ESSAYS ON CREDIT DEFAULT SWAPS

by
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A Thesis submitted in partial fulfilment of the requirements for the degree

Doctor of Philosophy (PhD) in Business

at

University of Greenwich

London, UK

August 2017

DECLARATION

I certify that this work has not been accepted in substance for any degree, and is not concurrently being submitted for any degree other than that of Doctor of Philosophy (PhD) being studied at the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise identified by references and that I have not plagiarised another's work.

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ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my supervisor Dr. Cesario Mateus for the continuous support of my PhD study, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I am grateful to Dr. Aleksandar Stojanovic for his support, guidance and suggestions.

I am also grateful to Dr. V L Raju Chinthalapati and Dr. Lesley Catchpowle for their valuable feedbacks in transfer viva.

Finally, I would like to thank my parents, especially my father Y. Klenin, for their encouragement and my partner, Boyd Woodruff, for his understanding and support during my research.

ABSTRACT

This research provides three self-contained empirical studies on the interrelationship between Credit Default Swap (CDS) and the bond and equity markets.

The first essay performs an analysis of the relationship between CDS premia denominated in Pound Sterling and bond spread denominated in Pound Sterling and the Euro currency. We found clear evidence that the CDS market leads the bond market and that the influence of CDS premia on bond spread was stronger before the financial crisis. We also found that the CDS premia has less influence on investment grade bonds than on junk bonds.

The second essay expands upon the first essay by employing a broader sample of both CDS premia denominated in Euro and bond spread denominated in Euros and United States dollars. We found that CDS premia leads the bond spread to be denominated in Euro. Before the financial crisis, the influence of CDS premia was stronger on the bond spread in USD than on the bond spread in Euros, while it also proved to be less for USD investment grade bonds.

The third essay contributes to the currently scarce literature on the interrelation between the three markets (CDS, bond and equity) by employing linear regression model, including consideration of firm specific and market factors to explain the change in the three markets. The results confirm the positive correlation between CDS and bond spreads and those which are negative between CDS premia and equity return. Market value and market return are shown to be positively correlated with equity market and negatively with CDS and bond markets.

At the same time, market volatility has a different influence on the markets. We found that equity return is negatively correlated with bond spread, although in some cases the correlation is positive, which confirms previous studies.

CONTENTS

INTRODUCTION

This research contributes to the literature on equilibrium price relationships and price discovery between credit default swap (CDS), the bond and equity markets and informational efficiency over three self-contained essays. In chapter two (Essay One), we investigate the relationship between Credit Default Swap (CDS) and bond spreads denominated in Pound Sterling (GBP) and Euro (EUR) currency. We implement stationary, causality and regression tests (Augmented Dickey–Fuller and Phillips-Perron tests followed by Granger Causality and linear regression models) so identifying which market leads to price discovery. In chapter three (Essay Two), we extend analysis by investigating the relationship between CDS and bond markets with the assets denominated in Euro (EUR) and the US Dollar (USD) currency. Chapter four (Essay Three) studies the price discovery process between CDS, equity and bond markets by employing set of explanatory variables to determine what factor influences each market.

Credit Default Swap (CDS) is a financial instrument, which is destined for risk diversification against credit events like credit deterioration or defaults by single-name or a basket of obligors. Default is an event that is triggered by credit risk, which arises when a company faces difficulties in paying its obligations or where delays begin in the payment process. Since the market was introduced, it has been growing to reach 57 trillion USD in 2008 with a decrease of notional amount in the aftermath. [1] (BIS, 2017)

Since the collapse of the financial system during the recent financial crisis, CDS has turned from a harmless risk diversification instrument into a subject of considerable ambivalence. Some academics argue that it is due to the 'nature' of CDS. A CDS contract can be considered as an 'insurance' against default but, according to Stulz (2010), there is a difference between insurance contracts and credit default swaps, which implies that an investor does not have to hold the bonds to buy a CDS on that bond, whereas with an insurance contract, an investor would typically have direct economic exposure to obtain insurance. Moreover, CDS contracts are

[1] The notional amount is a quantity of the underlying or variable specified in the contract. (Sangiuolo, Seidman and Taub, 2012)

traded over the counter (OTC), while insurance contracts are not. Despite the fact that CDS is traded OTC, it is recorded by Depository Trust Clearing Corporation (DTCC) (Stulz, 2010).

Even though financial experts describe CDS as a prominent villain, it can benefit financial institutions. In principle, CDS should make financial markets more efficient and improve the allocation of capital. Indeed, according to Blanco, Brennon and Marsh (2005) information mostly flows from CDS to bond prices making the CDS market more liquid. Moreover, the greater efficiency of CDS market in incorporating information benefits the pricing of all of a firm's securities. Hence, CDS helps make financial markets more efficient and transparent in price discovery and increase liquidity.

The debate on the theory of market efficiency has generated a significant amount of interest. For the same unique reference entity, the relationship between the markets/securities has progressively developed towards the aim of achieving a united conclusion as to how the securities of a unique reference entity are interrelated and what financial instrument leads to price discovery.[2] A limited number of research studies have described the information efficiency of CDS markets. As information flow plays a significant role in the determination of price discovery, earnings surprises can be a good proxy for a trigger of information flow. Zhang and Zhang (2013) have investigated U.S. CDS market and stated that CDS could benefit hedging activity. Moreover, proponents of CDS hold that an efficient CDS market can serve as a barometer to regulators and investors regarding the credit health of a company.[3] A good example of CDS s a as a barometer is Bear Stearns' widening spread pointing to increased risk. Studies conclude that based on the assumption that differently from the stock market where there are both informed and uninformed investors, the CDS market is dominated by informed investors who may have interpreted information more accurately CDS market is efficient and post-earnings drift is less likely to exist in the market.

[2] Unique reference entity is the issuer of the bond referred to CDS contract. (Fabozzi, 2010)

[3] Investors can benefit from basis arbitrage and informational efficiency. For instance, if CDS leads to price discovery it reflects to new information with higher speed and bond market adjusts, hence, investors, who aware of the relationship between the markets can benefit from it. For regulators CDSs can be an indicator of credit soundness of an entity. Moreover, CDS occupy a prominent position in global financial regulation, including in the Basel III guidelines, as CDSs tend to mitigate credit risk and reduced capital requirements for financial institution.

In addition, Zhang and Zhang (2013) conclude that CDS is a good indicator of entity's creditworthiness. Hence, if positive earnings surprises occur when CDS premia declines and rises for negative earnings surprises respectively, the question remains of whether CDS market makes financial markets more efficient and improves the allocation of capital.

Most economists who have contributed to the debate in the context of the relationship between CDS contract and other securities of a reference entity as bond or equity have assessed price discovery process. Even those who have since examined the relationship among CDS, bond and equity markets in a wider context have examined the dynamics of a limited number of reference entities, regions or countries or just assessed sovereigns, ignoring corporate entities or solely researched just two markets.

My inspiration and motivation is hence twofold: (i) to contribute to the debate by revisiting existing research and establish the areas that are currently thin in their composition or have not been examined; (ii) assess the relationship between the CDS, bond and equity markets regarding which factors determine the relationship as well as how the relationship has changed after the financial crisis.

1.1 Research Objectives

This study is based on the time series forecasting models of Granger-Causality. The main focus is to exploit the scopes available to predict the changes in a market. This will be realised by exploring informational efficiency through the understanding of price discovery role of the market. To understand which market leads to price discovery, we study causality link and regression between the markets.

In Chapter 2, the causality link and regression between CDS premia in GBP and reference bonds denominated in GBP and EUR are assessed. In Chapter 3, the causality link and regression between the CDS premia in EUR and reference bonds denominated in EUR and USD are assessed. In Chapter 4 we study the simultaneous relationship between CDS, equity and bond markets. To present the study in a meaningful and convenient manner, three self-contained essays are included in the thesis, forming chapters 2, 3 and 4. The research objectives of each essay are presented in this section.

1.1.1 Objectives of Chapter Two (Essay One)

The wide scope of the literature is to document and understand the relationship between debt and derivative markets as an important challenge in modern financial economics. In particular, one part of the literature focuses on the causality link between the markets and their correlation with each other, utilising macroeconomic and firm specific factors to explain market efficiency. Although the size, value and time dynamics of CDS market have drawn attention from a wide range of academics and practitioners, the existing literature mainly examines how sovereign CDS markets or CDS indexes are associated with a bond market. The consequence has been a lack of literature examining corporate CDS contracts for a broad range of countries, industries and regions during the multiple phases of the economic cycle.

To achieve the first objective of determining what market is more efficient in price discovery, we propose focusing on the following aspects: (a) how CDS premia is associated with a bond spread for CDS premia denominated in GBP; (b) if one market leads to price discovery, then how an increase/decrease of one asset will increase or decrease the other one.

The specific objectives can be outlined as follows. First, the data is tested on stationarity; this provides the results that lead us to a conclusion, which further approach should be applied. Second, whether it concerns levels or the first difference, stationary data is employed to conclude whether there is a relationship between CDS and bond markets and which market leads the other. Third, the correlation between the markets will also be determined, including explanatory variables.

This study will hence provide the results disclosing the causality link between CDS and bond markets, showing which one responds faster to new information.

1.1.2 Objectives of Chapter Three (Essay Two)

The relationship between CDS and bond in European markets is already well-documented for sovereigns, indexes or corporates associated with macroeconomic variables. Therefore, research into the relationship between CDS and corporate bond spreads of Euro currency for a broad sample variable will be considered a new empirical study defying the theory of efficient markets.

The objectives of chapter four (Essay Two) are twofold: first, extend the literature focused on how markets lead to price discovery for a set of corporate entities before and after the financial crisis; second, incorporate causality link to regression analysis. The specific objectives are firstly, to test the data on stationarity to provide the results that lead us to conclude whether the levels or the first differenced data will be analysed in the further analysis. Secondly, investigate stationary data in terms of whether levels or the first difference are employed, thus concluding whether there is a relationship between CDS and bond markets. Third, the correlation between the markets will be provided including firm-specific variables.

The research will provide the results that are supposed to disclose the causality link between CDS and bond markets, showing which one responds faster to changes in the financial system.

1.1.3 Objectives of Chapter Four (Essay Three)

The lack of literature on the simultaneous relationship between CDS, the equity and the bond market is surprising regarding the importance of analysis of the markets in the investment process.

The main objective of chapter four (Essay Three) is to contribute to the scarce literature on the analysis of the three most important markets of the financial system. Indeed, according to Belke and Gokus (2014), three variables indicate the performance of an entity: stock price, bond yield spread and credit derivatives. Moreover, the previous research will be interrogated to select an appropriate methodology. Hence, the objectives of chapter four (Essay Thee) are twofold: first, investigate the causality link between each pair of three markets separately; second, indicate the factors that influence the markets and by what extent.

To investigate the interrelationship between CDS, bond and equity markets and conclude which one is more efficient, we will investigate the causality link between the markets as well as the tri-variate relationship between CDS premia, bond spread and equity return. Furthermore, we will assess how financial aspects influence the relationship where a set of factors is regressed. The set consists of corresponding stock market indexes for each market, alongside volatility indexes, rating and market value. The criteria of factors is taken to be the most important because it indicates market return, market risk and company size.

So far, much of the literature has focused only on price discovery process and merely two of the three markets are considered. The current study extends this debate by analysing a wider set of research aspects. This wider set includes: (i) the number of companies for a longer period and (ii) a wider set of indicators of the relationship between CDS premia, bond spread and equity return. The empirical chapters addressing these issue and areas will examine not only the whole data sample but also the sample before and after the financial crisis.

The implication of the finding should be interpreted as follows: if the causality direction is found, then it can be concluded that where the direction is defined, the market leads to price discovery and reacts faster to new information. Following the causality analysis, we will then determine how lead-lagged spread can increase/decrease a caused spread.

1.2 Significance of the Research

Based on the research objectives we have performed empirical studies based on the most recent and broad data. The significance of the research and its main contributions to the existing literature are presented in the three self-contained essays summarised here.

1.2.1 Contributions of Chapter Two

- A comprehensive analysis of a broad data sample of corporate and sovereign securities for a broad period from 1st January 2004 to 1st September 2014 to analyse the causality link between CDS premia denominated in GBP and bond spread and so assess market efficiency.

1.2.2 Contributions of Chapter Three

The study extends the research of Chapter 2 for CDSs denominated in the Euro currency.

1.2.3 Contributions of Chapter Four

- In Chapter 4, together with studying of the relationship between CDS, bond and equity markets by regression models, we have contributed to the thin literature on the relationship between the three markets.

- The study uses the most recent data for corporates and sovereigns, including over period of the financial crisis.

