommunications	1800, 6000, 6100, 7010

Source: own estimation
**The descriptions for all used NACE codes are stated in Table 19 in Appendix*

Finally, to get comparative figures, we divided the financial ratios for each entity by the industry average ratios. The entities were then divided into halves for all three ratios based on the comparative financial margins.

4.2 Variables description

In this section, we describe the explanatory variables used for our econometric models. The variables represent firm-specific and market factors that may have an impact on the pricing of corporate CDSs and/or bonds. The choice of the theoretical determinants was inspired by previous studies on related topics, for instance Aunon-Nerin et al. (2002) or Blanco et al. (2005). The following table provides a list of all explanatory variables together with their properties (e.g. the units the variables are expressed in), expected sign of the estimated coefficient, and data source.

Table 4: List of explanatory variables

Variable	Name	Units	Expected sign	Source
Bond's mid price	$Bond\_price$	basis points	-	*Bloomberg Database*
Bond's bid-ask spread	$Bond\_bid-ask$	basis points	+	*Bloomberg Database*
CDS's bid-ask spread	$CDS\_bid-ask$	basis points	+	*Bloomberg Database*
Stock price	$Stock$	units	-	*Yahoo Finance*
Price-to-sales ratio	P/S	units	+	*Amadeus Database, Compustat Global, Annual Reports, Ycharts*
Stock price volatility	$Stock\_vol$	units	+	*Blomberg Database, own estimation*
12-month Euribor	$Euribor$	basis points	-	*Bloomberg Database*
Deutsche Bank's CDS	$Counterparty$	basis points	+	*Bloomberg Database*
Markit iTraxx Europe index	$iTraxx$	basis points	+	*Bloomberg Database*
DAX index	DAX	EUR	-	*Bloomberg Database*
DAX volatility index	$VDAX$	percent	+	*Bloomberg Database*
Exchange rate	ER	units	+	*Bloomberg Database*
Credit Rating	$Rating$	0/1/2/3	+	*Moody's, S&P*
Downgrade	$Downgrade$	dummy	+	*Moody's, S&P*
Upgrade	$Upgrade$	dummy	-	*Moody's, S&P*

Source: own estimation

The first three variables capture the impact of the respective security's characteristics on bond and CDS spreads. Daily data for all three variables was acquired from the Bloomberg database. We include the mid-price of a bond into regressions to check if the basic theoretical inverse relationship between the bond price and its yield holds for our data and to check if the bond price has any influence on the CDS spread. Correspondingly, the estimated coefficient should be negative and we expect it to be highly significant.

The bid-ask spreads of CDS and bond prices represent a proxy for liquidity. The difference between the ask and bid price of a security describes the cost for an investor who buys a security at the ask price and sells it immediately at the bid price. The lower the cost (i.e. the lower the bid-ask spread), the easier it is to buy or sell a security at its fair value and thus the higher its liquidity is. The low bid-ask spread is a proxy for high liquidity of a security, and it is expected to imply lower CDS and bond spreads, as it is easier to trade a security on a liquid market. We thus expect the estimated coefficient of the bid-ask spreads for both CDSs and bonds to be positive. The bid-ask spreads were calculated based on data from the Bloomberg database as a difference between the ask and bid prices of the bonds and CDS contracts in our sample.

The other set of variables, covering stock prices, price-to-sales ratio, and stock price volatility, represent a company's position in the market. We obtained daily data for each company's stock prices from Yahoo Finance. If the stocks are available in multiple stock exchanges, we have selected the stock exchange in the country of origin of a respective company, so that the prices are expressed in domestic currencies. To make the series comparable across entities we used daily historical exchange rates from the Bloomberg database to convert all domestic stock prices into euros. Also, as London Stock Exchange quotes stock prices in pence, we had to divide the stated prices by 100 to make them comparable. The higher a company's stock is valued by the market, the lower should be the spreads of its bonds and CDSs. The expected sign of the estimated parameters is thus negative.

Price-to-sales (P/S) ratio tells us how the market values one euro of a company's sales. A low P/S ratio may suggest undervaluation of a company, making its stock potentially more attractive. Nevertheless, the market price is usually derived based on expectations about future development and a high P/S ratio therefore indicates that a company has lots of opportunities for growth, which, after the growth had been realized, would bring the P/S ratio into a normal range. The expected relationship is thus negative as a high P/S ratio is an indicator of higher performance of a company, decreasing the bond and CDS spreads . The P/S ratios were constructed based on stock prices obtained from Yahoo Finance, number of outstanding shares obtained from Ycharts and sales values obtained from the Amadeus and Compustat Global databases. Also, if some required figures were not available from the given sources, we found the information in corresponding annual reports. The sales values were stated in domestic currencies, so the stock prices were recalculated only in cases they were expressed in a currency other than the domestic currency. The following formula was used for the calculation.

$$P/S\ ratio = \frac{Stock\ price * Number\ of\ outstanding\ shares}{Sales}$$

For computing the stock price volatility, we followed Molar (2012). The author assessed the performance of various volatility estimators, such as Parkinson, Malison, Garman-Class, or Rogers-Satchell and suggested the Garman & Class (1980) estimator to be the most efficient range base estimator. The stock volatility based on Garman & Class (1980) is demonstrated by the following formula:

$$\begin{aligned} GK_t^2 = 0.511(H_t - L_t)^2 \\ - 0.019\big((C_t - O_t)(H_t + L_t - 2O_t) - 2(H_t - O_t)(L_t - O_t)\big) \\ - 0.383(C_t - O_t)^2 \end{aligned}$$

where H, L, C, and O represent high, low, close, and open prices, respectively. As the second term of the equation is very small, Garman & Klass (1980) also suggest a more practical estimator, which is described as follows:

$$GK_t^2 = 0.5(H_t - L_t)^2 - (2log2 - 1)(C_t - O_t)^2$$

Our variable for stock volatility is calculated based on the second formula, which according to Garman & Klass (1980) achieves the same efficiency as the first one. The expected relationship between stock volatility and bond / CDS spreads is positive, as higher stock volatility decreases the predictability of future developments.

The next group of variables covers market factors, representing the prevailing market conditions. Data for all the market factors was obtained from the Bloomberg database. The first variable is the 12-month Euribor rate that stands for a rate at which a group of European banks lend to each other with the maturity of 12 months. The Euribor serves as a proxy for prevailing interest rates on the market that may have an influence on bond and CDS spreads.

Lower interest rates will motivate companies to issue bonds with low yields, which will in turn decrease the yields on existent bonds. The effect of a move in market interest rates on bond spreads will, however, be delayed. Contrasting arguments may arise concerning the relationship between the prevailing market interest rates and bond and CDS spreads. We follow the argumentation of Blommestein et al. (2016), which state that a rise in interest rates may signal higher economic growth as it may suggest the end of an expansionary monetary policy after economic recovery. Therefore, we expect the estimated relationship to be negative because low interest rates prevail in the trouble periods (central banks are forced to implement expansionary monetary policies), when the default risk is higher, implying higher bond and CDS spreads.

Inspired by Kapar & Olmo (2011) or Arora et al. (2012), we included a proxy for counterparty risk into the set of explanatory variables. To account for general counterparty risk on the CDS market we use data for CDS prices of Deutsche Bank, which is a European bank heavily involved in CDS investment activities. Higher prices of CDSs written on Deutsche Bank's debt suggest higher default probability of the bank, and thus higher counterparty risk. The expected sign of the estimated coefficient of the counterparty risk is positive as the probability of repayment in case of a bond issuer's default is lower.

As a proxy for overall market credit risk we use the Markit iTraxx Europe Index, comprising the 125 most liquid CDS contracts on European companies. To comply with our data we choose five-year maturity index. As the CDS contracts on our 34 sample companies are comprised in the index, the CDS spreads and the Markit iTraxx Europe Index should be positively related and the relationship should be significant. We suppose the relationship with bond spreads to be also positive, although less significant.

The overall conditions on the European stock market are characterized by Deutsche Boerse AG German Stock Index (DAX) and by its volatility (VDAX). DAX is a stock market index comprising 30 major German companies trading on the Frankfurt Stock Exchange. We chose the German index because Germany is the major player on the European market and German companies have a majority representation in our dataset. We expect a negative estimated coefficient as the higher the index, the higher the values of companies and consequently the lower bond and CDS spreads. VDAX measures the implied volatility of DAX index. Higher volatility on the stock market negatively affects the investment environment and overall economic conditions. Therefore, the higher volatility should produce higher bond and CDS spreads.

To control for the currency effect in the pricing of bonds and CDSs, we include daily exchange rates and volatility. Companies in our sample are based in ten different European countries, most of which share the common European currency. Therefore, from the Bloomberg database we acquired daily series of exchange rates of five European currencies with US dollars as the reference currency. The exchange rates are set in a way of how much of a European currency has to be paid for one US dollar. The stronger the currency, the lower the exchange rate is and we thus expect the estimated coefficient to be positive, as the depreciation of a currency is a signal of worsening economic conditions in that country.

Finally, the default risk of the reference entity plays a crucial role for pricing bond and CDS contracts. We use credit ratings as a proxy for default risk. The acquired ratings are for senior unsecured debt in domestic currency from Moody's. If the rating for the senior unsecured debt was not available, we used the rating for long-term debt; alternatively, we used the S&P rating and converted it to the Moody's scale. The ratings prevailing at the end of a year were used for a whole year. Consequently, we divided all the observed ratings into four groups, which are summarized in Table 5. Values 0, 1, 2, and 3 were assigned, respectively, to each of the groups. The probability of default increases with the increasing value and we thus expect the estimated coefficient to be positive, as higher default risk implies by definition higher bond and CDS spreads.

Table 5: Groups of credit ratings

Group 1	Aaa,Aa1,Aa2,Aa3
Group 2	A1,A2,A3
Group 3	Baa1,Baa2,Baa3
Group 4	Ba1,Ba2,Ba3, B1

Source: own estimation

Besides the actual rating, we include dummy variables downgrade and upgrade taking value 1 if a downgrade (upgrade) takes place in a previous year and zero otherwise. We considered the change in rating in previous years to account for the lagged effect of such change. In line with the previous reasoning, we expect the downgrade to have a positive effect and the upgrade to have a negative effect on bond and CDS spreads.

5 METHODOLOGY

The key novelty of this work is describing the differences in pricing of bonds and CDS contracts for various groups of companies. We first estimate the overall model that serves as a benchmark for comparison with various specifications of the model. Several related studies focused on comparing pricing in two time periods, but they mostly compared pre-crisis and crisis periods. The contribution of this work lies in using recent daily data, allowing us to capture the most recent economic developments. To our knowledge, this work is also the first one attempting to empirically model the differences in pricing of corporate bonds and CDS contracts across various groups of companies.

This section provides a description of the methodology used to test our hypotheses. The first hypothesis states that the influential power of some variables differs for the crisis and post-crisis period, as the turbulent economic periods imply lower predictability of variables' development. The creation of the groups of companies and estimation of the bond and CDS spreads for each group allow us to test the hypothesis that the pricing of bonds or CDS contracts is different for individual groups of companies.

More specifically, we assume that the pricing of bonds and CDSs does not differ significantly across the countries in our sample as the European bond and CDS markets are tightly interconnected. We expect, however, that the observed factors are reflected in the bond and CDS prices in a different way across industries and across the financial position of individual entities.

This section first describes our dataset and offers a thorough analysis of the data series with the help of graphs and summary statistics. Then, we check if our data meet all the necessary conditions to obtain valid results and finally, we specify the estimation equation for our model and explain the reasons behind the choice of a particular estimator.

5.1 Data analysis

In this section we analyze the properties of our data to get a general overview and to capture the differences in time and across the groups of companies. Our dataset is characterized as a long panel, meaning that we have more time periods T (1781) than we have cross sections n (34 companies). Also, we consider a balanced panel as we have observations for all time periods per each entity, resulting in a total number of nT, or 60,554 observations.

Our two dependent variables are bond and CDS spreads, which we will estimate one by one with the help of 15 independent variables that were described in the preceding section. The descriptive statistics of all included variables are summarized in Table 20 in Appendix. As can be seen, the bond spreads are not restricted to positive values, as one would expect, i.e. the risk-free interest rate exceeds bond yield in some cases. This phenomenon is apparently most present for the company Nestlé SA. The explanation for the negative bond spreads may be that the market sees the respective debt instrument as very safe, perhaps even safer than the underlying government, allowing the debtor borrow at a rate lower than the risk-free rate. Another explanation is that the market failed to correctly price the factors influencing the bond yield.

We admit that the reason for the negative bond spreads may also be an inappropriate choice of risk-free rate. Nevertheless, after testing for other potential risk-free rates (e.g. government bonds, Euribor) where we obtained even more negative values, we agree with previous research that the swap rates are at present the most accurate proxy for risk-free rates. Moreover, the mean for the bond spreads is 156 basis points and the median is 115, which means that on average the bond spreads are positive and the negative values are only a marginal phenomenon.

The bond spreads in our sample seem to be on average superior to CDS spreads as the means are 156 and 112, respectively. This finding does not support the arbitrage condition, stating that the difference between these two spreads should be zero. The difference between the maximum and minimum values for both bond and CDS spreads is quite significant, but the standard deviation shows that for most of the observations the dispersion is not so high (169 for bond spreads and 103 for CDS spreads).

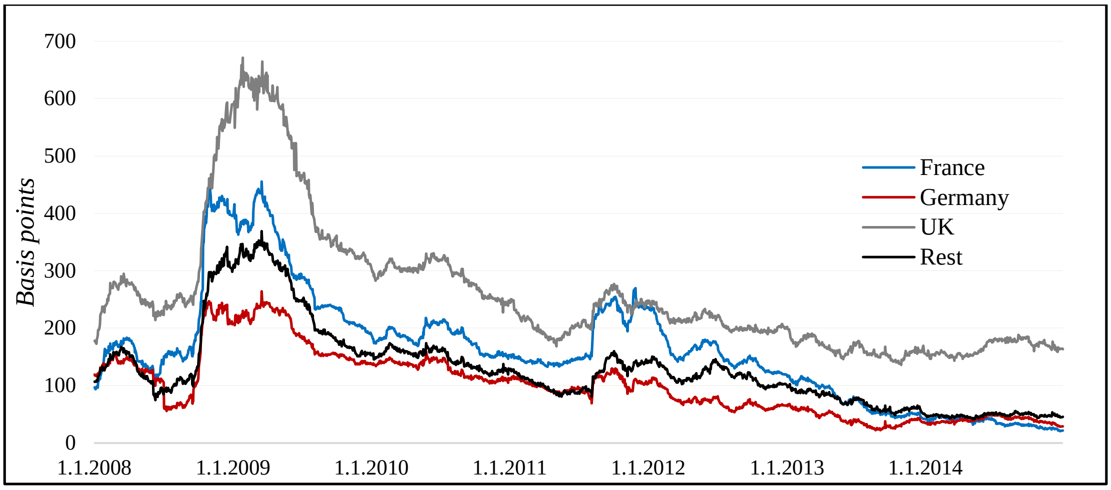
Another unexpected feature of the data are negative bid-ask spreads for CDSs. Theoretically, the ask price should be always superior to bid price as people are not willing to sell a security for a lower price than they would be willing to pay for it. The difference between the ask and bid price constitutes a profit for the market maker. In practice, negative bid-ask spread may occur in highly active markets or in case of highly volatile and high volume trading. The observations with negative bid-ask spreads represent less than 0.2% of the total dataset, which proves the rarity of the negative bid-ask spread's occurrence.

The main purpose of the work is to reveal the pricing differences for individual groups of companies. To prepare for the actual modeling of our parameters of interest, we first visually inspect the data. Figures 3 and 4 show the bond and CDS spreads' development for each country.

The development in both markets and across all countries seems to follow a similar pattern. The spreads grew sharply in 2009 in response to the global financial crisis and then again at a smaller scale at the end of 2011/beginning of 2012 as a consequence of the European debt crisis and other events affecting the stability of the European economy. At the end of 2014, all spreads have been converging towards zero. Overall, the CDS spreads show more volatile behavior.

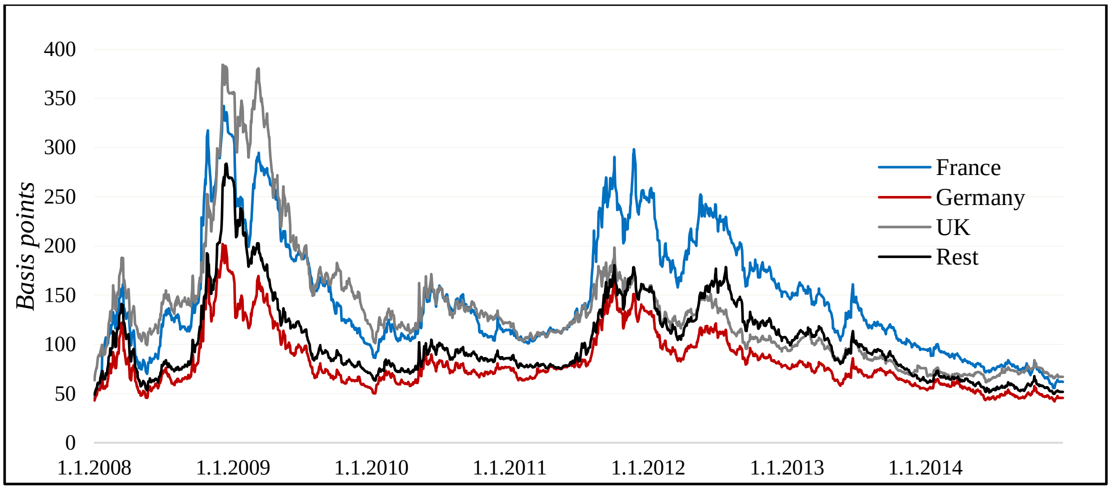
The bond and CDS spreads of British entities reacted the most violently during the world financial crisis as they reached the highest values in 2009. Considering the bond spreads' development, the British entities have been issuing bonds with the highest yields over the entire period. The prices of CDS contracts written on French companies, on the other hand, surged the most during the European debt crisis, as they almost reached the financial crisis levels. The German bonds and CDSs seem to be the most stable over the covered period.

Figure 3: Bond spread development across countries



Source: Bloomberg database, own estimation

Figure 4: CDS spread development across countries



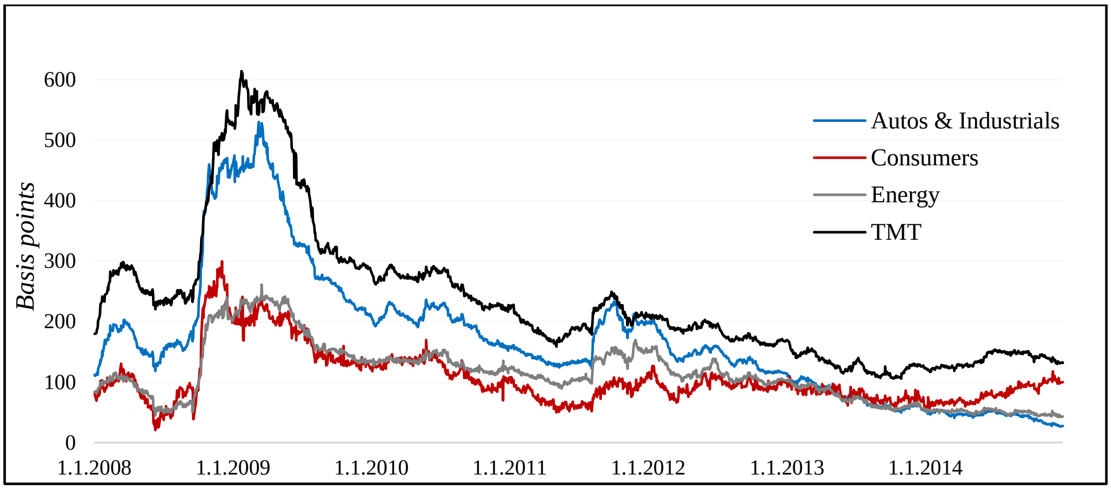
Source: Bloomberg database, own estimation

Another innovation in our research is the industry sector analysis. We decided to omit the Financials sector, as we had only one entity representing this sector. Therefore, we study the differences in pricing financial derivatives across four industry sectors – Autos & Industrials, Consumers, Energy, and Technology, Media & Telecommunications (TMT). Figures 5 and 6 show bond and CDS spread developments for individual sectors.