1.3 The thesis structure

The thesis is composed of five chapters and organised as follows: first, chapter one will provide an overview of the current state of knowledge on the efficiency and the relationship between CDS premia and bond spread and equity return and how financial and market factors influence the markets. In chapter two, the first empirical paper for this dissertation is presented with a comprehensive sample description, the methodology used to analyse data stationarity, the causality effect among CDS premia and bond yield spread and the identification of the correlation between the markets before the crisis and during post-financial crisis periods. We will also provide a critical discussion of the results and the implications of the results. Chapter three presents the research based on our objectives for CDS market with premia denominated in EURO currency. Here, the research employs the same methodology laid out in chapter two. In chapter four, we determine the association between the three markets and how financial factors influence it.

CHAPTER 1: Literature Review

2.1 Introduction

This chapter provides an overview of previous research on knowledge of CDS market and its interdependence with other capital markets. Many theories have been proposed to explain what leads CDS market. Although the literature covers a wide variety of empirical studies, this review will focus on five major themes, which emerge repeatedly throughout the literature reviewed. These themes are the market efficiency of CDS, bond and equity markets and the association between CDS and bond market as well as the relationship between CDS, bond and stock markets. The current chapter provides the main literature review associated with essay one, two and three.

The main purpose of the chapter is to survey previous studies on knowledge of the CDS market, its efficiency and interrelation with debt and equity markets. Additionally, factors that determine CDS premia, bond yield spread and equity return will be defined based on the existing empirical studies.

2.2 The Literature on the nature, size and structure of the CDS market

Credit default swap (CDS) is a financial instrument that constitutes a contract, which provides insurance against the default of a so-called reference entity. A reference entity is a corporate company or financial institute that issue debt written in the form of a bond. Default can be defined more precisely. According to Basel III accord, a default can be considered in either or both of the following events: the bank believes that the obligor is unlikely to pay its credit obligations to the bank group, or when the obligor is past due more than 90 days on any material credit obligation to the banking group. (Ferretti, 2016)

There are two sides in each CDS contract: a long (buyer) and a short (seller) side. A buyer is a debt holder, who agrees to make periodical payments to a seller, who issues CDS and agrees to compensate the protection to a buyer for the incurred loss in case of reference entity defaults during the period of a contract. A payment paid to CDS seller by CDS buyer is CDS premia and a payment paid by reference entity CDS buyer is bond yield. CDS contracts are traded over-the-counter (OTC) and they regulated by the ISDA, which is a global trade organisation of financial market participants for OTC derivatives and offers definitions, rules and framework for CDS contracts.

CDS was created by JPMorgan Chase in the middle of 90s with the goal to free up capital. “At that time JPMorgan Chase had provided a large amount of loans to corporations and foreign governments. By federal law they were required to keep huge amounts of capital in reserve in case any of the loans went bad. They came up with the idea to create the CDS inspired by hedging for fluctuations in interest rates and commodity prices. By using the CDS they could be protected if the loans defaulted and at the same time free up capital.” (Philips, 2008).

The size of the CDS market has grown from an exotic niche market to a large and active venue for credit risk transfer, making it one of the most significant financial innovations of the last years. (Oehmke and Zawadowski, 2016). Indeed, in 2011 its gross notional is concluded to be close to $28 trillion (£17 trillion). (Wilson, 2017) Overall, by March 1998, the global market for CDS was estimated at $300 billion, with JP Morgan alone accounting for about $50 billion of this. The highest gross notional amount of almost 60 trillion of USD Dollar reported in 2007, which was the peak of the market size. The CDS market was equal to approximately $900 billion and was considered as, and working in, a reliable manner long before the financial crisis. A limited number of participants took part in the earlier CDS transactions, so the market was not as complicated as it is today because parties were well acquainted with each other and understood the terms of the CDS product. As a result in most cases, the buyer of a CDS contract also held the underlying credit asset (loan or bond). (Zabel, 2008). Before the financial crisis speculation became rampant in the market leading to the stage when sellers and buyer of CDS did not own the underlying asset (bond or loan) but were just "betting" on the possibility of a credit event of a specific asset. Hence, by the beginning of the financial crisis, the CDS market had a notional value of $45 trillion, but the corporate bond, municipal bond, and structured investment vehicles market totalled less than $25 trillion. Therefore, a minimum of $20 trillion were speculative "bets" on the possibility of a credit event of a specific credit asset not owned by either party to the CDS contract. Moreover, the size and impact of the CDS market are different for different regions.

The size and dynamics of the CDS markets for particular regions were researched by academics. Benos et al. (2013) claim that the UK CDS market is relatively small (in terms of values traded) and trading is fairly infrequent. Moreover, dealers play a key role in this market, and the market continues to operate undisrupted during and at the peak of the financial crisis 2008, and the major dealers accommodated the increased demand for CDS protection from end-users. The UK CDSs are mainly traded in three currencies: EURO, the US Dollar and British pound. Analysing the network structure is crucial for understanding the functioning and potential sources of financial stability and risks of the CDS market. Trading network of the market participants can be grouped into six categories: dealers, banks, asset managers, hedge funds, insurance companies and other counterparties (including non-financials). Dealers and banks are reported as the most prevalent participants of the trading network for both buyers and sellers. (Benos et al., 2013) During the financial crisis the UK market performs as following: daily trading volumes hovered around 2 billion Euro in 2007 then declines throughout 2008 to reach a new lower level, between 500 million Euro and 1 billion Euro daily from 2009 onward. The number of CDS trades also drops from about 300 per day to between 100 and 200 days over the same period. The overall fall in volumes (and a number of trades) after the crisis is consistent with the general reduction in trading activity across a broad spectrum of financial contracts and securities (BIS, 2012). Interestingly, activity in the CDS market spiked in the weeks following the Lehman Brothers' default in September 2008.Regarding recent dynamics of the CDS, according to Pfaffenbach (2016) market was affected dramatically after the Brexit. On the 24th of June 2016 5-year UK CDS spread jumped by 23 basis points (BPS) to 56 bps from the previous day's close of 33 bps. The spread is reported to be the highest at least October 2012, according to financial data provider Markit. Concerning European CDS market since 2008 the gross notional value of CDS contracts written for Euro countries has been growing steadily. The increases in the net notional values in France, Germany, State and the UK CDS have levelled off for the euro-area aggregate since the beginning of 2010 and went from 400 billion EUR to 800 billion EUR. (Europa, 2012) Haworth et al. (2011) report the total 345 billion notional outstanding in USD equivalent and 105 billion for financials, 39 billion for energy, 38 billion for telecommunications and technology, 91 billion for consumer goods and consumer services, 28 billion for basic materials, 8 billion for healthcare and 37 billion for industrials on the 1st of July 2011. Concerning country distribution, the size of the sovereign CDS net notional amount in February 2011 is equal to 7.49 billion of the US Dollar for Portugal, 26.4 for Italy, 3.98 for Ireland, 5.6 for Greece, 17.24 for Spain, 16.55 for Germany and 18.79 for

France. Hence, the biggest European market is presented by Germany and Spain. Peltonen et al. (2014) continue research of the network structure of the CDS market and the factors that determine, using a unique dataset of bilateral notional exposures on 642 financial and sovereign reference entities. CDS network is centred around four major dealers, two central clearing parties and customers.

Kalbaska and Gątkowski (2012) discuss contagion effect of CDS markets and state that sovereign risk mainly concentrates in Eurozone countries. Spain and Ireland have the biggest effect on CDS market in particular, while since August 2007 CDS market in the UK does not cause a big distress in Eurozone, because the UK market has most immune to shocks. The authors assess the dynamics of CDS market before and after Greek bailout and conclude that the highest CDS spread is determined for Portugal from March 2010 to September 2010, while the lowest for Germany, France and the UK. Before the financial crisis CDS spreads of different countries were growing simultaneously, however, the UK CDS spread did not grow dramatically comparing to the Greek, Portuguese and Irish ones. Hence, Eurozone was strongly affected by the financial crisis making the CDS spread to increase. The UK CDS market didn't suffer during the financial crisis. However, CDS spread increased after the Brexit, meaning that if financial uncertainty increases it increases credit risk, and hence CDS spread. (Carney, 2017)

2.3 Market efficiency

An efficient market is defined as a market where asset prices reflect new information accurately and in real time. In this terms, if a market is found to be efficient there is information incorporated into the price as well as the speed with which new information is incorporated into the price (how fast information is "reflected"). At the efficient market there is no way to earn excess profits; however, mispricing can exist at inefficient markets. There are three types of market efficiency: strong, semi-strong and weak market efficiency. According to the weak form of the efficient, the current price fully incorporates information contained in the past history of prices only. The semi-strong-form of market efficiency hypothesis asserts that the current price fully reflects all publicly available information. Past prices and data reported in a company's financial statements can be examples of the public information. The strong form of market efficiency hypothesis states that the current price fully incorporates all existing information, both public and private (sometimes called inside information). (Clarke, Jandik and Mandelker, 2017) This means that if a market is strongly efficient, it reflects insider-information. Insider information is not publicly available plans of a public entity that could provide an arbitrage advantage when used to buy or sell securities. (Gerritsen, 2014)

If we compare market efficiency to informational efficiency, we can conclude that informational efficiency moves beyond the efficient market hypothesis. The informational efficiency states that new information about any given firm is known with certainty, and is immediately priced into the company's asset. Moreover, before any big news release, a security price may change in value, due to investors and traders speculating on the security's intrinsic value after the news release. In an informationally efficient market, there will be little to no price change after the news release comes out. Under this hypothesis any changes in security price, after a news release, would be due to the interpretation of the news by individual analysts. Thus, if a market is efficient, there is no chance to bid the market. According to Singal (2004), informational efficiency is different to structural, administrative and operational efficiency. Moreover, an efficient market will reflect the information in a few minutes, even in a few seconds. However, if a part of the information is reflected in an asset price immediately and the remaining part takes several days, then the market is less than fully efficient open an opportunity for making profits because the inefficiency causes a mispricing in assets. If a market reflects new information slowly than buying an asset of the market immediately after good news and holding it for few days would generate extra profit. In point of fact, the three forms of informational efficiency defined by Fama (1970) (weak, semi-strong and strong) could be considered as different levels of investors' ability to correctly evaluate information.

Market inefficiency is opposite to market efficiency, and it is caused by mispricing (some securities are overpriced, and others are under-priced). Indeed, an inefficient market is a market or tendency at the market, which asserts that the market prices of securities are not always accurately priced and tend to deviate from the actual discounted value of their future cash flows. Based on this assumption some investors can make excess returns while others can lose more than the thresholds settled by their level of risk exposure. Market efficiency theory assumes that events such as market-wide crashes and the dot-com bubble of the late '90s seem to reveal some inefficiency within the markets. According to Qin (2014), price inefficiency could be associated with higher expected returns. Woolley (2010) continues that asymmetry is shown as the source of inefficiency - mispricing, bubbles and crashes. There are different sources of information flow or news at financial markets that can lead to asymmetry. According to Ball and Mankiw (1994), there are three factors causing asymmetry: aggregate demand, sectoral shocks and optimal inflation. Grossman (1976) and Grossman and Stiglitz (1980) argue that perfectly informational efficient markets are impossible, because if markets are perfectly efficient, the return to gathering information is nil, in which case there would be little reason to trade, and markets would eventually collapse. Thus, it can be useful to define the efficiency of a market in a more general, continuous sense, with faster price reaction equating to greater informational efficiency.

2.3.1 Efficiency of CDS market

As market efficiency is determined by characteristics of a security to reflect new information it is important to know what type of information and factors affect a particular market. An efficient market is a market in which asset prices quickly reflect available information and trades are the mechanisms by which information can be incorporated in price, and if investors believe a market is highly efficient, they will usually accept market prices as accurately reflecting intrinsic values. Factors affecting market efficiency include the time frame of price adjustments, transaction costs and information-acquisition costs, market value versus intrinsic value, the number of market participants and their trading activity, financial disclosure and limits on trading (restrictions on short selling). Past market data is past patterns in stock prices (and trades) to identify future patterns in prices. Public information refers to the practice of using financial statements, announcements, and other publicly available information about securities. Private information is information that a company or an investor holds, but that is not reflected in the market price, in other words, it is “inside information” -information known to company management but not yet made public.