The highest spreads as well as the highest dispersion show Autos & Industrials and TMT sectors, where Autos & Industrials reach higher spreads in the CDS market and

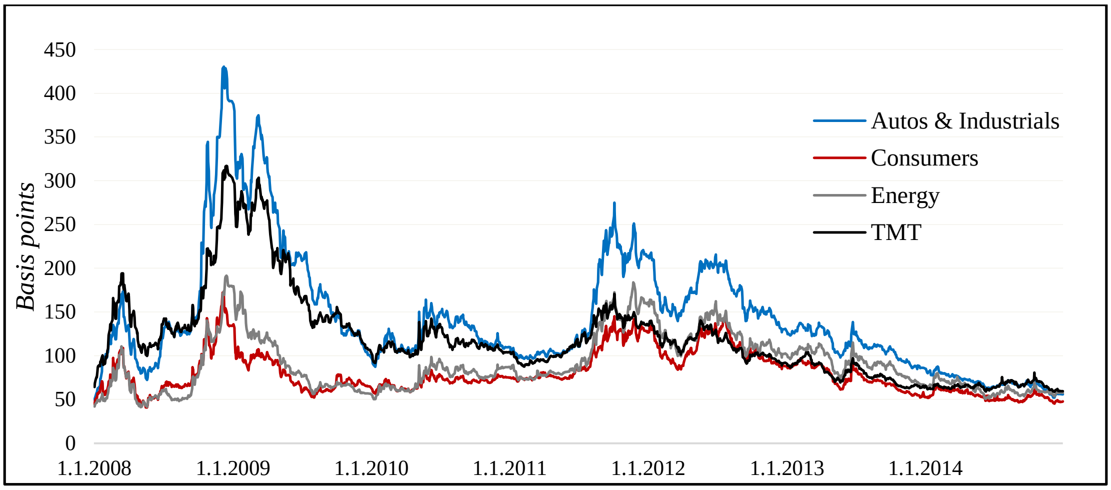
TMT in the bond market. Prices of CDSs in the Autos & Industrials sector reacted the most turbulently on the fragile situation in the European economy in 2012. Financial derivatives in the Consumers and Energy sectors seem to have been influenced by similar factors as their spreads have been developing in a similar way.

Figure 5: Bond spread development across sectors



Source: Bloomberg database, own estimation

Figure 6: CDS spread development across sector

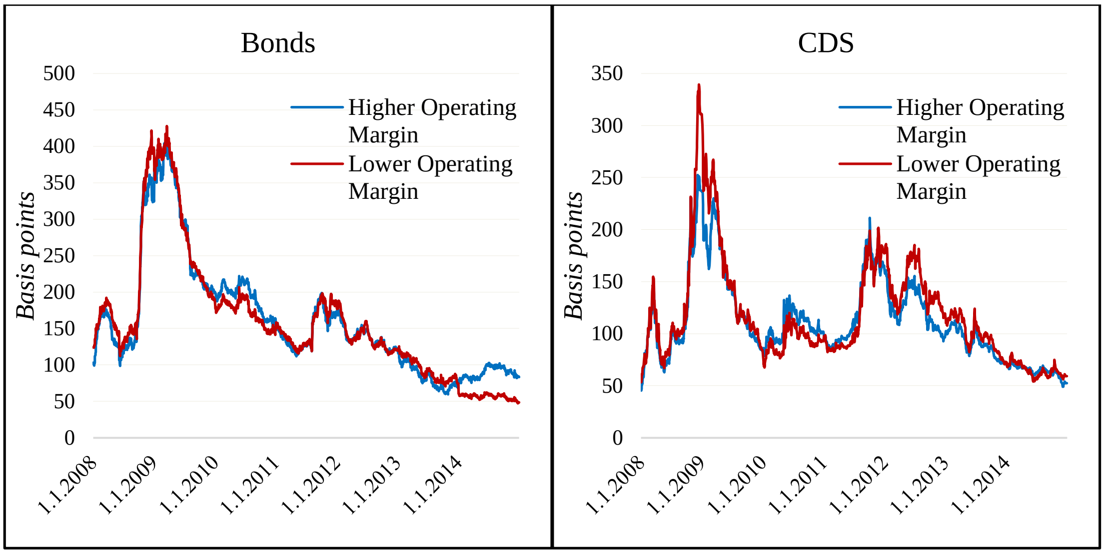


Source: *Bloomberg database, own estimation*

The last criterion for dividing the entities in specific groups is their financial performance. Figures 7, 8, and 9 depict the development of bond and CDS spreads based on the level of individual financial ratios. We split the sample of entities into halves based on their levels of financial ratios. A median for each series was chosen as the value, where we split the sample. The median value for Operating Margin ratio is approximately 1.7, the respective figure for Current Ratio is 0.7, and median for Debt Ratio is 1.1. These values imply that our sample companies have above average profitability, are characterized with under average liquidity, and are slightly more indebted than an average entity in the respective sector.

Neither Operating Margin (OM), nor Current Ratio seem to be too influential on bond and CDS spreads. Figure 7 reveals that CDS prices for less profitable entities (with lower OM) are slightly more volatile and reach higher values in trouble periods. This observation is understandable because CDS contracts written on less profitable entities cost usually more to compensate for higher default risk. Surprisingly, a similar tendency is not present for bond spreads, where we can even observe higher spreads for more profitable companies over the year 2014.

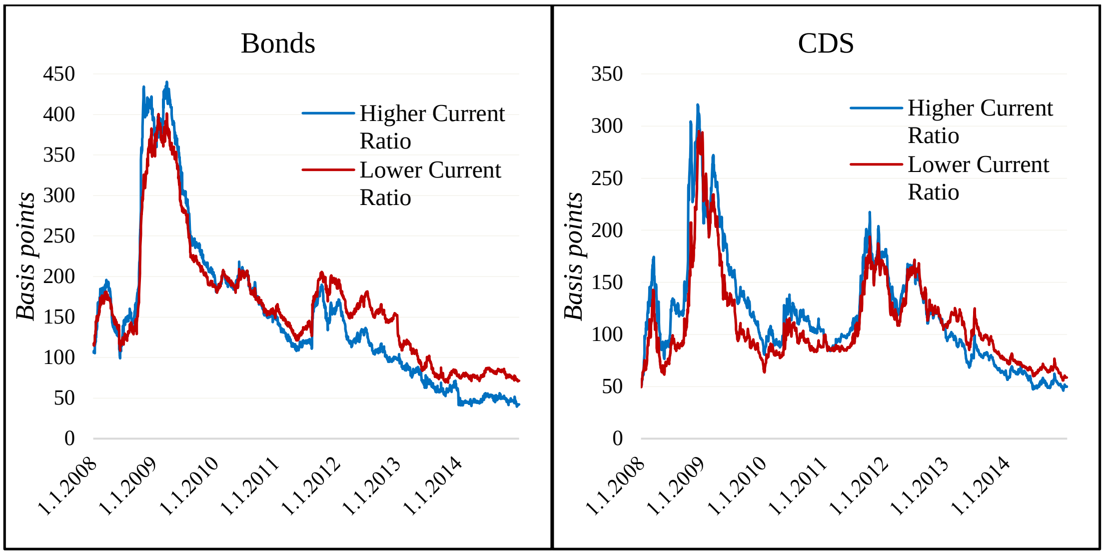
Figure 7: Bond and CDS spread development according to profitability



Source: Bloomberg database, own estimation

Figure 8 shows the development of bond and CDS spreads according to liquidity of the corresponding entities. The overall spread development follows a similar path irrespective of an entity's liquidity. Since 2012, however, liquidity seems to play a more significant role in pricing financial instruments, especially bonds, as the bond spreads for less liquid entities (with lower Current Ratio) reach higher values. This finding suggests that the public has started to place a higher priority on a company's balance sheet instead of its projected cash flows in the post-crisis period.

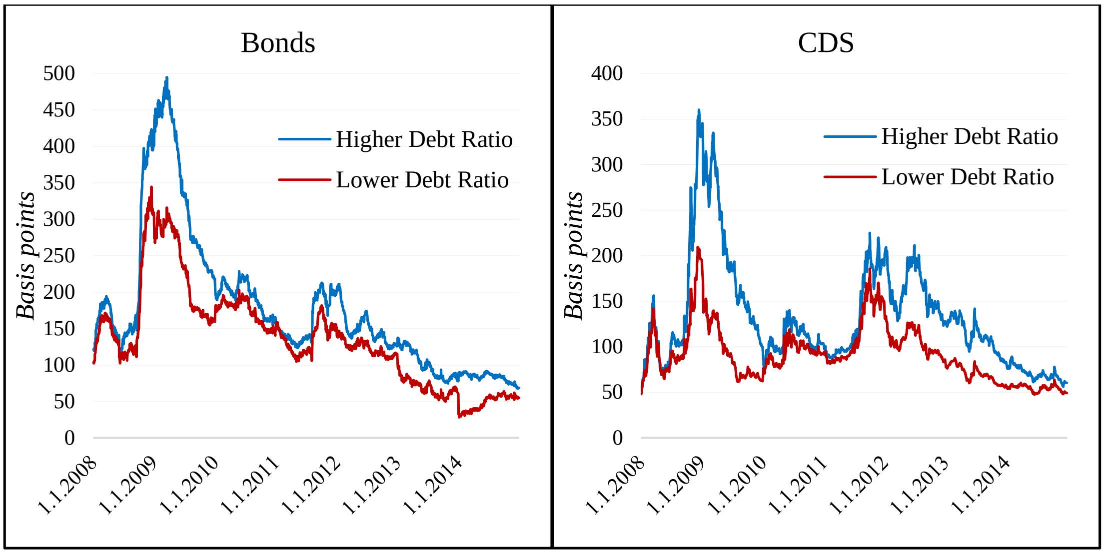
Figure 8: Bond and CDS spread development according to liquidity



Source: Bloomberg database, own estimation

Unlike the previous two ratios, the Debt Ratio seems to play a non-negligible role in pricing bond and CDS spreads. For both bond and CDS spreads we can observe in Figure 9 that the more indebted an entity is, the higher the corresponding bond and CDS spreads. This phenomenon is particularly evident during financial crisis period. The observation suggests that we might reveal different parameters of interest as some determinants may show themselves more significant or having higher influence on bond and CDS spreads for more or less indebted entities.

Figure 9: Bond and CDS spread development according to indebtedness



Source: *Bloomberg database, own estimation*

5.2 Testing

Before estimating parameters of interest, we need to test our variables to reveal potential problematic properties of the data that could bias our estimates or standard errors. To prevent spurious regression that could reveal a significant relationship between variables even in case of a non-existing relationship, we employ several unit root tests. The unit roots tests indicate whether a variable is stationary or contains a unit root process. To get correct results all variables have to be stationary, i.e. a shock to the system cannot be persistent.

The recent research proposed a number of panel unit root tests, which showed to be more efficient than applying individual unit root tests on each time series. Maddala & Wu (1999) and Choi (2001) proposed a Fisher type test based on combining p-values from unit root tests for each cross-section (Baltagi, 2008). The test allows for a heterogeneous coefficient of the first lag across cross-sections, which is a reasonable assumption for real data. The Fisher-type test is the only panel unit root test allowing for data with gaps and is therefore suitable for our case as our time series contain gaps of non-trading days.

Maddala & Wu (1999) compared three panel unit root tests most commonly used in practice – Levin, Lin and Chu; Im, Pesaran and Shin; and Fisher type tests – and concluded for the Fisher-type test to perform the best. We therefore use the Fisher type test as the primary tool to test the presence of unit root process in our data. Moreover, we apply the Phillip-Perron option for the test as it is robust to serial correlation.

The null hypothesis of the Fisher type test is that all time series contain a unit root against the alternative that at least one time series is stationary. Given the inconclusive alternative hypothesis, even the rejection of the null does not imply a clear conclusion about the properties of our data. Therefore, we reorganize our dataset so that we can check if our series is stationary with other panel unit root tests not allowing for gaps in time series.

Levin et al. (2002) proposed a panel unit root test assuming a common unit root process for all cross-sections. Levin, Li and Chu (LLC) test tests the null hypothesis stating that each individual time series contains a unit root against the alternative that each time series is stationary (Baltagi, 2008). The assumptions of the LLC test are restrictive and not suitable for our data; we therefore consult the test only as a supplementary measure.

Among the most widely used panel unit root tests is classified also the Im, Pesaran and Shin (IPS) test proposed by Im et al. (2003). The IPS test lets out the restrictive assumption of homogeneous autoregressive parameters. The null hypothesis assumes that each time series contains a unit root and the alternative allows for some (but not all) of the series to contain unit root (Baltagi, 2008). We use the IPS test to check the validity of the Fisher type test.

The applied panel unit root tests offer an option to subtract the cross-sectional means. We use this option for the security-specific variables, i.e. bond and CDS spreads, bond price, and bond and CDS liquidity, to control for cross-sectional dependence. We suppose the cross-sectional dependence to be the most apparent security-specific variables as they are closely related to the development of the correspondent security's market. For the market variables, we do not use any specification as the time series are the same for each entity.

The number of lags is specified by Akaike information criterion, which is offered by the LLC and IPS tests. After consulting the LLC, IPS and Fisher type unit root tests, we conclude that our variables, except for the DAX index, do not contain unit root. The DAX index is an integrated I(1) process, meaning that after differencing, the series becomes stationary. Therefore, we will run regressions with stationary series, implying that we do not have to deal with spurious regression issues.

Another common issue in panel data analysis is the presence of serial correlation, which may bias standard errors and make the results less efficient. We use a test for serial correlation proposed by Wooldridge (2002) with the null hypothesis of no serial correlation and the alternative suggesting the presence of first-order autoregressive AR(1) process. We reject the null hypothesis, implying that we have to deal with AR(1) serial correlation in our panel data.

The Hausman specification test, proposed by Hausman (1978), reveals the need of using fixed effects specification in our model. Therefore, to be able to use fixed-effects regression model estimated by the ordinary least squares (OLS), we need to test for a standard assumption of independent and identically distributed errors (Baum, 2001).

First, we use the modified Wald statistic to test for groupwise heteroscedasticity, i.e. if the error variance differs across cross-sections. The test is robust even in case of violation of the normality assumption. The low p-value of the test suggests that we should reject the null hypothesis of no groupwise heteroscedasticity.

Another reason behind the violation of the assumption of independent and identically distributed errors may be contemporaneous correlation, or cross-sectional dependence. The Breusch & Pagan (1980) Lagrange multiplier test statistic tests the null hypothesis of cross-sectional independence. Based on the resulting p-value equal to zero, we reject the null and consequently, we have to control for both groupwise heteroscedasticity and cross-sectional dependence in our model.

Finally, violation of the exogeneity assumption may have effect on the validity of our estimates. We suspect our data to suffer from the endogeneity issue due to the causal relationship between bond and CDS spreads. The bond and CDS markets are closely interrelated, and we expect that the present value of bond spreads is influenced by the value of the corresponding CDS spread the day before and vice versa. This relationship is supported in previous related literature, such as Coudert & Gex (2010).

Blommestein et al. (2016) encountered a similar issue in their model and suggested to use lagged independent variable as an instrumental variable. Therefore, we follow their suggestion and include the lagged bond/CDS spreads series as an instrument for the potentially endogenous bond/CDS spreads variable. The estimates from the regression with the lagged variable does not reveal significantly different results. We thus use the initial specification as the inclusion of the lagged independent variable may cause additional problems (Nickell, 1981). Nevertheless, we are aware of the potential issue and we focus thus more on describing the relationship between the variables rather than on estimating the effect of one variable on the other.

5.3 Model specification

Before choosing the appropriate model for estimating the parameters of interest, we first adjust several variables. Those variables that are not expressed in basis points or in percent or are not dummies were taken in logarithm to get elasticities, allowing for an easier interpretation of results. We had to deal with zero values for stock volatility as the logarithm of zero is not specified. We followed a standard procedure used in literature and added a constant of 1 to the series values. To account for the I(A) process contained in the DAX index, we transformed the series into continuous returns in the following way.

$$\log(\frac{DAX_t}{DAX_{t-1}})$$

Finally, the initial estimation equation for estimating bond spreads, including the explanatory variables described in the preceding chapter, is structured as follows:[2]

$$Bond\ spread_{it} = \beta_0 + \beta_1\ CDS\ spread_{it} + \beta_2 Bond\ price_{it} + \beta_3 Bond\ bid - ask_{it} + \beta_4 CDS\ bid - ask_{it} + \beta_5 \log(Stock)_{it} + \beta_6 \log(P/S)_{it} + \beta_7 \log(Stock\_vol)_{it} + \beta_8 Euribor_{it} + \beta_9 iTraxx_{it} + \beta_{10} \log(DAX)_{it} + \beta_{11} VDAX + \beta_{12} \log(ER)_{it} + \beta_{13} Rating + \beta_{14} Downgrade + \beta_{15} Upgrade + u_i + \varepsilon_{it}$$

$$i = 1, \dots, 34$$

$$t = 1, \dots, 1781$$

Based on the Wooldridge (2002) serial correlation test, we have concluded that our data is characterized by AR(1) process. The autoregressive process contained in errors is described by the following equation:

$$\varepsilon_{it} = \rho \varepsilon_{it-1} + \xi_{it}$$

where ρ stands for an autoregressive parameter, establishing the autocorrelation relationship of errors. As the presence of serial correlation and heteroscedasticity in our sample violates the Gauss Markov theorem, the OLS and Fixed Effects (FE) regressions may produce biased results (Wooldridge, 2002).

Several procedures exist to correct for the presence of autocorrelation, such as inclusion of a lagged dependent variable into the model, differencing, Generalized Least Squares (GLS) estimation with AR(1) disturbances, or Prais-Winsten estimation. Nickell (1981) states that the inclusion of the lagged dependent variable may cause severe biases of other independent variables. Differencing is too restrictive as it assumes ρ to be equal to 1 across all cross-sections.

To test the appropriateness of the GLS models, we implement two approaches - Baltagi & Wu (1999) estimation and feasible GLS (FGLS) estimation with panel-specific AR(1) disturbances. Baltagi-Wu GLS model estimates an aggregate AR(1) process,

[2] The estimation equation for CDS spreads is analogous.

whereas FGLS allows for different autoregressive parameters across panels. As FGLS model accounts for heterogeneity across panels, we prefer this model to the Baltagi-Wu specification.

The Prais-Winsten estimator proposed by Prais & Winsten, (1954) controls also for contemporaneous correlation in addition to the serial correlation and heterogeneity across panels. Different estimates produced by the Prais-Winsten estimator compared to FGLS suggest the presence of significant correlation in errors, which implies possible biases of FGLS results. Therefore, we apply the Prais-Winsten model with panel-corrected standard errors that proposes the best fitted solution on our data and allows us to estimate the pure effect of the determinants after controlling for AR(1).

The Prais-Winsten estimator is a common option in literature for estimating panel data model containing AR(1) process. Among others, the Prais-Winsten estimator was implemented in Gatto et al. (2008), Ismail et al. (2009), and Leblang & Mukherjee (2005) where influential factors of mean and volatility of stock prices were examined.

The Prais-Winsten estimation is based on transformation of the model to get rid of the AR(1) process contained in data. It is an iterative GLS procedure that repeatedly estimates the coefficients and autoregressive parameters ρ until the convergence of ρ. The Prais-Winsten procedure follows these steps (Plumper, Troeger, & Manow, 2005):

1. Estimate the standard linear regression: $y_{it} = \beta x_{it} + \varepsilon_{it}$
2. Estimate the autoregressive parameter ρ by the equation: $\varepsilon_{it} = \rho\varepsilon_{it-1} + \xi_{it}$
3. Transform the data for $t > 1$ in the following way:
   $y_{it} - \rho y_{it-1} = \beta(x_{it} - \rho x_{it-1}) + \varsigma_{it}$
4. Transform the data for $t = 1$ in the following way:
   $\sqrt{1-\rho^2}y_1 = \beta\sqrt{1-\rho^2}x_1 + \sqrt{1-\rho^2}\varsigma_1$
5. Repeat the whole process until the convergence of ρ

We suppose that the Prais-Winsten transformation of our data allows us to produce consistent and efficient estimates, and the delivered results are thus reliable.

6 RESULTS

In this section, we present results from our empirical analysis. We are aware of a potential sample selection bias as the sample entities were not chosen randomly. Our sample includes only European entities with most traded CDS contracts. Therefore, the presented results are valid only for our sample and may not be generalized across all entities.

The aim of the empirical analysis is to stress the differences in pricing of bonds and CDS contracts across various specifications of the model. To present our findings in a meaningful way, we structure this section as follows. First, we provide regression results together with interpretation of coefficients of the benchmark model. Next, we run the separate regressions for data covering crisis and post-crisis periods and we compare the two sets of estimates. Finally, we proceed with presenting the results for various subsamples that we created based on geographical, industry sectors, and financial criteria.

6.1 Overall model

In this section we describe the benchmark regression output, resulting from whole sample estimations. We run separate regressions for bond spreads and CDS spreads as a dependent variable, including the other variable among independent variables. First, we provide regression results for bond spread estimation and later, we compare the acquired results with the CDS spread estimation.

Table 6 shows the estimation results for bond spreads as the dependent variable. We can see that the model is well specified. Most of the variables are statistically significant (only two variables are not significant at 0.05 level), which justifies their inclusion into the model. The R-squared of 79 percent is high, but we have to take into account that we estimate the transformed model, so the indicated R-squared may have a slightly different meaning than how much of observed variation in bond spread is explained by the independent variables.