One source of positive or negative information is credit rating changes as they mitigate problems of asymmetric information between participants of the capital market. (Norden and Weber, 2009) Norden and Weber (2009) analyse the response of stock and CDS markets to rating announcements by employing traditional event methodology. The announcements are made by the three major rating agencies during the period 2000–2002. The findings show that the markets anticipate downgrades prior by 90-60 days before the announcement day but not positive news. This result is consistent with analysis conducted by Hull et al. (2004), who show that CDS spread changes have predictive power for downgrades by Moody's. The results reveal significantly positive adjusted CDS spread changes before negative rating events for 1998-2002. The rating announcements are correlated with price adjustment examined by market efficiency. Finnerty, Miller and Chen (2013) document the ability of the CDS market to anticipate favourable as well as unfavourable credit rating change. Wengner, Burghof and Schneider (2015) confirm that for 2004-2011that both credit downgrades and upgrades have an impact on the CDS spread of event and non-event firms on the event date. Downgrades are more anticipated than upgrades. Micu, Remolona and Wooldridge (2006) state that outlooks, reviews and rating changes, whether positive or negative – have a significant impact on CDS prices for 2001-2005. The impact of negative rating announcements is greatest for issuers at risk of being downgraded to speculative grade. Moreover, the impact of positive rating announcements is greatest for issuers just below the investment grade. For European region for 2000-2003 Lehner and Neske (2006) state that the release of information concerning the creditworthiness of a company does certainly influence the CDS spread. A negative (positive/stable) outlook report does lead to a significant increase (decrease) in the CDS spread. Johansson and Nederberg (2014) investigate the European CDS markets response to earnings announcements between the years 2011-2013. It is concluded that earnings announcements provide valuable information to the CDS market. Norden (2011) conclude that the results of the research suggest that the CDS market quickly and accurately incorporates public information and that rating announcements are particularly informative when informational asymmetries are high. Hence, rating announcements can be considered as a source of positive/negative information for market efficiency. Indeed, CDS spreads and credit ratings are two indicators and measures of credit risk. Since ratings are a source of information, CDS spread should move following the type of information being released. Positive rating announcements should decrease CDS spreads and negative announcements in the opposite direction. As rating announcement is information flow, then if CDS premia changes before the announcement it indicates that the market tends to be efficient.

CDS market is defined as inefficient before the financial crisis 2008. Nevertheless, the level of efficiency improves over time. Mispricing in the CDS market is analysed over the years 2002 to 2006, and the market is found to be inefficient for the beginning of the time span. However, the market became efficient in the years of 2004 and 2005. (Imbierowicz and Cserna, 2008) By employing Credit Grades, the Zhou, and the Leland and Toft model the authors find that these pricing models produce CDS spreads close to market premiums. However, while some models overestimate market premiums, some models produce the lowest average pricing error with an overestimation of just 26 basis points. These deviations already indicate CDS market inefficiency. Jenkins, Kimbrough and Juan (2014) continue the research by testing the degree of semi-strong market efficiency in the CDS market by analysing the relationship between subsequent CDS returns and previously announced quarterly earnings surprises and quarterly accruals for crisis and the post-crisis time period, both of which have been the source of stock market anomalies. The authors conclude that for the whole period starting before the financial crisis up to the time of and after the credit crisis the CDS market was efficient. The research confirms the previous findings stating that collectively, the CDS market is efficient during periods of financial stability but call into question its efficiency during less stable economic periods. Zhang (2009) confirms the existence of market efficiency in the market during the pre-crisis period of 2001-2005. However, according to Marsh and Wagner (2012), during pre-crisis period and crisis period of 2004-2008 CDS market is inefficient, due to a negative note on the efficiency of CDS market by significantly positive autocorrelation and significantly negative correlation with lagged equity returns, which confirms the previous conclusion made by Imbierowicz and Cserna (2008). For particular markets like the US CDS market Zhang and Zhang (2013) supports the efficiency of the CDS market.

The overall conclusion is that most studies agree that initially, CDS market tended to be inefficient. However, prior to the financial crisis market efficiency improved, and was more efficient from 2004 to 2008. However, during the financial crisis the results call into question of the market's efficiency.

2.3.2 Efficiency of debt market

The bond market as a counter to CDS market has an earnestly long history. Initially bonds are traded in the primary market; however, after bonds were issued they are traded between investors in the secondary market of security exchange. Bond market participants include institutional investors, governments, traders and individuals. The outstanding size of the global bond market equals to 100 trillion of USD in 2012, while the UK market is equal to 3.5 trillion of USD. (London Stock Exchange Group, 2015) For European bond market, in particular, government bonds dominate the bond market and bonds issued by financial intermediaries. Besides, municipal bonds and agency bonds are major components of this market. A market so important should be efficient and liquid. (Biais et al., 2006) The efficiency of these OTC dealer markets has become an important issue for regulators, investors, and financial institutions. According to Biais et al. (2007), it would be extremely useful to understand the price formation and liquidity supply process in this market.

The markets have been researched by academics on the topic of market efficiency. The pioneers of the research Huang and Ederington (1993) confirm that bond markets are efficient. Hotchkiss and Ronen (2002) and Pesando (1978) state that bond market is stated to be efficient during 1993-1995 and 1961-1973 respectively. Reichenstein (1999) confirms the existence of market efficiency for bond fund returns from 1994 to 1998. However, the efficiency of the corporate bond market is not well understood. Most recent research, which analysed the link between asset prices and information fundamentals embodied in news announcement effect concludes that the bond market is less informationally efficient compared with the stock market. Before the financial crisis a data sample for 2002-2005 is analysed on how quickly new information is incorporated in corporate bonds' prices and its impacts on price duration at the intraday level. (Ying, 2006) It is concluded that information is only incorporated into bond prices slowly over time. The findings are followed by Bai, Fleming and Horan (2013) who claim that for 384 unique bonds issued between 1996 and 2011 the hypothesis of market efficiency is rejected.

To measure the efficiency of the bond market some analytics focus on the liquidity of markets as reflected by the tightness of the quoted bid-ask spread and the turnover ratio. Other researchers assess price adjustment approach. According to Downing et al. 2009, the bond market is efficient; however, it is less efficient than the stock market, which will be described in the next subsection. The authors conclude that for 2002-2005 period hourly equity returns lead bond spread for non-convertible junk- and BBB-rated bonds, and that stock returns lead bond returns for convertible bonds in all rating classes. These results mean that the corporate bond market is less informational efficient than the equity market, notwithstanding the recent improvements in bond market transparency and associated reductions in corporate bond transaction costs. Hence, if one market leads the other one it means that new information is first incorporated into the leading market, which makes it more efficient and the other one less efficient. The assumption is confirmed by Tolikas (2017) who applies lead-lag analysis and finds that stock returns lead the returns of high yield bonds but not those of investment grade bonds, which indicates that the stock market is relatively more informational efficient than the bond market. The findings imply trading opportunities for the bonds that are highly sensitive to the release of new information.

2.3.3 Efficiency of equity market

The stock market is most investigated market regarding market efficiency topic among the three markets. Rodriguez et al. (2014) analyse Dow Jones Industrial Average on daily, monthly and yearly basis and conclude that for the period 1929–2014 in line with the adaptive market hypothesis, the efficiency of the DJIA is not uniform over time. Moreover, the degree of market efficiency is also a function of the time scale, with higher predictability for relatively small time horizons (up to weekly time scales). According to Kristoufek and Vosvrda (2014), who measured market efficiency geographically for 41 stock indices in the period between 2000 and 2011, conclude that the Japanese NIKKEI is the most efficient market. From a geographical point of view, the more efficient markets are dominated by European stock indices, and the less efficient markets cover mainly the Latin America, Asia and Oceania, meaning that the most developed economies represent efficient markets. Indeed, more specifically, the least efficient markets are Venezuelan, Malaysian, Slovakian, the market of Sri Lanka and Peruvian market (the most inefficient stock market in the analysed set). The reasons of weak stock market efficiency can be: weak institutions (Johnson and Mitton, 2003; Fisman, 2001 and Bertrand et al., 2002), weak property rights protection, and political shocks (Morck et al., 2000) broker and insider influences (Khwaja and Mian, 2005 and Phan and Zhou , 2014) size of stock market (Lagoarde-Segot and Lucey, 2008), volume of turn over (Smith and Ryoo, 2003), market manipulation capacity (Magnusson and Wydick , 2002). Anagnostidis, Varsakelis and Emmanouilides (2016) research the impact of the recent financial crisis on the weak form of market efficiency. According to the results, the 2008 crisis has adversely affected stock price efficiency in most of the Eurozone capital markets, leading to the emergence of significant mean-reverting patterns in stock price movements. Borges (2010) analyses the European market before the financial crisis and concludes that for France, Germany, UK, Greece, Portugal and Spain, from January 1993 to December 2007 the stock market index follows a random walk, meaning that the market is efficient. Urquhart (2014) argues that during the period 1988 to 2012 the efficiency of the market is found to be country-debatable. The results of the whole sample are mixed, the market efficiency is accepted for Netherlands, and it is completely rejected for Ireland, with the other markets providing mixed evidence for market efficiency. The subsample period results indicate that while some markets became more efficient after the introduction of the Euro currency, such as Spain and Finland, and some markets became more inefficient, such as France, some were not influenced by the introduction of the Euro, such as the Netherlands and Italy. Dragotă and Ţilică (2013) analyse Eastern European market and conclude that for some countries for the period January 2008–December 2010 for some assets the market is defined as efficient. However, the results have shown that there are serious doubts concerning the stock market efficiency for all the countries in the analysed period.

2.4 Price discovery and market efficiency

Market efficiency is strongly related to information flow and, hence, if in the relationship between two markets one market leads it means that this market incorporates new information faster and is more informationally efficient. Price discovery determines the leading role of a market. In the market microstructure literature, the price discovery process has been variously interpreted as “the search for an equilibrium price"(Schreiber and Schwartz, 1986), "gathering and interpreting news"(Baillie et. al, 2002) and "the incorporation of the information implicit in investor trading into market prices"(Lehmann, 2002). These interpretations suggest that price discovery is dynamic, and an efficient price discovery process is characterised by the fast adjustment of market prices from the old equilibrium to the new equilibrium with the arrival of new information (Yan and Zyvot, 2010). Hence, it is possible to conclude that market efficiency is closely related to price discovery and price adjustment. For instance, in the efficient market all information is incorporated into the price, and the price adjusts fast. Hence, there is no chance to bid the market.

2.5 The relationship between CDS and bond markets.

According to Hull, Predescu and White (2004), in theory CDS premia should be close to the excess of the yield on a bond issued by the same reference entity over the risk-free rate.

However, on practice CDS premia may differ from the bond spread. This difference is called basis. The CDS-bond basis, the difference between the CDS premia and corporate bond spread, is often interpreted as an indicator of mispricing. (Kim, Li and Zhang, 2016). The authors state that there is an arbitrage opportunity by buying bonds with a low residual basis and selling bonds with high residual basis. Moreover, CDS-bond basis arbitrage can help to bring the prices of corporate bonds to their fundamental values and improves the efficiency of the corporate bond market.[4] Hence, the size of a basis determines a level of mispricing. De Wit (2006) confirms that despite theoretically markets for CDS and bonds of the same reference entity and maturity are bound by no-arbitrage conditions, but the average CDS-bond basis is positive in the period 2004-2005 in the research. Choudhry (2006) continues that fluctuations in the basis give rise to arbitrage trading opportunities between CDS and bond markets. However, a non-zero basis does not essentially characterise pure arbitrage opportunities because it could be due to pledged differences between CDS and corporate bonds or risks involved in basis arbitrage. Therefore, it is possible to conclude that such factor as risk, in the case of bond-CDS relationship-credit risk or

[4] 'Since CDS tend to lead corporate bonds in price discovery, basis arbitrage could help to bring market prices of corporate bonds to their fundamental values and improve the efficiency of the corporate bond market' (Shleifer and Vishny, 1997).

risk of default, in particular, can be under review as well as distinctions between the markets.

Despite the fact that the markets are strongly bounded by the purpose to reduce credit risk and mitigate the consequences of default of reference entity there is a difference in the nature of the markets. The essential difference is that CDS and bond contracts are traded at OTC and at primary market respectively. However, after a bond was issued it is traded between investors in the secondary market of security exchange. At security exchange markets there is a regulator through which transactions are completed, while in OTC markets there is no regulator. Thus, security exchange markets have fewer chances of price manipulation, while there are a lot of competing traders in OTC markets that can manipulate prices. Exchange markets ensure transaction security, while OTC markets are disposed to fraud and dishonest traders. According to Chovancová and Gregor (2017), historically OTC markets that were established at the beginning of the 20th century are significantly fragmented and inefficient. In inefficient market prices are significantly influenced by investor irrationality and behavioural bias. (Pedersen, 2015) In an efficient market all information is accounted for in a security's price. Hence the availability and flow information can be a determinant of market efficiency especially in such fascinating tandem of CDS premia and bond spread. A good indicator of information flow between the markets can be price discovery process. Indeed, Jiang and Lo (2010) conclude that bond price changes are mainly driven by public information shocks, as reported in macroeconomic news announcements and events. Moreover, according to the authors, heterogeneous private information contributes significantly to price discovery. Thus, price discovery process is a key factor, which determines the outcomes of flow of information and hence it influences market efficiency. Therefore price discovery can be used to identify market efficiency or how fast prices adjust. Yan and Zivot (2010) propose the concept of price discovery, which 'is the dynamic process by which market prices incorporate new information and it is arguably one of the most important functions of financial markets. They claim that there is a notable trend in financial markets, which is the trading of identical or closely related assets in multiple markets. The important issues related to price discovery are determining which market first incorporates new information about the underlying fundamental asset, and how the efficiency of price discovery depends on trading mechanisms, market liquidity, and the prevalence of asymmetric information.