Table 6: Overall estimation of bond spreads

Prais-Winsten regression, correlated panels corrected standard errors (PCSEs)

Group variable: Company	Number of obs = 60520
Time variable: Day	Number of groups = 34
Panels: correlated (balanced)	
Autocorrelation: panel-specific AR(1)	R-squared = 0.7933
	Wald chi2(16) = 35754.73
	Prob > chi2 = 0.0000

$Bond\_spread$	Coefficient	Panel-corrected Std. Err.	p-value
CDS_spread	.203	.008	0.000
$Bond\_price$	-13.039	.088	0.000
$Bond\_bid-ask$	3.920	.554	0.000
$CDS\_bid-ask$	.038	.018	0.029
$Log(Stock)$	-4.795	.473	0.000
$Log(P/S)$	-7.612	1.00	0.000
$Log(Stock\_vol)$	23.748	14.2	0.095
$Euribor$	-.354	.017	0.000
$Counterparty\_CDS$	-.049	.023	0.034
$iTraxx$	.137	.036	0.000
$Log(DAX)$	39.881	5.11	0.000
$VDAX$	.192	.075	0.011
$Log(ER)$	-5.520	2.76	0.045
$Rating$	65.283	1.53	0.000
$Downgrade$	1.687	1.40	0.228
$Upgrade$	-15.499	2.58	0.000
$rhos$	.97805 .98442	.97333 .98422 .98354	… .97117

Source: own estimation

The last line of the regression results provides the support for the choice of the model. Rhos, the autoregressive parameters, are high and vary across panels suggesting that the Prais-Winsten estimator with panel-specific AR(1) processes was a meaningful choice. The number of observation is 60,520 out of possible 60,554 due to the DAX index variable, which we had to difference and thus lost the first observation for each panel.

The most influential variable shows to be credit rating. The coefficient suggests that, assuming all other factors fixed, the entities in our sample possessing the worst credit rating have bond spreads 195 basis points higher on average in comparison to the best rated companies.[3] The economically significant coefficient of rating proves the importance of default risk while pricing the bonds. The more likely a bond is to default, the higher premium in form of a higher yield investors require.

Variable upgrade is also very influential suggesting that a bond upgraded in a previous year shows a lower spread than a bond keeping an unchanged rating. More specifically, the occurrence of rating upgrade in previous year lowers this year's bond spread on average by 15 basis points, keeping other factors fixed. On the other hand, downgrading of a bond does not seem to have any effect on bond spread. All in all, the prevailing credit rating of a bond is a more important determinant of bond spreads than any former rating change. Moreover, the impact of upgrade/downgrade on bond spreads might be overweighed as we give an entity a value of 1 if it has been upgraded/downgraded just one notch, whereas the individual rating groups cover several ratings (notches).

Regarding the firm-specific determinants, the positive and statistically significant coefficient of CDS spread proves the interconnection between bond and CDS markets and the positive relationship between bond and CDS spreads. The significantly negative coefficient of bond price proves the theoretical relationship between yield and price. For our sample, a one basis point increase in bond price decreases the bond spread by 13 basis points, keeping other factors fixed. Both bond and CDS liquidity positively influence bond spread, although the CDS liquidity's influence is less economically and statistically significant. Stock prices, P/S ratio, as well as stock price volatility have expected coefficients, but the volatility is only significant at a 0.1 level. The economic effect of either stock price or P/S ratio is, however, not substantial.

[3] We have created four groups of entities based on their credit rating. The groups are arranged from the best rated ones and labeled by numbers 0, 1, 2, and 3, respectively. Based on the estimation results, an entity belonging to group 1 would have a bond spread 65 basis points higher on average compared to the entities in group 0. Therefore, the worst rated entities in group 3 have bond spreads 3*65=195 basis points higher on average compared to entities in group 0.

Market variables are generally significant with Euribor, iTraxx index and DAX index volatility having expected signs of coefficient. The Deutsche Bank CDS, DAX index, and exchange rate, on the other hand, do not correspond to our expectations about their influence on bond spreads. Neither Deutsche Bank CDS, nor exchange rate seem to be too significant. The most surprising is the regression result for DAX index that reveals to be strongly positively related to bond spreads. The reason behind the surprising coefficient may be the inclusion of continuous DAX returns instead of DAX index in levels as the regression with the DAX index in levels reveals an expected negative coefficient.

Table 7: Overall estimation of CDS spreads

Prais-Winsten regression, correlated panels corrected standard errors (PCSEs)

Group variable:	Company	Number of obs	= 60520
Time variable:	Day	Number of groups	= 34
Panels:	correlated (balanced)		
Autocorrelation:	panel-specific AR(1)	R-squared	= 0.8199
		Wald chi2(16)	= 44682.51
		Prob > chi2	= 0.0000

CDS_spread	Coefficient	Panel-corrected Std. Err.	p-value
$Bond\_spread$	.289	.004	0.000
$Bond\_price$	-2.840	.062	0.000
$Bond\_bid-ask$	4.41	.742	0.000
$CDS\_bid-ask$	.561	.028	0.000
$Log(Stock)$	3.701	.316	0.000
$Log(P/S)$	-1.284	.261	0.000
$Log(Stock\_vol)$	10.259	18.8	0.586
$Euribor$	-.105	.005	0.000
$Counterparty\_CDS$	.153	.015	0.000
$iTraxx$	.639	.021	0.000
$Log(DAX)$	-22.732	3.49	0.000
$VDAX$	-.011	.049	0.817
$Log(ER)$	-1.664	.468	0.000
$Rating$	23.310	.710	0.000
$Downgrade$	-2.137	.929	0.021
$Upgrade$	15.677	1.73	0.000
$rhos$	.8402 .9067	.8356 .8583 .9737 …	.8690

Source: own estimation

As in the case of the bond spread regression, almost all coefficients in the CDS spread regression (depicted in Table 7) are significant. We still have two insignificant variables at 0.05. Besides the stock volatility, DAX index volatility also becomes insignificant compared to the bond spread estimation, whereas exchange rate becomes significant, but with an unexpected sign of coefficient. The insignificance of market volatility correspond to the findings of Kapar & Olmo, 2011, whose data also did not support the expected positive relationship between market volatility and CDS spreads. R-squared is comparable to the bond regression, implying that our set of independent variables is suitable to explain as much variation in bond spread as in CDS spreads. This suggests that pricing of bond and CDS markets respond to similar factors.

In line with findings of Blanco et al. (2005), the proxy for CDS liquidity becomes more economically significant in the CDS spread regression. Nevertheless, the influential power of bond liquidity is still stronger. The explanation may be that the observations of bid-ask spreads are substantially more dispersed for CDSs, implying that a one basis point change is more common for CDS bid-ask spread and has thus lower explanatory power. In addition, CDS spreads may be more influenced by the corresponding bond characteristics rather than on the other way around.

The stock price, unlike the P/S ratio, does not have an expected sign of coefficient, but the economic significance of both variables is negligible, as one percent change in stock price or P/S ratio would imply less than 0.04 basis point change in CDS spread, assuming all other factors fixed.[4]

From the market variables, the proxy for counterparty risk and DAX index reveal a change compared to the bond spread estimation. Both factors have the expected influence on CDS spreads. Kapar & Olmo (2011) states that the counterparty risk has started to be priced in CDS contracts since the break of the financial crisis in reaction to the collapse of some CDS dealers during the most recent crisis. Therefore, the more likely Deutsche Bank, as a CDS seller, is to default, the higher its CDS spreads are, which should increase the corporate CDS spreads, as the counterparty risk is higher.

[4] An interpretation of a coefficient in case of level-log regression is governed by the following equation: $\Delta y = \frac{\beta}{100} \% \Delta x$ (Wooldridge, 2002).

This variable has understandably a negligible influence on bond spreads as investors are in that case interested only in default probability of the bond issuer, and not of the CDS issuer.

Credit rating is still the most influential factor, but its explanatory power tends to be lower for CDS spreads. The reason may be that the corporate CDS spreads are influenced more by other factors, such as the counterparty risk or the market credit risk, given by iTraxx index, and thus consider less the default risk of the respective entity. The dummies for downgrade and upgrade do not correspond to our expectations, suggesting that other unobserved factors may exist, influencing the estimated coefficients.

Our findings support the study of Fontana & Scheicher (2010) that found the credit market information, represented by the iTraxx index, plays a major role in pricing of bonds and CDSs, whereas market volatilities are not important determinants. The authors provided an evidence of a stronger relation of the iTraxx index with CDS spreads than bond spreads, which is also in line with our findings. Another common feature with previous studies is the effect of credit quality, proxied by credit rating, which appears to be strong and significant for both spread regressions, as was suggested, for instance, by Blanco et al. (2005).

6.2 Differences in time

To observe the pricing differences of bonds and CDSs in different time periods, we divide our sample into two parts. We want to distinguish the pricing strategies in the crisis and post-crisis period. Therefore, the crisis period in our sample is defined from the beginning of 2008 until the end of 2011. The post-crisis period stretches from the beginning 2012 until the end of 2014. In the first part of this section we study pricing differences over time for bonds and we follow up with an examination of pricing determinants of CDSs over time.

Table 8 depicts the substantial differences in estimation results for corporate bond spreads over different time periods. In the below table, the first column summarizes the results from the whole period regression; the second and the third columns present the results for the crisis and post-crisis periods, respectively; and the last column indicates, whether the estimated results are similar over all three model specifications or not.

Table 8: Bond spread estimation – specific time period

$Bond\_spread$	Overall	Crisis	Post-crisis	Similarity
CDS_spread	.203***	.180***	.228***	✓
$Bond\_price$	-13.039***	-14.094***	-5.710***	✓
$Bond\_bid-ask$	3.920***	2.847***	7.675***	✓
$CDS\_bid-ask$	.038**	.049*	.011	✗
$Log(Stock)$	-4.795***	-4.691***	-5.028***	✓
$Log(P/S)$	-7.612***	-2.042	.408	✗
$Log(Stock\_vol)$	23.748*	17.778	-7.028	✗
$Euribor$	-.354***	-.435***	-.328***	✓
$Counterparty\_CDS$	-.049**	-.026	-.044	✓
$iTraxx$	.137***	.148**	.039	✗
$Log(DAX)$	39.881***	47.851***	8.546	✗
$VDAX$	.192**	.280**	-.203	✗
$Log(ER)$	-5.520**	-12.165***	-14.250***	✓
$Rating$	65.283***	51.375***	28.941***	✓
$Downgrade$	1.687	.580	6.699***	✗
$Upgrade$	-15.499***	-3.269	1.389	✗
$R-squared$	0.7933	0.8359	0.4253	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

A substantially lower R-squared together with less significant variables for the post-crisis estimation suggest that bond spreads are influenced by other unobserved factors. These unobserved factors are more pronounced in the post-crisis period, which is characterized by numerous events affecting the European economy, such as the European debt crisis or the Greek crisis.

The most important determinants of bond spreads seem to be bond price, bond bid-ask spread, and rating, which keep their statistical and economic significance over all three specifications, suggesting that firm-specific variables are the major determinants, which is in contrast with Blanco, et al. (2005), stating that bond spreads react more to market variables. Stock price, Euribor, and exchange rate are reflected in bond spreads in a similar manner over the entire studied period, but their explanatory power is lower.

On the other hand, some factors cease to be significant for pricing bond spreads in the post-crisis period, such as the iTraxx index, the DAX index, or its volatility. These finding prove that bond spreads after 2011 are less dependent on market conditions, and more on idiosyncratic factors. Based on the different estimation results under various specifications, we may conclude that pricing of bond spreads is time dependent, as was suggested, for instance, by Fontana & Scheicher (2010).