There is a significant number of financial research that determines the existence of an equilibrium between bond spread and CDS premia. One stream of literature focuses on investigating the presence of price discovery states that CDS market leads the bond market. (Blanco, Brennan and March 2005; Gomes and Brandi 2005; Berggren and Mattsson 2008; Buhler and Trapp 2012; Alagoz, 2012 and Shim and Zhu 2014) However, Ammer and Cali (2011) and Lehtonen (2012) argue that bond market leads to price discovery. Moreover, Arce, Mayordomo and Pena (2013), O'Kane (2012), Lehtonen (2012) and Gyntelberg et al. (2013) claim that the relationship can be country dependable. 'Country dependable' indicates the manner in which market leads to price discovery depends on a country.

Alexopoulou, Andersson and Georgescu (2009), who analysed the price of credit risk in CDS and corporate bonds for European countries during the financial crisis, conclude a relationship exists between these two markets in the long term. The results show that the sample up to end-July 2007 little influence on CDS and corporate bond spreads since 2004. The authors conclude that the leading role of the CDS premia in the price discovery process strengthened relative to the corporate bond markets during the financial crisis period. Fontana and Scheicher (2016) also analyse the relation between CDS premia and spread of sovereign bonds for the European region for 2006-2010. The study does not indicate econometric evidence of a relationship for most of the countries before the crisis. Moreover, CDS and bond spreads are not cointegrated during this period. However, since September 2008 all pairs of CDS and bond spreads are cointegrated. The authors conclude that since the beginning of the financial crisis CDS market plays the major role in terms of price discovery. The relationship is different across the countries, for half of the sample CDS premia leads to price discovery, however, for the other half bond spread leads to price discovery inversely. O'Kane (2012) who also tests CDS bond relationship for sovereigns during 2009-2011 finds a one day lag from CDS to bond for Greece and Spain, and that the relationship is inverse for France and Italy. For Ireland and Portugal a feedback relationship is concluded. The results support the idea of country-dependence. Granger causality tests give indications of the direction of any information flow, and the results of the tests are mixed. The results suggest that the dominant direction of causality is from CDS to bonds for Greece, but from bonds to CDS for France and Italy, while Ireland and Portugal exhibited Granger causality in both directions, implying a feedback system. Berggren and Mattsson (2008), who investigate 5-year CDS for 2004-2008 for banks and financial institutions, find significant evidence that CDS spread causes bond spread. Lehtonen (2012) continues, that from 2005 to 2010 the relationship between CDS and bond markets was not specified clearly in any period but there is evidence of bond market to be the price discovery location for the most of the countries before crisis but after the beginning of crisis the price discovery location is strongly country depended. Moreover, the results of the study show potential arbitrage opportunity through constant positive. Coudert and Gex (2010) assess both corporates and sovereigns to determine which the leader in the price discovery process is. The authors analyse a sample, which contains 5-year CDS premia and states that CDS market has a lead over the bond market for corporates as well as for sovereigns. Additionally, CDS premia's leading role is fuelled by the financial crisis. Moreover, CDS premia are expected to co-move closely with bond spreads. Buhler and Trapp (2012) found information spillover from the CDS to the bond market, particularly for financial firms of 2007-2011. The authors relate CDS and bond spread to liquidity factor stating that the bond market's liquidity dries up as the default risk increases and CDS premia becomes more liquid during times of high default risk. Moreover, the research provides a credit risk model, which allows explaining both positive and negative values of the basis, defined as the difference between the CDS premium and the bond spread, and the liquidity of the two markets varies. Zhu (2006) finds that CDS premia regularly moves ahead of the bond spread in price adjustment, particularly for US entities from 1999 to 2002. Liquidity is confirmed as a factor that determines CDS role in price discovery. Blanco, Brennan and March (2005) also indicate that prices in the CDS market lead changes in the bond market for the US and European bonds and CDS contracts during 2001-2002.

Ammer and Cali (2011) emphasise that, while CDS premia often move ahead of the bond market, bond spread leads CDS premia for emerging market sovereigns more often than has been found for investment-grade corporate credits. CDS market leads with lower extent for sovereigns that have issued more bonds, suggesting that the relative liquidity of the two markets is a key factor of where price discovery occurs. The authors assess 5-year to maturity CDS premia for the period 2001-2006. In the majority of cases papers investigate 5-year to maturity CDS premia as the most liquid one and match it with a corresponding bond of the reference entity. Gyntelberg et al. (2013) confirm that CDS premia adjust more quickly to reflect new information than bonds spreads more frequently. The authors assess French, German, Greek, Irish, Italian, Portuguese and Spanish market. The assessed period starts in 2008 and ends in 2011. Arce, Mayordomo and Pena (2013) confirm that the relationship was state-dependable for European region in 2004-2010. Counterparty risk and market-illiquidity are also found to be influencing factors for price discovery process. Alagoz (2012) reports that the CDS spreads have a price discovery role for 49 institutions listed in Markit iTaxx for 2006-2012. After the financial crisis Calice, Chen and Williams (2013) find substantial variation in the patterns of the transmission effect between maturities and across countries for the CDS market. The main findings suggest that for several countries, including Greece, Ireland and Portugal the liquidity of the sovereign CDS market has a substantial time varying influence on sovereign bond credit spreads. Moreover, regarding other regions Gomes and Brandi (2005) report CDS market-leading role in the price discovery process for Brazil for 2003-2004. Additionally, CDS premias and spreads are not highly correlated. However, after the financial crisis the correlation for certain institution became stronger. For European region Delis and Mylonidis (2011) analyse daily data on 10-year government yield spreads for Greece, Italy, Portugal and Spain. These spreads are matched with the corresponding 10-year euro-denominated CDS mid bid-ask prices. The results show that 2004-2010 CDS almost uniformly Granger-cause spreads. Feedback causality is, however, detected during times of intense financial and economic turbulences. This may indicate that high-risk aversion tends to perplex the transmission mechanism between bond spreads and CDS prices. The results are confirmed by Baba and Inada (2009) for Japanese market stating the leading role of CDS in price discovery. Appendix A summarises the outcomes of the previous research and reports that CDS premia leads in PDP for the whole period starting from 1999 to 2012. However, during and after the financial crisis the relationship tends to be more country-dependable. The leading role of CDS premia increases during the crisis. The reason for such change can be explained by higher demand for 'insurance' against default during abnormal times and the level of financial suffering in different countries across the world.

Thus, it is important to understand what market leads to price discovery process: whether it is CDS premia or bond spread. The CDS market depends on a continuous flow of information from lots of countries and requires a high degree of transparency. The information flow can be influenced by political, macro and micro economic, environmental, health and other factors. These factors have an impact on asset prices. One of these factors is information that can be publicly or privately available. In the case of CDS bond relationship price discovery process is assumed to show what market reacts first to new information. The main benefits of understanding how price discovery works are market efficiency understanding, efficient risk management, arbitrage and regulatory opportunities. Chakravarty, Gulen and Mayhew (2004) highlighted that investors, who trade CDS and bond simultaneously, as well as those, who are active only at one market, can find many valuable benefits from research on the topic. For example, if the results show that the CDS premia leads significantly to price discovery, some information is firstly reflected in the derivative market, and movements in the market will be of interest to investors trading the underlying asset. Regulators could also find it critical to understand at what market informed traders choose to trade and what factors influence their choice. The information could be used to prevent illegal actions. This statement leads to a conclusion that understanding of how CDS premia bond spread “cooperate” can bring a contribution to market efficiency theory.

Regarding the methodological framework a set of tests is run to conclude what market leads in price discovery process. Data is tested of stationarity, cointegration and finally, it is checked whether CDS premia causes bond spread or the relationship inverses.

In summary, it can be stated that because CDS market has become a growing financial market, it has become an attractive topic to be researched. However, there is still no general concept of its mechanisms. Several researches have been conducted that lead to the conclusion that long-run relationship links between CDS premia and bond market exist and that CDS premia causes bond yield spread. The academics focus on causality link between the markets applying various methodologies. The causality increases during financial distress and becomes country and industry dependable. The causality link determines price discovery process. If a market leads to price discovery, it means that new information is first incorporated in the price of a security of this market. Price discovery is an important process that can be understood by disclosing how quickly CDS and bond spreads react to information flow and can be beneficial for market participants. Finally, the data that has been analysed covers either sovereigns or small data samples that prevent us from an understanding of the entire picture. Moreover, there is a very small number of papers that look into the period after the financial crisis and those that exist focus more on sovereigns. Finally, the previous research focuses mostly on CDS premia bond spread relationship and doesn’t pay attention to market efficiency. Thus, a broad data sample, which covers many industries and contains companies from different countries with different ratings, could be a good proxy to analyse CDS premia bond yield spread relationship during and after the financial crisis.

2.6 The relationship between CDS, bond and equity markets

In this section the relationship between CDS, equity and bond market will be discussed. The literature on the topic of the simultaneous relationship is limited, but it exists. This section is organised as follows: first, the relationship between CDS and equity markets will be discussed; second, the relationship between bond and equity markets will be discussed, and, third, the simultaneous relationship between the markets will be reviewed.

2.6.1 The relationship between CDS and equity market.

A soundly new stream of literature intends to explore the relationship between the equity and credit derivatives markets with respect to informed traders' investment decisions. Equity or stock market, where shares of a firm are issued can be traded through exchange or OTC markets. The market can benefit both investors and companies by giving first ones potential to realise gains based on its future performance and access to capital to the other ones. The global financial crisis of 2008 that had its origin from the USA was alleged to have had a varying degree of impacts on different capital markets in various countries and in particular on the equity market. Indeed, according to Mollah, Zafirov and Quoreshi (2014), the Dow Jones index went down by 6% in value during the month of September 2008. On the 1st of September the index had lost nearly 20% of its value and lost nearly 25% of its value by the end of 2008. It continued to decline until March 2009, when it recovered to redeem a significant portion of its losses. Thus, the market was noticeably affected by the financial crisis since the great depression. Indeed, the market crashes and bears during the great depression in since 1929. The Dow Jones closed at $230 – down 23% from the opening of $299. (Shankar, 2015) It is stated that stock market accords to market efficiency. However, Cohen et al. (2012) argue that the presence of market efficiency questionable. Moreover, EMH was called as one of the causes of the financial crisis. (Ball, 2009) Hence, researching of markets relationship can help to understand the flow of information and by applying lead-lag analysis to understand what market leads to price discover, hence what market responds quickly to new information available. Moreover, an essential parameter in CDS pricing is the amount of credit risk associated with the underlying reference entity and to calculate this amount an investor can apply a variety of approaches. An investor can rely on rating agencies that rate individual entity's' capability of servicing and repaying their obligations (Moody's and Standard & Poor's are two of the better-known rating agencies). Another approach based on applying traditional scoring models that typically attempt to measure the amount of credit risk using accounting information. The last approach is to extract information about credit risk from the market; if the market acknowledges credit risk, then there must be ways of filtering the information contained in market prices to get measures of credit risk. Moreover, apart from credit risk management CDS is the common underpinning of price discovery. (Cao et al., 2010). The link between stock prices and CDS premia is an important feature for financial and credit risk management in a decision-making process. While CDS may be used to hedge risk or for speculation purpose, a stock return is a profit on investment. It is a measure of the performance of an investment over time.