Table 9: CDS spread estimation – specific time period

CDS_spread	Overall	Crisis	Post-crisis	Similarit
$Bond\_spread$	.289***	.474***	.115***	✓
$Bond\_price$	-2.840***	-.855***	-2.677***	✓
$Bond\_bid-ask$	4.41***	-.737	10.456***	×
$CDS\_bid-ask$	.561***	.842***	.107***	✓
$Log(Stock)$	3.701***	12.623***	-.658**	×
$Log(P/S)$	-1.284***	-3.424***	-5.083***	✓
$Log(Stock\_vol)$	10.259	3.898	9.366	✓
$Euribor$	-.105***	.025***	.023	×
$Counterparty\_CDS$	.153***	.203***	.089***	✓
$iTraxx$	.639***	.574***	.741***	✓
$Log(DAX)$	-22.732***	-28.218***	-30.066***	✓
$VDAX$	-.011	-.048	-.289***	×
$Log(ER)$	-1.664***	-9.334***	8.267***	×
$Rating$	23.310***	25.617***	16.346***	✓
$Downgrade$	-2.137**	-9.388***	10.177***	×
$Upgrade$	15.677***	50.428***	9.079***	✓
$R-squared$	0.8199	0.8688	0.8914	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Table 9 shows the regression results for estimating CDS spreads in different time periods. Unlike the regressions for bond spread, CDS spread regressions reveal similar R-squared, implying that the covered variables are able to explain similar amount of variation in CDS spreads under all three specifications. The significance of variables is also comparable, except for bond bid-ask spread, Euribor, and volatility of DAX index. The bond bid-ask spread reveals no effect on CDS spread during the crisis, whereas it becomes a highly significant determinant in the post-crisis period. The significant influence of bond bid-ask spread, as well as bond price, on pricing CDS spreads suggests that the bond and CDS market are more interconnected since 2012.

The explanatory power of several variables on CDS spreads seem to stay stable over the whole period. The stock price volatility, for instance, stays insignificant and it is therefore not reflected in the pricing of CDS spreads. The counterparty CDS, the iTraxx and DAX indices, on the other hand, reveal an expected statistical significant influence on pricing CDS spreads over the whole period. It implies that CDS spreads are on average affected more by market factors than entity-specific factors, which is again in contrast to the findings of Blanco, et al. (2005).

Most of the estimated results, however, differ significantly for the two time periods. The signs of coefficients of stock price, downgrade, and exchange rate do not correspond to our expectations for the crisis period, whereas their predicted influence in the post-crisis period is as expected. This signifies the unpredictability of economic activity during crisis periods. Just as for bond spreads, we conclude that a specific time period matters for pricing corporate CDS spreads, which was concluded by Blommestein, et al. (2016) as well.

6.3 Subsampling

Several previous works studied the differences in determinants of bond and CDS spreads across various time periods. We extend the related literature by estimating the differences also across various groups of entities. We divide the sample based on three criteria. First, we create groups of entities linked by geographical location, next, we use industry sector as a criterion for the sample division, and finally, we split the sample of entities based on their financial position.

6.3.1 Geographical division

First, we divide the entities into four groups based on their geographical location. The four country groups are: Germany, France, United Kingdom, and rest of countries, which cover Belgium, Finland, Italy, Norway, Sweden, Switzerland, and the Netherlands. The regression results for individual country groups are depicted in the following table. Again, we include the last column indicating whether the results are similar across the country groups or not.

Table 10: Bond spread estimation – specific country group

$Bond\_spread$	Germany	France	United Kingdom	Rest	Similarity
CDS_spread	.223***	.077***	.174***	.062***	✓
$Bond\_price$	-12.962***	-7.205***	-15.434***	-11.04***	✓
$Bond\_bid-ask$	2.529**	3.384***	3.118***	-.671	×
$CDS\_bid-ask$	-.031	.024	.152***	.004	×
$Log(Stock)$	-74.191***	-1.774***	.350	-13.01***	×
$Log(P/S)$	60.617***	15.066***	16.741***	-1.851	×
$Log(Stock\_vol)$	65.991***	10.477	-168.480*	12.818	×
$Euribor$	-.242***	-.104***	-.493***	-.230***	✓
$Counterparty\_CDS$	-.030	-.059***	-.033	-.038*	×
$iTraxx$	.115***	.113***	.352***	.158***	✓
$Log(DAX)$	34.793***	.597	26.288***	31.124***	×
$VDAX$	.179**	.248***	.071	.159**	×
$Log(ER)$	112.44***	69.513***	77.319***	15.155***	✓
$Rating$	-36.138***	23.646***	80.734***	21.219***	×
$Downgrade$	-1.352	5.279***	-18.518***	-1.297	×
$Upgrade$	(omitted)	.512	-42.925***	11.112***	×
$R-squared$	0.7394	0.3308	0.9550	0.6398	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

From the first look, we can see that the results differ substantially across the countries. The significance of the variables is lower for the Rest group and France, for which the

R-squared is considerably lower. This finding suggests that, especially bonds of French entities, are influenced by idiosyncratic factors that are not included in our model. The included variables, on the other hand, seem to explain a high amount of variation in bond spreads for British entities as the R-squared reaches almost 96 percent.

CDS spread, bond price, Euribor, iTraxx index, and exchange rate influence bond spreads in a similar way across the countries. Exchange rate reveals expected signs of coefficients unlike the overall regression. The reason is that the country subsampling allows us to focus on the effect on bond spreads of appreciation or depreciation of a currency over time rather than by comparing the prevailing level of exchange rates across countries. The positive coefficients indicate that currency depreciation with respect to US dollars increase the corporate bond spreads as it may be a signal of worsening economic conditions in the respective country. Exchange rate seems to play the most important role for pricing bonds in Germany.

Some variables, such as bond bid-ask spread or P/S ratio differ only for the group of remaining countries. The group Rest is rather heterogeneous as it includes prosperous countries, such as Switzerland or the Netherlands, but also Italy, which suffered significantly from the impacts of the financial crisis. We checked the results individually for Italian entities and they did not substantially differ from the rest of countries. We thus do not assume them to cause any substantial bias, which could be produced by some outliers.

The remaining variables differ across countries mainly in their statistical significance, as they are statistically significant at a 0.01 level for some countries and not significant even at a 0.1 level for other countries. The exceptions are the dummy variables for ratings, which differ also in the sign of coefficients. An explanation for this phenomenon may be that we focus more on the time dimension due to the subsampling. The credit ratings are more significant for pricing bonds while distinguishing among individual entities and their development in time is probably not so deterministic for pricing bonds of a specific entity.

One may argue that the geographical division is not too meaningful in our case as the entities in the sample are spread out all over the Europe and are thus not influenced solely by factors specific to the country, where the headquarters of a parent company is located. Nevertheless, subsidiaries across Europe are governed by the decisions of parent companies, which are largely influenced by the conditions in the domestic market.

We proceed in the same way while estimating CDS spreads. Table 11 shows the regression results for CDS spreads with respect to the four country groups. The R-squared figures reveal that the included variables explain the largest variation in CDS spreads for British entities, as was the case for bond spreads.

Table 11: CDS spread estimation – specific country group

CDS_spread	Germany	France	United Kingdom	Rest	Similarity
$Bond\_spread$	.354***	.091***	.346***	.135***	✓
$Bond\_price$	-1.059***	-1.271***	-1.509***	-2.144***	✓
$Bond\_bid-ask$	5.876***	2.595***	-13.996***	24.86***	×
$CDS\_bid-ask$	.214***	.746***	.886***	.677***	✓
$Log(Stock)$	-92.586***	9.049***	-10.070***	-23.77***	×
$Log(P/S)$	76.541***	-12.74***	-5.989***	5.526***	×
$Log(Stock\_vol)$	77.459***	11.839	128.731	-27.16	×
$Euribor$	-.020	-.008***	.032***	-.082***	×
$Counterparty\_CDS$	.202***	.038***	-.095***	.006	×
$iTraxx$	.642***	.596***	.730***	.794***	✓
$Log(DAX)$	-39.707***	-31.46***	-27.422***	-30.82***	✓
$VDAX$	.341***	.331***	.040	-.196***	×
$Log(ER)$	-2.718	28.535***	132.10***	25.217***	×
$Rating$	53.780***	22.862***	30.634***	21.065***	✓
$Downgrade$	4.394***	2.244***	-49.556***	27.865***	×
$Upgrade$	(omitted)	16.587***	38.303***	18.378***	×
$R-squared$	0.7806	0.7014	0.9120	0.8213	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

In the CDS regressions, six variables influence the CDS spreads in a similar way for all country groups. These variables are bond spread, bond price, CDS bid-ask spread, iTraxx index, DAX index, and rating, all of which reveal an expected sign of coefficient. The CDS contracts of German entities appear to be priced most closely in line with economic theory as almost all significant coefficients correspond to our expectations. Another explanation may be that comparing to the whole set of entities, the German entities create a more homogenous sample, which allows us to exclude any heterogeneity bias. Also, the

Unlike the bond spread regressions, the CDS bid-ask spread is significant for all countries while estimating CDS spreads, proving that the bond spreads are less influenced by the corresponding CDS characteristics. The causal relationship between bond and CDS spread thus may be structured more in a way of a CDS spread to be influenced by bond spread than on the other way around.

Similarly to the bond spread regressions, we conclude that the geographical location matters for pricing of CDSs. The results for the individual countries differ in predicting the statistical, as well as economic significance of individual variables on CDS spreads. The results of bond and CDS spreads regressions across the countries may not correspond to the theoretical expectations because the created subsamples are small (i.e. they include an insufficient number of entities) and thus the regressions may under or overestimate the true effect.

6.3.2 Industry sector division

Another criterion for dividing the sample is the type of industry. The entities in our sample are representatives of five different sectors, but due to an insufficient number of entities in the financial sector, we study the differences in estimated coefficients only across four sectors. These sectors are Autos & Industrials, Consumers, Energy, and Technology, Media & Telecommunication (TMT). The regression results for estimating bond spreads are summarized in the following table.