Regarding the association between CDS and equity markets Friewald, Wagner and Zechner (2014), who analyse the relationship before and during the financial crisis for the period of 2001-2010 conclude that a strong link between CDS spread and expected credit risk premia drive equity price. Furthermore, the relationship is found to be positive, as firms' equity excess returns increase with CDS-implied risk premia. However, there are plenty of research documenting a negative relation between the real-world default probability and stock returns. For instance, Dichev (1998) uses the Altman (1968) Z-score and the Ohlson (1980) O'score to measure default risk and reports a negative correlation between the markets. The negative results are also shown by Eyssell, Fung and Zhang (2013) before the financial crisis. The results are confirmed by Hilscher, Pollet and Wilson (2015), who argue that equity returns lead CDS returns at daily and weekly frequencies, while CDS returns do not lead equity returns for 2000-2001. These results may mean that informed traders are primarily active in the equity rather than the CDS market. Moreover, informed traders primarily participate in the equity market and only liquidity traders participate in the CDS market. However, CDS returns respond more quickly during outstanding news events, showing that the price adjustment is sensitive to 'financial health'. Bystrom (2006), who presents the first paper studying the relationship between equity and CDS markets and employs iTaxx for CDS, detects an interesting aspect that firm-specific information is embedded into stock prices before it is embedded into CDS premia. Also, stock price volatility is significantly correlated with CDS premia and the premia is found to increase (decrease) with increasing (decreasing) stock price volatilities before the financial crisis. It is confirmed that for 2004-2009 equity price and CDS premia are negatively correlated. Moreover, equity price influences CDS premia, but the relationship is not inverse. The author states that understanding stock return, stock volatility and CDS spread is important not only for risk managers, who are using CDS for hedging purposes but also to anyone trying to benefit from arbitrage possibilities in the CDS market. Buus et al. (2009) confirm a negative correlation between the markets and that equity prices lead CDS spreads and not the other way around during the period from January 2004 to May 2009 for 265 firms present in S&P 500 in 2002. According to Wang and Bhar (2014), information spillover between CDS market and equity return for 252 United States firms during 2004 -2010 showing significant information flow from the stock market to the CDS market under turmoil conditions for investment-grade firms. Credit protection returns are predicted at a horizon of up to five days. Moreover, the response of the markets to credit announcement day leads to the conclusion that there may be informed trading in the CDS market for high-credit-rating firms. However, the situation is inverse for non-investment-grade firms. Regarding industry analysis Narayan, Sharma and Thuraisamy (2014) who also analyse price discovery process find that the stock market leads to price discovery in most industries while CDS market contributes to price discovery in only a few industries during the financial crisis. When investment grade stocks are considered, the importance of the CDS market in price discovery improves but the stock market still dominates the price discovery process. Da Fonseca, Ignatieva and Ziveyi (2016) assess the co-movement of CDS and equity markets for 2004-2013 in four Asia-Pacific countries at a firm and index level. The results show that stock returns lead the CDS, whereas at index level the lead-lag relationships are shared among all asset classes. The volatility spillover effects between the asset classes confirm the importance of equity volatility (either realised or implied) as a major contributor to global market volatility. However, the relationship is not perfectly straightforward, especially, during the financial turmoil. Coronado et al. (2011) analyse the links between sovereign CDS and stock indexes during the period 2007-2010 and conclude a major leading role of the stock market during the sample period, but when the year 2010 is isolated they find a change in this relationship and a key role of the CDS markets incorporating new information.

Similar results were obtained for other research with different conditions. Berndt and Ostrovnaya (2014), who analyse time series from 2002 to 2006 research the contribution of CDS market to price discovery relative to equity and equity option markets. The authors run a thorough analysis of whether and to what extent the CDS market acquires information prior to the equity one and vice versa. Opposite to previous empirical literature reviewed in the paragraph it is concluded that there is a significant information flow from both CDS and option markets to equity markets in the days leading up to adverse credit or option market events. Moreover, the indication for a significant incremental revelation of information in the CDS market relative to equity and equity option markets for high-yield firms is found. The evidence is detected when news of accounting scandals breaks or adverse earnings announcements are made. Acharya and Johnson (2007) who analyse insider trading state information flow from the CDS market to the stock market from 2001 to 2004 state that the information flow is concentrated on days with negative credit announcements, and for entities that experience or are more likely to experience adverse credit events. However, the overall conclusions are not clear. Regarding the contribution of understanding of the market efficiency Amadori, Bekkour and Lehnert, (2014) state if according to previous research informed traders prefer CDS markets over stock markets to exploit their informational advantage and if credit derivative markets contribute more to price discovery compared to stock markets it is valuable to investigate informational efficiency of stock and CDS markets. The results show a lead-lag relation between the CDS market and the other markets, in which changes in CDS spreads can forecast changes in equity prices consistently. The research is followed by Ehlers et al. (2010) for European markets, who examine the lead-lag-relationship between European equity and CDS studying the lead-lag-relationship between European equity and CDS markets in the context of the financial crisis and states that equity market leads CDS one and the relationship strengthen during the financial crisis. Kiesel et al. (2016) extend the research regarding the efficiency of CDS and equity markets of 538 US and European firms from 2010 to 2013 and state that CDS market is found to be efficient. Cornett et al. (2014), who analyse the influence of stock issuance to CDS premia in the US market, state that equity prices do not react to new issues in the pre-crisis period, but react negatively during the crisis. However, during the whole time period CDS premia decreases in response to equity issuance announcements. It is affected more significantly during the financial crisis 'when the federal government injected equity into financial institutions to ensure their viability.' (Cornett et al. 2014) Finally, the results indicate that single-name CDS based on financial entity's' default probabilities are potentially useful for private investors and regulators. The authors use changes in the CDS spread to measure changes in the market's perception of the probability of a debt default. The conclusions are important as issuance of new equities can influence CDS as well as it can affect bond yield spread, showing that the three markets are interconnected. The analysis employ abnormal return model to obtain the results. Pereira da Silva, Rebelo and Afonso (2014) find symmetric dependence and tail dependency parity between CDS and stock markets for European banks. This can explain that the association between stock prices and spreads does not surge during the financial crisis for the banking sector. Moreover, there is no structural break during the financial crisis. The study concludes that understanding of the relationships between CDS spread of the financial sector and equity return is essential for the evaluation of financial stability, and more precisely it is one of the crucial factors regarding supervision, regulation and market discipline. The authors apply the copula-based approach to indicate the association between stocks of European financial institutions and CDS markets. Copula approach is 'a multivariate probability distribution for which the marginal probability distribution of each variable is uniform. Copulas are used to describe the dependence between random variables.' (Pereira da Silva, Rebelo and Afonso, 2014). The analysis extends with a statement that by applying Granger causality, cointegration, and an error-correction model the results suggest that there is a close link between these markets, but there is no evidence that the co-movement increases in periods of financial crisis. Hence, lead-lag analysis confirms a strong relationship during times of stability. It is evident that the markets are related.

In summary, the existing literature provides results of the analysis that investigate CDS, and equity market relationship for different industries in the various countries before, during and after the financial crisis. However, the results are not straightforward. Some authors state that CDS premia leads to price discovery while others argue that the relationship is inverse. In general, a strong link is found between CDS premia and equity price. The information flows from equity to CDS market is spotted and informed traders prefer to participate in the stock market. Hence, in price discovery equity price tends to lead CDS spread during the crisis. Hence informed investors prefer to trade at equity markets, while liquidity traders chose CDS market. Moreover, for most of the previous research the general conclusion is that CDS spread is negatively correlated with equity price, meaning that if credit risk raises the equity prices go down and vice-versa.

2.6.2 The relationship between bond and equity market

As opposite to CDS market bond and equity markets are well researched as well as the relationship between them. CDS and equity markets, their history and dynamics were described in previous sections. In this section debt market will be described as well its relationship with the equity market. The US bond market has been existing since 1910. During the great depression a yield on sound bonds with rating higher or equal to A rose by 5-15%. (Homer, 1975) Moreover, bonds are traded first traded at the stock exchange and in the aftermath at OTC.

Regarding the relationship between the markets Mao (2012) states that for a sample of 214 companies corporate bond markets contribute 12.6% on average to price discovery from 2009 to 2011. Moreover, corporate bond market price discovery increases with the riskiness of the underlying firm value. Tucker and Laipply (2013) analyse iBoxx $ Liquid Investment Grade Index, an index of U.S. dollar-denominated investmentgrade corporate bonds from September 2010 to September 2011, concluding that bond market liquidity leads to degraded price discovery. Before the global financial crisis for German, French, Italian and Spanish sovereign securities speed of the yield adjustment to the long-term equilibrium relationship varies over time and is affected by quote durations. Moreover, according to Tillier (2016) when equity prices increase, bond prices decrease. In other words, bonds and stocks have an inverse relationship. The logic behind this is obvious. Investors have to choose between less risk, but relatively low return, of bonds, or the risky nature, but high return, of equities. If they are fully invested they have to sell one in order to buy the other, though, so bond prices tend to drop when stocks are rising and vice versa. Despite the fact that it sounds logical, the exact opposite has occurred on many occasions over the last few years; stocks and bonds have risen and fallen in tandem. Indeed, since 1998 changes in bond yields and equity performance have been positively correlated, (i.e. equities and bond yields have risen together. It is concluded that there is influence by changes in bond spread to equity return. The influence is observed to be positive. (Kwan, 1996) However, Downing, Underwood and Xing (2009) examine the lead-lag relationship between high-frequency returns on individual stocks and bonds. They find that hourly stock returns lead to price discovery in bond equity relationship for non-convertible junk and BBB-rated bonds, and convertible bonds in all rating classes. The outcomes of the research indicate that the corporate bond market is less efficient in digesting information than the stock market. Hong, Torous and Volkanov (2007) analyse the lead-lag relationship between industry portfolios and general stock market movement. The authors claim that a significant number of industry returns, including retail, commercial real estate, metal, and petroleum, predict the equity market by up to two months and the eight largest non-US stock markets show remarkably similar patterns. These results suggest that equity markets react to the information contained in industry returns about their fundamentals with a delay and only response to the information gradually across markets.

Overall, some research suggests that bond market leads to price discovery. However, the results are doubtful. Moreover, it is stated that the correlation between the market is not as clear as it could turn up. Thus, the topic requires more precise research in terms of lead-lag analysis as well as how one market influences the other one.

2.6.3. The relationship between the three markets

The question of the interrelation between three markets CDS, bond and stock is economically essential; however, it is not discussed as broadly as the relationship between CDS and equity markets or CDS and bond markets. Since 1990 an empirical relation between stock returns and bond yield spread has been described. However, the relationship between derivative, debt and equity market is not fully analysed. Chan-Lau and Kim (2004), who are pioneers in the topic, investigate equilibrium price relationship and price discovery between CDS, bond, and equity markets for emerging market sovereign issuers. The authors analyse eight emerging markets for the period March 2001–May 2003. The results of the paper suggest that in Brazil, Bulgaria, Colombia, Russia, and Venezuela, there is a strong correlation between CDS premias and bond spreads. This finding suggests that arbitrage forces CDS and bond spreads to converge despite various pressures that arise in the market due to a number of technical factors. In most countries, however, price equilibrium relationship between equity and bond markets is not defined. As for price discovery, the results are mixed, and it is difficult to conclude that one particular market dominates in the price discovery process.

Schempp (2013), who follows Chan-Lau and Kim (2004), finds that CDS premia reacts differently than bond spread to changes in the stock market and that the sensitivity between the markets is affected by additional factors such as credit quality for 2001-2010. CDS market reacts slightly faster to the equity market and is more sensitive to equity price movements. The outcomes of the research implicate for capital structure arbitrage. The research is based on a concept that the fundamental basis of arbitrage between equity and debt is that positive equity returns are associated with negative CDS and bond spread changes: A rise in the stock price of a company typically goes along with an increase in the entity's financial soundness that lowers the probability of the company to default on its debt. The results are structured as following: Stock and CDS markets lead the bond market, The CDS market is more sensitive to the stock market than the bond market, the strength of co-movement increases the lower the credit quality, the magnitude of relationship changes with sentiment through time and correlation naturally doesn’t always hold – special corporate events can lead to extreme, adverse movements. Firm-specific regressions are employed by the study as a methodological part of the research. However, the research on the relationship between three markets is limited, and the previous researches are more focused on CDS equity relationship. Norden and Weber (2009) analyse the empirical relationship between credit default swap, bond and stock markets during the period 2000-2002 and conclude that stock returns lead CDS and bond spread changes, CDS premia changes causes bond spread changes for a higher number of firms than vice versa and the CDS premia is significantly more sensitive to the stock return than the bond spread and the magnitude of this sensitivity increases when credit quality becomes worse. Finally, the CDS premia plays a more important role for price discovery than the corporate bond spread. The authors analyse data for corporate unique references. Corzo, Gomez-Biscarri and Lazcano (2012) analyse the relationship between sovereign CDSs, sovereign bonds and equity markets for thirteen European countries during the period 2008-2011. The leading role of equity markets in incorporating new information during 2008-2009 is confirmed. However, during 2010 sovereign CDS markets took over this role and led the process. The authors also find that the role of CDSs with respect to the other two assets is state dependent, i.e., sovereign CDSs play a stronger role in economies with higher perceived credit risk.

Regarding methodology that is employed to assess interdependency among the markets it is observed that in the major of researches Merton structural model is applied to trace the relationship between CDS premia and stock price. The model is performed to assess the credit risk of a company by characterising the company's equity as a call option on its assets. Another way to assess the correlation structure of CDS and equity markets is Copula- based multivariate model. According to Pereira da Silva, Rebelo and Afonso (2013), it allows 'to build the marginal distributions separately from the dependence structure (copula) that links these distributions to form the joint distribution.' The model permits to increase the degree of flexibility in specifying the model, in comparison to other methods. The detailed structure of it will be described in methodology. Wang and Bhar (2014) employ regressions to assess the relationship between the markets as well as define the period of cumulative response from credit protection returns to a 1 percent decrease in equity returns. In the current empirical paper, first, the dependence structure is tested in case of extreme events. Second, applying Merton structural model tests strengthening of the relationship between equity return and CDS premia during the financial crisis. Merton model is applied to calculate the market value and volatility of the entity's assets based on equity values to improve their accuracy in obtaining the distance-to-default. Third, the autocovariance of the dependence structure of the performance of both markets is investigated. For the analysis of the three markets Chan-Lau and Kim (2004) apply cointegration analysis and Granger causality tests. Norden and Weber (2009) and Corzo, Gomez-Biscarri and Lazcano (2012) employ a VAR model is appropriate to analyse the co-movement of markets because it captures lead-lag relationships.

Overall, a conclusion can be made that the literature on the relationship between the three markets is limited, and it is presented by only a few academic papers, that state that CDS market tends to lead the bond market, while equity returns lead to price discovery, however, results are mixed and are defined as country-dependent. Moreover, bond and CDS market are positively correlated, and equity and stock market are negatively correlated. The results of the existing literature are limited but important for all market participants, as according to Belke and Gokus (2014), three variables indicate the performance of an entity: stock price, bond yield spread, and credit derivatives.

2.7 Factors that determine CDS, bond and equity markets

In this section, the factors that determine a change in CDS, bond and equity markets will be discussed based on the existing empirical literature on the topic. The section is organised as follows: first, factors that determine credit risk are described, second determinants of CDS premia are presented, third, the drivers of debt market are discussed, fourth factors that influence stock markets are reviewed, and, finally, the drivers of CDS bond basis are presented.

2.7.1 Credit risk determinants

A credit risk is the risk of default on a debt that may result from a borrower failing to make required payments. Based on the definition we can conclude that CDS is directly related to credit risk, as it is a protection against default. Podpiera and Ötker (2010) analyse the fundamental variables that drive the credit default swaps during the 2008-2009 time period and conclude that business models of large European financial intuitions, earnings potential, and economic uncertainty are the most significant determinants of credit risk. Moreover, Chaibi and Ftiti (2015) analyse European markets presented by Germany and France for 2005-2011 and assess NPLs' ratio, loan loss provisions, inefficiency, leverage, noninterest income, size, ROE, inflation, GDP growth, interest rate, unemployment and exchange rate. Among macro economic determinants, Castro (2013) underlines GDP growth and share price, unemployment rate, interest rate, appreciation of the real exchange rate. Moreover, a substantial increase in the credit risk during the recent financial crisis period is observed. For the UK market Cerrato and Zhang (2016) analyse363 firms with 14 firm-specific variables and six macro economic variables in our data set spanning from 1986 to 2014 and conclude that profitability, leverage and reinsurance are significant for assessing companies' credit risk. Additionally, insurance firms are exposed to some common determinants, and new firm-specific risk factors like usage of financial derivatives and investment profitability are found. GDP growth, interest rate, wholesale price and credit provided by financial institutions are among macroeconomic factors. Firm specific factors consist of underwriting profit, leverage, growth premium written, reinsurance, incurred claims, excess capital, combined ratio, investment profit, usage of derivatives and organisational form.

Consequently, CDS spread is strongly related to the credit risk associated with entities. In the next section we will describe the factors that drive CDS market that suppose to be similar to the factors that determine credit risk. Moreover, credit risk is negatively correlated with factors that determine the soundness of financial stability of a company and economy, such as GDP growth, liquidity, etc.

2.7.2 CDS spread determinants

Due to the growing interest in the CDS market the factors that determine the swap spread are important for analysis. Abid and Naifar (2006) outline rating, time to maturity, risk-free interest rate, slope of the yield curve and volatility of equities as determinants of credit default swap rates. After the independent factors were regressed it was concluded that most of the variables have a significant impact on fixing the levels of credit default swap prices for European countries during 2000 and 2001. For North American region between January 1, 2002 and April 30, 2009 Tang and Yan (2013) determine that CDS spreads are mostly driven by fundamental variables such as firm volatility and leverage, market conditions, and investor risk aversion. However, excess demand and liquidity are important additional factors. Include returns, stock price volatility, leverage, CDS volatility, the return of a CDS market index and tail-dependence measures for the Northern American region for 5-year CDS contracts for the time period of 2001-2014. (Pelster and Vilsmeier, 2017) For the earlier period Galil, Shapir and Ben-Zion (2012) state that stock return and volatility determines CDS spread as well as leverage. Leverage can be determined as book debt divided by the difference between book debt plus equity value. Moreover, spot rate, the differences between the 10-year Treasury Constant Maturity Rate and the 2-year Treasury Constant Maturity Rate, rating, market volatility and Fama and French (F&F) factors and Pastor and Stambaugh (P&S) liquidity factor are among the most decisive drivers. Chen and Härdle (2015) examined 5 and 10-year to maturity before during and after the financial crisis and found that the common risk factors in the pre-crisis period are mostly determined by the conditions of the North American market. During the crisis, the European interest rate term structure and credit quality determine the common risk factors. However, the interpretation of the period after the financial crisis only attributes to the European variables. Junge and Trolle (2015) conclude that changes in bid-ask spreads have a positive and significant effect on CDS spreads before and after August 2007. The positive sign of bid-ask spreads indicates that CDS illiquidity contributes to the increase of CDS spreads. Changes in the number of contributors have a positive and significant effect on CDS spreads before August 2007. Kim, Park and Park (2017) found that business cycle variables-the expected market risk premium, financial conditions index, and industrial price index-are strongly significant. The variable increases explanatory power considerably for the pre-crisis period and the post-crisis period, and is robust over the full sample and for the pre-crisis and post-crisis periods, independent of the number of portfolios. For the UK market Kajurova (2015) investigates 19 CDSs on senior debt of the UK financial entities for the time of pre-crisis, crisis and post-crisis periods. The results conclude that the bond market is influenced by equity volatility, equity returns, CDS Bid-Ask spread, market return, market volatility, risk free rate and 10y-2y UK government bond.

2.7.3 Bond spread determinants

Fama and French (1993), who are pioneers in researching of debt and equity market identify five common risk factors as interest rate, default factor for the bond market and book-to-market, size, which is related to the probability of default and excess market return. For sovereign debt market Poghosyan (2014) depicts debt-to-GDP ratio, potential growth for long-run bonds and inflation, short-term interest rates for short-run bonds for 2005-2011. Petrova, Papaioannou and Bellas (2010) add that in the short run, financial fragility is a more important determinant of spreads than primary indicators. The short-term coefficient of the financial stress index appears to be highly significant in all estimations, while the short-term factors of the primary variables are less robust. For European markets, in particular, Krylova (2016) confirms that the rating effect was the key factor of corporate bond spreads during the pre-crisis period, while the recent financial crisis was determined by increased cross-country and cross-sector heterogeneity. Afonso, Arghyrou and Kontonikas (2015) analyse sovereign bond market of European Economic and the Monetary Union for January 1999-December 2012 and find that during the pre-crisis period macro- and fiscal fundamentals are generally not significant in explaining spreads. By contrast, since summer 2007 the movements of macro and fiscal fundamentals explain spread movements well and in a way consistent with theoretical expectations. Explanatory variables include: 10 year government bond yield, S&P 500 implied stock market volatility index, second principal component of spread, 10 year government bond bid-ask spread, CPI based real effective exchange rate, expected budget balance divided by GDP, expected debt divided by GDP, industrial production annual growth, long-term divided by total general government debt, dummy variable of the financial risk 2008, credit rating and credit outlook. Alexopoulou, Bunda and Ferrando (2010) continue to analyse the factors that determine European bond spread. The study research EU government bond spreads (Bulgaria, Czech Republic, Latvia, Lithuania, Hungary, Poland, Romania and Slovakia) and macroeconomic indicators over the period 2001-2008 and conclude that external debt-to-GDP, inflation and exchange rates, countries' openness to trade, short-term interest rates differentials with the corresponding euro area rates as well as the equity market volatility in the euro area are the main long-run determinants of spreads. Marshall and Ho (2006) assess the UK debt market from 1 January 2001 to 30 June 2004 and find a positive relation between the default risk factor and swap spreads as well as a positive relation of liquidity premium to UK swap spreads for medium- and long-term swap spreads. Wei Chee and Fan Fah (2013) examine the bond spread of the UK market. The paper studies the relationship between eight macro economic determinants and the UK government bond yields for the time period from November 2006 to December 2010 and conclude that short term interest rates have strong and negative impact on 5-year, 10-year and 20-year UK government bond yields and the exchange rates have significant and positive relationship with 5-year UK government bond yield.

2.7.4 Stock market determinants

For equity market a summary of research shows that dividend or its surrogates can be defined as an integral factor bearing an impact on equity prices. Moreover, book value, retained earnings, price earnings ratio, financial leverage, size, etc. are among other important stock drivers. According to Mitchell (2017), there are five economic factors that affect equity return: interest rate, balance of payments, government policy, intermarket relationship and supply and demand. Before the financial crisis in 2005-2011, according to AL- Shubiri (2010), stock prices are determined by micro economic factors such as asset value per share, market price of stock dividend percentage, GDP, and negative significant relationship on inflation and lending interest rate for the banking sector. The factors are confirmed by Oseni (2009) additionally to the lending interest rate, the foreign exchange rate 2001 to 2007. For the UK market Tsoukalas and Sil (1999) indicate fundamental variables such as dividend yields, common set of stock market variables and the term structure of interest rates. Among macro economical factors economic growth, saving rate, banking sector development, trade openness, foreign direct investments, institutional quality and stock market liquidity are found to be main factors that determine stock market development in the literature by Bayar (2016). Garcia and Liu (1999) state that real income, saving rate, financial intermediary development, and stock market liquidity are major factors that determine stock market capitalisation, while macro economic volatility does not prove significant effect and stock market development and financial intermediary development are complements instead of substitutes. For European market Naceur, Ghazouani and Omran (2010) conclude that before the financial crisis stock market is defined by income level, saving rate, stock market liquidity, and interest rate. The results also show that the banking and the stock market sectors are complementary instead of being substitutes. The institutional environment as captured by a composite policy risk index does not appear to be a driving force for the stock market capitalisation in the region. Sukruoglu and Temel Nalin (2014) continue that for 1995-2011 income, monetazation ratio, liquidity ratio, saving rate and inflation influence stock market development. Monetazation ratio and inflation affect the market negatively while income, liquidity ratio, saving rate has positive an effect on stock market development. Liquidity ratio highlights that the equity market liquidity help to improve equity market development. Moreover, income and saving rate are correlated with stock market growth.

2.7.5 The determinants of the CDS-bond basis

Despite the question what factors influence CDS, bond and equity market is fascinating to understand how the markets are related there is another interesting question that should be addressed. What factors influence CDS basis? CDS basis is the difference between CDS and bond spreads. It can be negative, meaning that the bond is the cheap asset and the CDS is the expensive asset. If the basis is positive, it means that CDS is the cheap asset and bond is the expensive asset or CDS spread exceeds bond spread. As in normal condition the basis should be equal to zero it is an interesting topic to research to see what drives securities' choices to deviate. Bai and Collin-Dufresne (2011) analyse CDS basis for the period before the financial crisis, between the subprime credit crisis and the bankruptcy of Lehman Brothers and after the crisis and find that funding costs of financial intermediaries lead to a more negative average basis. The results are in line with research conducted by Kryukova and Copeland (2015). The negative basis is confirmed by Fontana (2010) during the financial crisis and found that market volatility, liquidity, OIS-T-Bill spread and Libor-OIS spread explains basis dynamics. Before the crisis according to De Wit (2006), the basis tend to be positive. The study outlines positive basis drivers, which are CDS cheapest to deliver option, CDS premia are floored at zero, CDS restructuring clause - technical default, bond trading below par, profit realisation, issuance patterns, and demand for protection. The drivers of negative basis are funding issues; counterparty default risk, accrued interest differentials on default, bond trading above par and synthetic CDO issuance. Factors that make the basis either positive or negative are coupon specificities and Relative liquidity in segmented markets. A positive basis is confirmed by Buhler and Trapp (2012). Bond and CDS-related liquidity measures influence basis. Moreover, on the one hand, the rating influences bond yield spreads more strongly than CDS premia and thus has a positive impact on the basis. On the other hand CDS premia is more affected by the market-derived option-implied volatility than bond yield spread. Oliveira and Pinto (2016) analyse Brazilian market and conclude that CDS basis is influenced by micro economic and macro economic factors. Long-term interest rates and term structure of interest rates affect immediate and more intensely bond than CDS. Share return, volatility in the share return, bond and CDS liquidity, bond issuance on the date, rating, and debt, tend to impact more on CDS, at first, and less on bond.