Table 12: Bond spread estimation – specific sector

$Bond\_spread$	Autos & Industrials	Consumers	Energy	TMT	Similarity
CDS_spread	.066***	.108***	.159***	.268***	✓
$Bond\_price$	-15.875***	-9.670***	-8.567***	-15.43***	✓
$Bond\_bid-ask$	2.551**	36.957***	11.671***	2.125**	✓
$CDS\_bid-ask$	.001	.006	.071**	.097***	×
$Log(Stock)$	-46.400***	-.147	-4.193	-1.130	×
$Log(P/S)$	25.039***	-98.26***	49.591***	-10.66***	×
$Log(Stock\_vol)$	87.330***	29.93	6.684	133.03*	×
$Euribor$	-.581***	-.080***	-.295***	-.466***	✓
$Counterparty\_CDS$	-.012	-.169***	-.013	-.024	×
$iTraxx$	.176***	.154***	.101***	.210***	✓
$Log(DAX)$	47.374***	8.571	11.015**	45.078***	×
$VDAX$	.167**	.512***	.194***	.139	×
$Log(ER)$	17.925***	270.40***	90.640***	-6.916	×
$Rating$	32.764***	111.55***	-.666	59.484***	×
$Downgrade$	-1.211	2.943***	4.893***	-6.705**	×
$Upgrade$	3.039	(omitted)	(omitted)	-24.93***	×
$R-squared$	0.8478	0.6108	0.4818	0.8985	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Similar to our experience when country subsampling, we can observe significant differences in estimated coefficients across industrial sectors. R-squared also differs across sectors, with Energy sector having the lowest value. Entities in the Energy sector are often supported (at least partially) by the state, which may be the reason why the explanatory power of our model is lower in the Energy sector, as the entities are not so exposed to the movements in the observed factors. Nevertheless, the bond-specific factors still influence bond spread in a similar way across all specifications and their results are thus the most persuasive.

Compared to country subsampling, the levels of estimated coefficients of exchange rate and rating vary more substantially for individual industry sectors. For instance, the coefficient of exchange rate for the Consumers sector implies that a one percent depreciation of a domestic currency increases the bond spread by 2.7 basis points, which is almost 16 times more than the effect the exchange rate has on bond spread in the Autos & Industrials sector. This finding suggests that entities in the Consumers sector are more influenced by movements in exchanged rate as they often pay suppliers in a different currency than what they receive from customers.

The same regressions have been conducted for CDS spread as dependent variable to reveal different pricing procedures of CDS contracts in individual industrial sectors. The following table shows the regression results for the four analyzed industry sectors.

Table 13: CDS spread estimation – specific sector

CDS_spread	Autos & Industrials	Consumers	Energy	TMT	Similarity
$Bond\_spread$	.262***	.019***	.156***	.418***	✓
$Bond\_price$	-4.198***	-.052	-.715***	.863***	✗
$Bond\_bid-ask$	.846	6.584***	6.867***	-10.696**	✗
$CDS\_bid-ask$	.351***	-.007	.623**	.518***	✗
$Log(Stock)$	16.916***	.155	-27.087***	-91.067	✗
$Log(P/S)$	14.020***	-22.890***	-8.638***	41.580***	✗
$Log(Stock\_vol)$	-103.67*	-7.281	-4.835	-80.655	✗
$Euribor$	-.131***	.070***	.036***	-.052***	✗
$Counterparty\_CDS$	.236***	.071***	.133***	-.054**	✗
$iTraxx$	.812***	.397***	.368***	.400***	✓
$Log(DAX)$	-38.013***	-22.562***	-8.977**	-18.40***	✓
$VDAX$	.339**	.131***	-.227***	.018	✗
$Log(ER)$	-10.650***	72.51***	106.971***	120.44***	✗
$Rating$	41.460***	29.790***	10.267***	-6.574***	✗
$Downgrade$	-11.187***	10.450***	6.280***	-9.170**	✗
$Upgrade$	-11.897***	(omitted)	(omitted)	30.647***	✗
$R-squared$	0.7680	0.7019	0.6891	0.9192	

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

The lowest R-squared figure for the Energy sector supports our previous assumption that entities in the Energy sector are less influenced by the observed factors due to state support. The estimated coefficients of CDS regressions are even more heterogeneous across industry sectors than across countries as only three variables reveal similar results for individual sectors. Comparing to country subsampling, even estimated coefficients of bond price, CDS bid-ask spread, and rating are no more persuasive as the coefficients cease to be significant or even switch the sign for some sectors.

In general, the estimated coefficients for individual sectors differ significantly from our expectations, suggesting that some unobserved factors exist for each sector, which influences the way the observed factors are reflected in the pricing of CDS contracts. The results for the TMT sector, for instance, are almost opposite to what we expected. The unpredictable coefficients together with suspiciously high R-squared suggest that we might encounter an endogeneity issue, due to an omitted variable.

Similar to the country subsampling, the individual industry sectors' subsamples contain an insufficient number of entities, which may question the reliability of our results. The acquired results are thus applicable only to our sample of entities and may not be generalized.

6.3.3 Financial division

The last criterion for dividing the sample are financial ratios of individual entities. To be able to run panel data regressions for the individual groups of entities, we had to average the financial ratios of each entity over the period, so that the entities belong to one group over the entire period. Table 14 indicates the results for bond and CDS regressions for two groups of entities with high and low Operating Margin.

Considering the bond spread regressions, the first difference between the estimation for high and low profitability entities is the influence of bond and CDS bid-ask spread on pricing of bond spreads. For high profitability entities, the proxies for bond and CDS liquidity do not seem to matter as they are not significant even at a 0.1 level, whereas both bond and CDS liquidity influence the bond spread at a 0.01 significance level for low profitability entities. It suggests that pricing of bonds of low profitability entities is more dependent on the respective bond characteristics.

Table 14: Bond and CDS spread estimation – specific Operating Margin

	Bond spread		CDS spread	
	High OM	**Low OM**	**High OM**	**Low OM**
CDS_spread	.194***	.201***		
$Bond\_spread$			.351***	.151***
$Bond\_price$	-15.387***	-11.961***	-3.464***	-2.767***
$Bond\_bid-ask$	.349	7.891***	6.047***	4.887***
$CDS\_bid-ask$	.011	.087***	.444***	.485***
$Log(Stock)$	-2.557***	-13.781***	5.310***	-13.612***
$Log(P/S)$	-13.138***	27.668***	11.310***	-14.153***
$Log(Stock\_vol)$	101.622***	-8.045	-44.112	7.377
$Euribor$	-.371***	-.377***	-.134***	-.107***
$Counterparty\_CDS$	-.024	-.040*	.186***	.033*
$iTraxx$	.165***	.155***	.509***	.845***
$Log(DAX)$	42.298***	31.286***	-22.638**	-30.089***
$VDAX$	.243**	.228***	.146***	.032
$Log(ER)$	11.776***	-26.293***	-2.577***	17.048***
$Rating$	67.938***	44.361***	34.487***	7.010***
$Downgrade$	2.866	1.201	-11.522***	4.647**
$Upgrade$	-2.124	2.101	14.718***	9.422***
$R-squared$	0.7821	0.7876	0.8396	0.8092

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Other discrepancies lie in a different sign of coefficients of P/S ratio and exchange rate. Pricing of bonds of lower profitability entities considers a low P/S ratio as an indicator of a company's undervaluation, which would imply a good investment opportunity. The pricing of bonds of high profitability entities, on the other hand, reflects the P/S ratio according to our expectations, suggesting that a company with high P/S ratio has lots of opportunities to growth. The exchange rate reveals an expected sign of coefficient only for high profitability entities. The volatility of stock price plays an important role in pricing bonds for high profitability entities, whereas it reveals no influence on bond spreads for low profitability entities.

The CDS spread regressions reveal results for bond and CDS-specific variables to be consistent across the profitability levels. Nevertheless, the estimated coefficients for stock price, P/S ratio, and exchange rate differ substantially in their influence on CDS spread across the two groups of entities. The divergence of the sign of coefficient, however, is opposite to the bond estimation for P/S ratio and exchange rate. The effect of P/S ratio on CDS spread is positive for high profitability entities and negative for low profitability entities and vice versa for the exchange rate. Also, the DAX index has an expected sign of coefficient only in CDS regressions. These findings suggest that bonds and CDS contracts reflect certain factors in a different way in their prices.

Another ratio used to split the sample in two to observe potential differences in pricing across the groups is the Current Ratio, which measures a company's liquidity. The following table shows the regression results for bond and CDS spreads for the two groups of entities divided based on their liquidity.

Table 15: Bond and CDS spread estimation – specific Current Ratio

	Bond spread		**CDS spread**	
	High CR	**Low CR**	**High CR**	**Low CR**
CDS_spread	.228***	.308***		
$Bond\_spread$			.365***	.288***
$Bond\_price$	-13.864***	-12.073***	-1.325***	-1.650***
$Bond\_bid-ask$	1.262	6.472***	5.468***	1.760
$CDS\_bid-ask$	.025	.088***	.407***	1.369***
$Log(Stock)$	-2.219***	-16.724***	2.569***	1.042***
$Log(P/S)$	-19.587***	8.664***	14.590***	-.273
$Log(Stock\_vol)$	195.420***	2.694	-61.189	7.393
$Euribor$	-.288***	-.391***	-.061***	-.088***
$Counterparty\_CDS$	-.054**	-.071***	.150***	.014
$iTraxx$	.128***	.122***	.542***	.920***
$Log(DAX)$	39.413***	37.550***	-32.972**	-34.383***
$VDAX$	.204**	.128*	.205***	-.235***
$Log(ER)$	28.253***	3.374***	-11.955***	17.180***
$Rating$	33.686***	69.999***	44.001***	4.045***
$Downgrade$	1.641	1.144	-1.265	2.255*
$Upgrade$	2.754	-.598	1.781	-19.719***
$R-squared$	0.7395	0.9099	0.8010	0.8385

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

The estimation results for bond spread of specific liquidity groups are rather consistent with the estimation of the profitability groups. This finding may have two explanations. First, the pricing of bonds is similar for higher profitability and more liquid entities, as well as for lower profitability and less liquid entities. Second, the higher profitability companies in our sample coincide to the more liquid ones.

The estimation results for the liquidity subsampling distinguish themselves in the influence of credit rating and exchange rate. The rating has a higher economic significance for higher profitability entities than for lower profitability ones, whereas it has twice as large of an effect on bond spread for less liquid entities than for more liquid ones. The exchange rate has a positive effect on bond spread for less liquid entities, whereas it reveals a negative influence for lower profitability entities.

Compared to the bond estimation, the CDS estimation across liquidity groups differ more substantially from the profitability subsampling, suggesting that some sample entities belonging to the higher profitability group may belong to the less liquid group and vice versa. The bond bid-ask spread ceases to be significant for less liquid companies in favor of the CDS bid-ask spread that reveals higher economic impact on CDS spread.

Stock price now reveals an unexpected sign of coefficient for both more and less liquid entities. P/S ratio also shows an expected positive coefficient for more liquid entities and ceases to be statistically significant for less liquid entities. Similarly, the counterparty risk seems to matter only for more liquid entities.

Volatility of the DAX index and exchange rate switch their sign of coefficient for the individual liquidity group. The volatility DAX index is correctly reflected in the pricing of CDS contracts for more liquid entities, whereas the predicted coefficient of exchange rate corresponds to our expectations only for less liquid entities. Additionally, the credit rating serving as a proxy for default risk is almost ten times more economically significant for more liquid entities.