2.8 Conclusion

The relationship between CDS, bond and equity markets, price discovery and informational efficiency has received attention in empirical studies. A lot of empirical studies look for the relation between the markets and conclude that CDS market leads the bond market. (Blanco, Brennan and March 2005, Gomes and Brandi 2005, Berggren and Mattsson 2008, Buhler and Trapp 2012, Alagoz (2012) and Shim and Zhu (2014). However, Ammer and Cali (2011) and Lehtonen (2012) argue that bond market leads to price discovery. Moreover, Arce, Mayordomo and Pena (2013), O'Kane (2012), Lehtonen (2012) and Gyntelberg et al. (2013) claim that the relationship can be country- dependable. Based on the literature reviewed it has been found that CDS market reacts faster to a new information flow, while the relationship varies and bond market leads for a particular period of time or region. CDS and bond spreads are positively correlated, and the relationship is stronger during the financial crisis.

While CDS bond relationship is well documented the relationship between CDS, bond and equity markets can be considered as a new empirical study defying the theory of efficient markets. CDS and equity markets lead the bond market Schempp (2013) and equity return leads CDS and bond spreads. (Norden and Weber, 2009 and Corzo, Gomez-Biscarri and Lazcano, 2012) Solely CDS leads bond and equity market for some periods of time. (Corzo, Gomez-Biscarri and Lazcano, 2012) For the relationship between CDS and equity markets the results are mixed. However, it has been clearly stated that the correlation between the markets is negative. The results regarding bond equity relationship state that the researchers did not come to a unified conclusion how markets are correlated.

Moreover, initially, the CDS market is concluded to be inefficient. However, the market became efficient in the years of 2004 and 2005. During the financial crisis, the efficiency of the market is disputed.

CHAPTER 2: Global Financial Crisis and Price Discovery between Credit Default Swaps premia and Bond Yield Spreads

Abstract

This paper investigates the relationships between credit default swap (CDS) premia and bond yield spread. It investigates price discovery process between the two markets using daily data for CDS premia and bond yield spread from the 1st of January 2007 to the 1st of September 2014. The initial sample includes 697 entities for CDS premia denominated in the Pound Sterling (GBP). Thereafter, each daily observation for CDS premia is matched with bond yield spreads denominated in GBP and Euro (EUR) and the entire sample consists of 193 unique reference entities. This paper contributes to the empirical financial literature by employing an extended data sample that covers various sectors, markets and regions, by analysing the time period before and after the financial crisis and by employing a new approach to match CDS premia and bond yield spread. We provide empirical evidence of the CDS-Bond relationship and its implications for price discovery process and market efficiency employing causality and regression analysis. The results show, that, first CDS premia leads to price discovery in CDS bond relationship during the whole assessed period, second, before the financial crisis the impact of lagged CDS premia on bond yield spread remain similar to the impact after it, and, third, for investment grade bonds change of lagged CDS premia effects bond yield spread for GBP/EUR pairs, but the influence is lower.

Keywords: Credit Default Swap, bonds, financial crisis, price discovery, market efficiency.

JEL Classification: G01, G14, G15

1. Introduction and background

Credit Default Swap (CDS) is a contract, which provides insurance against default by a particular company or sovereign entity. Default is an event, which is triggered by credit risk. Credit risk arises when a firm faces difficulties to pay its obligations or there start to be delays in the payment process. The CDS market has existed since the 1990s when employees of Bankers Trust, later bought by Deutsche Bank, and JP Morgan developed the first CDSs as a way for the banks to protect themselves against their exposure to large corporate loans they made to their clients. From a relatively small market equalled to low hundreds of billions by the late 1990s, the product swelled during the nineties, and in 2011 their gross notional is concluded to be close to $28 trillion (£17 trillion). (Wilson, 2017) Before the financial crisis the CDS market was approximately $900 billion and was viewed as, and working in, a reliable manner. A limited number of parties took part in the earlier CDS transactions, so the parties were well acquainted with each other and understood the terms of the CDS product. As a result in most cases, the buyer of a CDS contract also held the underlying credit asset (loan or bond). (Zabel, 2017). Since 2000 speculation became rampant in the market leading to the stage when sellers and buyer of CDS did not own the underlying asset (bond or loan) but were just "betting" on the possibility of a credit event of a specific asset. Hence, by the beginning of the financial crisis the CDS market had a notional value of $45 trillion, but the corporate bond, municipal bond, and structured investment vehicles market totalled less than $25 trillion. Therefore, a minimum of $20 trillion were speculative "bets" on the possibility of a credit event of a specific credit asset not owned by either party to the CDS contract. Moreover, the size and impact of the CDS market are different for different regions.

The contagion effect of CDS market is discussed by Kalbaska and Gątkowski (2012), who state that sovereign risk mainly concentrates in Eurozone countries. Spain and Ireland have the biggest effect on CDS market in particular, while since August 2007 CDS market in the UK does not cause a big distress in Eurozone, because the UK market has most immune to shocks. The authors assess the dynamics of CDS market before and after Greek bailout and conclude that the highest CDS spread is determined for Portugal from 01/03/2010 to 01/09/2010, while the lowest for Germany, France and the UK. Before the financial crisis CDS spreads of different countries were growing simultaneously, however, the UK CDS spread did not grow dramatically comparing to the Greek, Portuguese and Irish ones. However, after the

Brexit the cost to protect against UK banks also rose, with CDS spreads in HSBC and Barclays. (Mehta, 2017) Indeed, with response to shock after voting UK 5-yr sovereign CDS spread has widened by 69%. Thus, even shock-resistant UK CDS market has been volatile since the time of the financial crisis 2008, which makes it fascinating for research to benefit financial market participants and regulators.

In the UK market, CDS contracts are mainly traded in three currencies: EUR, US dollar, and GB pound sterling. (Benos et al., 2013). The total notional amount is equal to 3.88 trillion Euro during Jan. 2007–Dec. 2011. CDS contracts are traded over-the-counter (OTC) and regulated by the *International Swaps and Derivatives Association* (ISDA) and are measured by spread, or premia the premia that CDS buyer pays to protect obtained debt against default, and the premia is measured in basis points or percentage.

Theoretically a CDS spread on a bond will be less than the conventional credit spread quoted for the same bond by its swap spread, however, on practice, the prices may vary leading to arbitrage opportunities. Thus to understand the relationship between two markets in *price discovery process* (PDP) is important for all market participants. The reason why *price discovery process* is important can be explained by a phenomenon that derivative market is highly dependable on information flow as it is OTC market. For example, if the results show that the CDS premia, but not bond spread, contributes significantly to price discovery, this indicates that information is first reflected in the derivative market, and movements in these markets will be of interest to investors trading the underlying asset and if the results show that bond spread, but not CDS premia, contributes significantly to price discovery, this indicates that information is first reflected in the debt market, and movements in these markets will be of interest to investors trading debt protection. Moreover, the results will be of relevance to both policy makers and exchange regulators as well as to the academic and financial communities.

One stream of literature focuses on investigating the presence of price discovery states that CDS market leads the bond market. (Blanco, Brennan and March, 2005; Gomes and Brandi, 2005; Berggren and Mattsson, 2008; Buhler and Trapp, 2012; Alagöz, 2012 and Shim and Zhu 2014). However, Ammer and Cali (2011) and Lehtonen (2012) argue that bond market leads to price discovery.

Moreover, Arce, Mayordomo and Pena (2013), O'Kane (2012), Lehtonen (2012) and Gyntelberg et al. (2013) claim that the relationship can be country-dependable. This means that what market leads to price discovery depend on the assessed country.

Regarding the UK market in particular previous literature is limited but is in agreement that CDS premia tended to lead the bond spread for sovereigns and financial institutions for years started from 2001 to 2002. (Blanco, Brennan and March, 2005). The researched data sample includes 33 reference entities for 5-year maturity CDS and interpolated bond yield mostly traded at the US market, however, the sample includes data from the UK markets presented by Barclays, British Telecom, United United and Vodafone. For the 27 firms out of 33 for which the equilibrium relation holds, the CDS market contributes on average around 80% of price discovery in four of the remaining six cases, CDS prices Granger-cause credit spreads, suggesting price leadership including Barclays and Vodafone. The results of CDS leading role are confirmed by Blanco, Brennan and March (2005), Gomez and Brandi (2005) for a Brazilian market, Berggren and Mattsson (2008) and Buhhler and Trapp (2012) for financial institutions, Alagoz (2012) and Shim and Zhu (2014).

During the financial crisis, CDS premia leads to price discovery and its leading role is fuelled by the crisis for sovereigns and corporate companies (Alexopoulou, Andersson and Georgescu, 2009 and Fontana and Scheicher, 2016). Alexopoulou et al. (2009) examine firm-specific, common factors and liquidity influences on CDS premia movements and a long-term equilibrium relationship between CDS premia and bond spread for European financial and non-financial firms over the period January 2004 to October 2008 including two UK companies. The authors found strengthen of CDS role in price discovery by the financial turmoil and that it brought closer correlation between firm- specific and common factors and, finally, the large increase in sensitivity to systematic factors of CDS market since the beginning of the crisis. The results are confirmed for other countries. By this means Fontana and Scheicher (2016) confirm the relationship for sovereigns. Buhler and Trapp (2012) and Alagoz (2012) state that CDS leads to price discovery for financial institutions.

Fontana and Scheicher (2016) examine the further period of 2008-2010. The researched data consists of weekly CDS spreads and benchmark bond yields for 10-year CDS denominated in US dollars for Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. The relationship is found to be *country-dependable*, since, in half of the sample, price discovery takes place in the CDS market, and in the other half, price discovery is observed in the bond market. The tendency is valid before and during the financial crisis. Arce, Mayordomo and Pena (2013), who examine daily 5-year sovereign bond yields and CDS spreads for European sovereigns for the period 2004-2008, confirm state-dependence and provide evidence of industry factor influence on *price discovery process*. After the financial crisis CDS premia continues to lead to price discovery (Fontana and Scheicher, 2016 and Alagöz, 2012). Alagöz (2012), who analyses companies covering Eurozone and the UK, confirms the leading role of CDS results for the period of January 6, 2006, until December 30, 2012. Hence CDS market keeps leading role after the financial crisis; however, some studies find that the relationship is country-dependent. Finally, it is evident that a large piece of research has been made on the topic. However, the literature on CDS market is still inadequate and promiscuous due to many reasons as limited data, the way this data is collected and matched and models applied to analyse it. Thus, this empirical paper aims to provide a general comprehensive understanding of how CDS premia is associated with bond yield spread based on a broad data sample, which covers different time periods, countries, industries and types of entities. Moreover, the influence of firm specific and market factors will be discussed. The recent research on the topic shows that taking into account the fact that CDS spreads are often understood as a leading indicator of development of creditworthiness, and therefore it can point out the potential situation in a company or economy, these spreads are such a useful indicator and market participants should pay attention to the factors which can have the impact on these spreads. Kajurova (2015) analyses firm specific and market factors on CDS of the UK financial institutions for pre-crisis, crisis, post crisis period for 19 CDSs on senior debt of the UK financial entities. The results show that for the pre-crisis period company specific factors were statistically significant. The changes in liquidity leverage and in equity volatility led to the changes in CDS spreads. The changes in leverage had a much bigger impact compared to the changes in other factors. During the crisis period the changes in market factors became much more significant than in the pre-crisis period. The most significant were changes in the European stock market return, followed by changes in risk-free rate and the changes in the European volatility index. After the financial crisis the changes in liquidity lost its significance, but the changes in leverage and in equity volatility were statistically significant and in accordance with the expectations.

The changes in the market factors were not such significant like they were in the crisis period, but still, their significance should not be underestimated.

The aim of this study is to analyse the relationship between CDS premia denominated in British pounds and bond yield spread during and after the financial crisis with an application of stationary tests and Granger Causality analysis that are intended to present a comprehensive picture how the CDS and bond markets are correlated and what market leads to price discovery.

The current study employs a data sample, which consists of 5-year CDS premia, as the most liquid one, (Coudert and Gex, 2010). Each CDS premia is matched with bond yield spread for every single reference entity of a CDS contract. The period of the researched sample covers the global financial crisis and time after it. Additionally, the data will be divided into two sub-periods. The first one starts from January 2007 to July 2010. The second one starts in July 2010 and ends in September 2014. To match a bond yield spread with a corresponding CDS premia, '*the remaining maturity*' approach is applied for every year for every single reference entity. The approach is described in details in the '*Sample*' section.