Finally, we divide the sample based on the indebtedness level of individual entities. We run regressions of bond and CDS spreads for two groups of companies with high and low indebtedness levels. The estimated results are summarized in the following table.

Table 16: Bond and CDS spread estimation – specific Debt Ratio

	Bond spread		**CDS spread**	
	High DR	**Low DR**	**High DR**	**Low DR**
CDS_spread	.262***	.279***		
$Bond\_spread$			.255***	.198***
$Bond\_price$	-12.726***	-12.937***	-3.903***	-2.031***
$Bond\_bid-ask$	8.928***	-1.128	2.450***	.083
$CDS\_bid-ask$	.011	.102***	.470***	.775***
$Log(Stock)$	-7.162***	-14.697***	7.180***	-15.540***
$Log(P/S)$	13.207***	-13.546***	14.793***	7.200***
$Log(Stock\_vol)$	-9.113	15.074	-15.180	-28.184
$Euribor$	-.382***	-.302***	-.162***	-.046***
$Counterparty\_CDS$	-.052**	-.062***	.201***	.045***
$iTraxx$	.136***	.102***	.817***	.571***
$Log(DAX)$	31.884***	43.410***	-36.175***	-20.587***
$VDAX$	.258***	.099	.203***	-.199***
$Log(ER)$	19.079***	6.324*	-1.411**	15.864***
$Rating$	44.105***	42.734***	19.373***	18.486***
$Downgrade$	7.822***	-1.619	-8.475***	11.411***
$Upgrade$	-1.208	-28.619	-16.851***	30.079***
$R-squared$	0.7723	0.8271	0.8181	0.8280

Source: own estimation

*Note: *** p<0.01, ** p<0.05, * p<0.1*

In the bond spread estimations, several variables reveal significant influence for highly indebted entities, but cease to be significant for less indebted companies. These variables are bond bid-ask spread, volatility of DAX index, exchange rate, and downgrade. The CDS bid-ask spread, on the other hand, is only significant for highly indebted entities. Another difference in coefficients between more and less indebted entities is the P/S ratio. The sign of coefficient of P/S ratio on bond spread corresponds to our expectations for less indebted entities, but reveals a positive sign for more indebted entities.

Other observed factors seem to influence the pricing of bonds in a similar way for both groups of entities. The estimated coefficients for CDS spread regressions, however, reveal more pronounced differences across the indebtedness level than in the case of bond estimation. Five coefficients in CDS spread regressions reveal a different sign of coefficient for more and less indebted entities, suggesting that the level of indebtedness matter while pricing CDS contracts because the observed factors are reflected in the CDS price in a different way.

Similarly to bond estimations, the bond bid-ask spread seems to have no effect on CDS spreads for less indebted entities. Nevertheless, the credit rating as a proxy for default risk is priced similarly for the two groups of companies and plays an important role in pricing both bonds and CDS contracts.

Several related works, such as Fontana & Scheicher (2010), Kapar & Olmo (2011), or Blommestein et al. (2016), concluded that the pricing of bonds or CDS contracts is dependent on the prevailing market conditions and it thus varies over time. Our findings suggest that the pricing is not only time dependent but varies also across countries, industries, and financial position. The pricing of bonds and CDS contracts is thus also firm-specific.

7 CONCLUSION

The main goal of the thesis is to estimate the determinants of corporate bond and CDS contract pricing. We conducted the estimations using information on 34 European companies over the period 2008-2014. The chosen time period allows us to reflect the most recent economic developments in Europe, such as the Greek crisis and the European debt crisis.

The thesis extends the existing related literature by using recent data. In addition, a primary contribution lies in studying the differences in pricing of bonds and CDSs for different groups of companies. We created subsamples of companies based on three criteria – geographical location, industry sector, and financial position. The models were estimated separately using the Prais-Winsten estimator with panel specific errors in order to control for autocorrelation and cross-sectional dependence present in the data.

The visual inspection of the data revealed that bond and CDS spreads follow similar paths over the covered period. Some differences in reactions to turbulent periods were discovered across countries and industries. The visual analysis based on financial ratios suggested that the public in the post-crisis period started to place higher priority on balance sheets instead of projected cash flows as more liquid companies had lower bond and CDS spreads. Also, more indebted companies showed higher bond and CDS spreads, particularly during the crisis periods.

The results of the overall regressions suggest that pricing of bonds and CDS contracts is linked and influenced by similar factors, with credit rating being the most influential variable. Another important factor appears to be liquidity for both bonds and CDS contracts, which is in line with previous studies. The impact of the iTraxx index and counterparty risk, on the other hand, is more significant in pricing CDS contracts.

Based on regressions over different time periods, we concluded that bond spreads are more influenced by firm-specific factors, whereas pricing CDS contracts is more dependent on market factors. The differences in coefficients for the two time periods support the findings of previous studies that the pricing of bonds and CDSs is time-dependent.

Moreover, the predicted estimates vary substantially across created subsamples of companies, suggesting that pricing of the financial instruments is also firm-specific. The estimated results are, however, suspicious under certain specifications. We therefore concluded that the pricing of particular bonds and CDSs is influenced by idiosyncratic factors that impair standard economic theories. Another problem may be the insufficient number of companies in individual subsamples, which may bias the results and preclude application of the results to all companies.

We contributed to the existing literature on bond and CDS pricing with an innovative way of estimating the determinants of bond and CDS spreads across different time periods and different samples of companies. A potential extension of the work may be enlarging the sample set to eliminate the sample selection bias, and to ensure more companies included in individual subsamples.

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DATA SOURCES

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https://www.standardandpoors.com

YahooFinance

http://finance.yahoo.com/

Ycharts

https://ycharts.com/

APPENDIX

Table 17: List of sample companies

Company	Country	Industry	Currency
Airbus Group SE	France	Autos & Industrials	EUR
Allianz SE	Germany	Financials	EUR
Atlantia SpA	Italy	Autos & Industrials	EUR
BASF SE	Germany	Autos & Industrials	EUR
Bayer AG	Germany	Autos & Industrials	EUR
Bayerische Motoren Werke AG	Germany	Autos & Industrials	EUR
Bouygues SA	France	Autos & Industrials	EUR
British Telecommunications PLC	United Kingdom	TMT	GBP
Carrefour SA	France	Consumers	EUR
Diageo PLC	United Kingdom	Consumers	GBP
E.ON SE	Germany	Energy	EUR
Electricite de France SA	France	Energy	EUR
EnBW Energie Baden-Wuerttemberg AG	Germany	Energy	EUR
Enel SpA	Italy	Energy	EUR
Engie	France	Energy	EUR
Fortum OYJ	Finland	Energy	EUR
GKN Holdings PLC	United Kingdom	Autos & Industrials	GBP
ITV PLC	United Kingdom	TMT	GBP
Koninklijke Ahold NV	The Netherlands	Consumers	EUR
Koninklijke DSM NV	The Netherlands	Autos & Industrials	EUR
National Grid PLC	United Kingdom	Energy	GBP
Nestle SA	Switzerland	Consumers	CHF
RELX PLC	United Kingdom	TMT	GBP
Royal Dutch Shell PLC	The Netherlands	Energy	EUR
RWE AG	Germany	Energy	EUR
Sky PLC	United Kingdom	TMT	GBP
Solvay SA	Belgium	Autos & Industrials	EUR
Telefonaktiebolaget LM Ericsson	Sweden	TMT	SEK
Telenor ASA	Norway	TMT	NOK
Veolia Environnement SA	France	Energy	EUR
Vodafone Group PLC	United Kingdom	TMT	GBP
Volkswagen AG	Germany	Autos & Industrials	EUR
Volvo AB	Sweden	Autos & Industrials	SEK
Wendel SA	France	Autos & Industrials	EUR

Source: our estimation

Table 18: Credit ratings scale

	Moody's	S & P	Fitch	*Meaning*
Investment Grade	Aaa	AAA	AAA	Prime
	Aa1	AA+	AA+	High Grade
	Aa2	AA	AA	
	Aa1	AA-	AA-	
	A1	A+	A+	Upper Medium Grade
	A2	A	A	
	A3	A-	A-	
	Baa1	BBB+	BBB+	Lower Medium Grade
	Baa2	BBB	BBB	
	Baa3	BBB-	BBB-	
Speculative Grade	Ba1	BB+	BB+	Speculative
	Ba2	BB	BB	
	Ba3	BB-	BB-	
	B1	B+	B+	Highly speculative
	B2	B	B	
	B3	B-	B-	
	Caa1	CCC+	CCC	Substantial Risks - Default
	Caa2	CCC	CCC	
	Caa3	CCC-	CCC-	
	Ca	CC	CC+	
	C	C	CC	
			CC-	
		D	D	

Source: Moody’s, S&P, Fitch

Table 19: Descriptions of used NACE codes

NACE code	Description
2000	*Manufacture of chemicals and chemical products*
2900	*Manufacture of motor vehicles, trailers and semi-trailers*
2930	*Manufacture of parts and accessories for motor vehicles*
3000	*Manufacture of other transport equipment*
4200	*Civil engineering*
5220	*Support activities for transportation*
1000	*Manufacture of food products*
1101	*Distilling, rectifying and blending of spirits*
4711	*Retail sale in non-specialized stores with food, beverages or tobacco predominating*
4719	*Other retail sale in non-specialized stores*
3510	*Electric power generation, transmission and distribution*
6510	*Insurance*
1800	*Printing and reproduction of recorded media*
6000	*Programming and broadcasting activities*
6100	*Telecommunications*
7010	*Activities of head offices*

Source: Eurostat

Table 20: Descriptive statistics of included variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Bond spread	60554	156.82	169.63	-171.05	1531.15
CDS spread	60554	113.24	103.81	19.08	1248.44
Bond price	60554	107.65	11.16	44.90	155.14
Bond bid-ask	60554	0.56	0.36	0.02	7.54
CDS bid-ask	60554	7.34	7.43	-36.53	133.58
Stock price	60554	37.37	38.86	0.17	533.00
P/S ratio	60554	1.41	2.04	0.04	15.84
Stock volatility	60554	0.00	0.00	0.00	0.20
12-month Euribor	60554	170.73	141.31	32.70	552.60
CDS Deutsche Bank	60554	112.25	40.21	41.91	311.60
iTraxx index	60554	111.78	35.69	52.67	217.58
DAX index	60554	6951.39	1505.70	3666.41	10087.12
DAX index volatility	60554	22.43	8.85	10.80	74.00
Exchange rate	60554	1.23	1.67	0.49	9.32
Credit Rating	60554	1.31	0.76	0.00	3.00
Downgrade	60554	0.12	0.33	0.00	1.00
Upgrade	60554	0.03	0.18	0.00	1.00

Source: own estimation