This study contributes to CDS market literature by examining the relationship between CDS and bond markets in the UK. The relationship between markets was first documented by (Blanco, Brennan and Marsh, 2005). The study assesses companies including 4 UK entities out of 33. The current study contributes into three directions. First, it employs extended data analysis comparing to previous empirical papers, which use limited data of European and the US financial and non-financial institutions (Berggren and Mattsson, 2008, Alexopoulou, Andersson and Georgescu, 2009 and Buhler and Trap 2012) and sovereigns (Fontana and Scheicher, 2016, Arce, Mayordome and Pena, 2013, O'Kane, 2012, Lehtonen 2012 and Gyntelberg et al., 2013). In particular, the paper employs daily observations for 697 unique reference entities, which includes both companies of different industries, and sovereign entities.
Second, this study analyses data for the extended time period including pre-crisis and crisis time period employed in previous studies as well as post-crisis period applying break point analysis to determine the date of financial distress. Third, this paper applies an absolutely new approach to match CDS premia and bond yield spread. We match CDS and bond spreads based on bond remaining maturity as close to 5 year

CDS maturity as possible. Finally, the study employs various factors to explain a change in bond yield spread.

This research will provide the results that are supposed to disclose the causality link between CDS and bond markets, showing which one response faster to changes in the financial system. In summary the results show, that, first CDS premia leads to price discovery in CDS bond relationship during the whole assessed period, second, before the financial crisis the impact of lagged CDS premia on bond yield spread remain similar to the impact after it, and, third, for investment grade bonds change of lagged CDS premia effects bond yield spread for GBP/EUR pairs, but the influence is lower.

The remainder of the chapter is organised as follows. First, data sources and sample, as well as data collection process and matching approach, will be described. Second, the methodology will describe the tests that will be implemented to obtain the results and, finally, the results of the empirical analysis will be discussed and the conclusion based on the results provided.

2. Data sources, sample and matching procedure

2.1 Data sources and sample

To investigate the relationship between CDS premia and bond yield spreads the necessary data is collected from *Markit* and *Datastream* databases. The databases are chosen due to the fact of specific nature of required information.

Markit collects and gathers CDS information directly from traders. It provides daily reports for a set of CDS transactions, which consists of CDS premia, ticker and short name, recovery rate, currency, type of CDS, called '*DocClause*' which describes collateral, rating, and a number of providers of information, called '*CompositeDepth5y*', sector, region and country.[5] It is a major derivative database which provides verified reference data to the credit derivatives market in particular. *DataStream* database was selected to obtain bond yield spreads. This database provides up to date as well as historical international data on stocks, indices, bonds, commodities, futures, options, etc. being one of the major databases for corporate bond collection. The CDS sample is selected based on the criteria as follows.

First, the sample covers the time period before, during and after the financial crisis and starts from 01 January 2007 to 01 September 2014. *Second*, the final CDS sample is filtered and selected based on CDS currency. The currency is specified to be British Pound Sterling (GBP, one of the most CDS traded currency). The sectors defined include Basic Materials, which means mining and refining of metals, chemical producers and forestry products and usually sensitive to changes in the business cycle, Consumer Goods, which contains clothing, food, automobiles and jewellery. The sample also includes Consumer Service, Energy, Government, Industry, Technology, Telecommunication Service and Utilities. The annual allocation of unique reference entities and daily observations for CDS and per sector denominated in GBP are presented in Table 1.

The largest number of daily observations and unique reference entities is reported for 2008 at the beginning of the financial crisis, and the lowest figures are from 2011 and 2014. The sample begins with 504 unique reference entities in 2007 that provide 109,132 observations. During 2009 and 2010 the number of entities

[5] Daily data is chosen because given the information technology has developed enormously, and markets react almost instantaneously, the use of daily data will capture better the linkage among CDS and bond markets.

presented in the sample declined respectively to 479 and 459 entities, comparing to 509 in 2008. The number of reference entities and observations continues to decline with a slight increase in 2012 and 2013. The total number of observations for the whole period is 698,150 for 697 unique reference entities. The general trend shows that after the financial crisis of 2008 the number of CDS contracts in our sample started to decline.

Table 1: Unique reference entities/daily observations for CDS with 5-year maturity denominated in GBP per year and sector

Years	**Unique Reference Entities**	**Daily observations**	**Sectors**	**Unique Reference Entities**	**Daily observations**
2007	504	109,132	Basic Materials	51	52,175
2008	509	112,828	Consumer Goods	70	82,770
2009	479	108,742	Consumer Services	105	107,045
2010	459	93,695	Energy	19	17,454
2011	312	70,249	Financials	242	204,157
2012	320	76,421	Government	17	10,358
2013	315	77,629	Healthcare	13	14,186
2014	313	49,454	Industrials	66	73,023
			Technology	9	11,234
Total	**697**	**698,150**	Telecommunications Services	38	46,372
			Utilities	67	79,376
			Total	**697**	**698,150**

Financial and Consumer Service industries are dominant in the sample while Healthcare and Technology are less presented in the derivative market. Financial sector reaches 34.7% of all 697 unique entities of the sample, which is equal to 242 entities and covers 204,157 daily observations. The share of the Healthcare and Technology sectors is small and equal to 1.9% and 1.3% respectively.

Third, the collateral type is defined. *Modified-Modified* (MM) is.[6] MM was introduced with a maturity limit of 60 months for restructured obligations and 30 months for all other obligations. The reason for choosing MM collateral type is that it is the most used in Europe. We also collect CDS implied rating provided by *Markit* for risk proxy.[7] The summary of country statistics for CDS sample (reference entities and daily observations) are presented in Table 2. Concerning country and region diversification the largest number of unique reference entities and daily observations for CDS market is collected for Germany, France and mostly for the United Kingdom. The United Kingdom market provides data for 248 entities out of 697, which is 35.6% of the market and covers 260,532 daily observations. In contrast, Curacao, Guernsey, Hong Kong, India, Netherlands Antilles, Panama, South Africa, United Arab Emirates and Saudi Arabia provides data only for one unique reference entity. Europe and North America prevalent in the sample, compared to insignificant Africa, Caribbean,

6 Collateral criteria covers 96% of European Restructuring Clauses.

7 Calculated on a weekly basis by comparing the issuer's 5-year senior standard trading convention spread to the 5-year spreads of the sector curves and applying the rating of the logarithmically nearest rating curve unique to that sector.

India and Middle East. In particular, in Europe CDS is traded mainly in the financial sector and is represented by 609 reference entities. The North America region with 52 entities that provides 25,179 observations takes the second place. Furthermore, we report in Table 3 reference entities and daily observation per region (Asia, Eastern Europe, Europe, Latin America, Middle East, North America, Oceania and Offshore) and sector. Figure 1 below presents a daily average of 5-year CDS premia from 2007 to 2014. It shows that the CDS premia increases dramatically at the time of the financial crisis from 2% to 7.5% in 2008 and returns at 2% at the end of 2009. Moreover, there is an interesting observation, that CDS premia of 1 and 3-year maturity exceeds 5-year CDS during the crisis, while the tendency is opposite at the normal financial period. It can be explained by higher demand for short maturity insurance during abnormal periods. The trend is also discernible for industry analysis, which was performed only for the sectors with many observations. While it is widely accepted that financial sector suffered above all other industries during the crisis, Figure 2 contradicts that evidence. It shows that the highest premia for a daily average of CDS premia with 5-year maturity premia is observed in consumer service sector. In figure 3 we also report interesting results regarding the CDS daily average premia dividing between Investment grade and junk bonds. We can observe a similar pattern across the time, but however, the financial crisis and periods of increased uncertainty are amplified in junk bonds CDS than their counterpart.

Figure 1: Daily Average CDS GBP premia (Maturity)

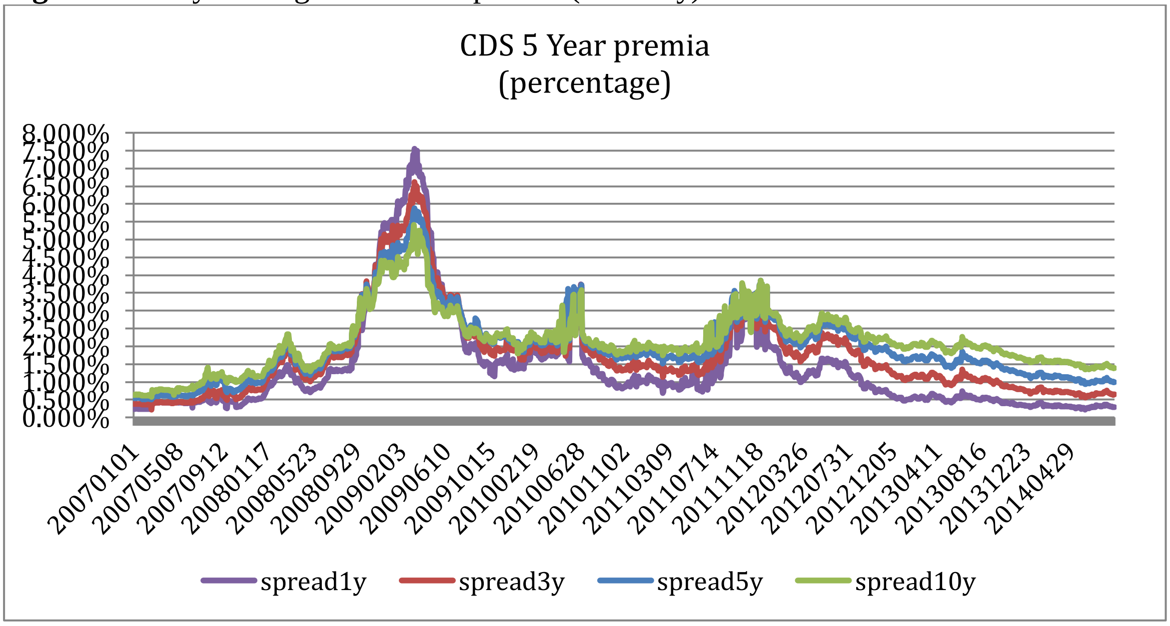


Table 2: Unique reference entities/daily observations for CDS with 5-year maturity denominated in GBP per country

Countries	Unique Reference Entities	Daily observations	Countries	Unique Reference Entities	Daily observations	Countries	Unique Reference Entities	Daily observations
Australia	8	5,518	Guernsey	1	1,791	Panama	1	1,083
Austria	7	4,036	Hong Kong	1	572	Portugal	7	6,721
Belgium	5	3,823	Iceland	3	1,389	Russian Federation	3	1,141
Bermuda	2	84	India	1	849	Saudi Arabia	1	8
Canada	2	1648	Ireland	12	12,045	South Africa	1	932
Cayman Islands	8	3,520	Italy	23	28,069	Spain	17	20,962
Channel Islands	2	193	Japan	5	2,430	Sweden	18	24,465
Curacao	1	944	Jersey	4	2,517	Switzerland	23	26,546
Denmark	10	9,738	Luxembourg	16	9,408	Ukraine	3	773
Finland	9	11,706	Netherlands	46	47,191	United Arab Emirates	1	896
France	75	88,761	Netherlands Antilles	1	16	United Kingdom	248	260,532
Germany	71	81,483	Norway	10	9,170	United States	48	23,447
Greece	4	3,743						
						Total	**697**	**698,150**

Table 3: Unique reference entities/daily observations for CDS with 5-year maturity denominated in GBP per sector and region

Region	**Obs.**	**Unique Reference Entities**	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Government	Healthcare	Industrials	Technology	Telecommunications Services	Utilities
Africa	932	1	---	---	---	---	---	1	---	---	---	---	---
Asia	3,002	6	---	1	2	---	3	---	---	---	---	---	---
Caribbean	944	1	---	---	---	1	---	---	---	---	---	---	---
Eastern Europe	1,914	6	1	---	---	---	4	1	---	---	---	---	---
Europe	654,096	609	48	63	94	16	195	13	11	61	7	36	65
India	849	1	---	---	---	---	1	---	---	---	---	---	---
Latin America	1,083	1	---	---	1	---	---	---	---	---	---	---	---
Middle East	904	2	---	---	1	---	---	1	---	---	---	---	---
North America	25,179	52	2	6	7	2	24	1	2	4	2	1	1
Oceania	5,518	8	---	---	---	---	7	---	---	1	---	---	---
Off-Shore	3,729	10	---	---	---	---	8	---	---	1	---	1	1
TOTAL	**698,150**	**697**	**51**	**70**	**105**	**19**	**242**	**17**	**13**	**66**	**9**	**38**	**67**

Figure 2: Daily Average CDS GBP premia (Sectors)

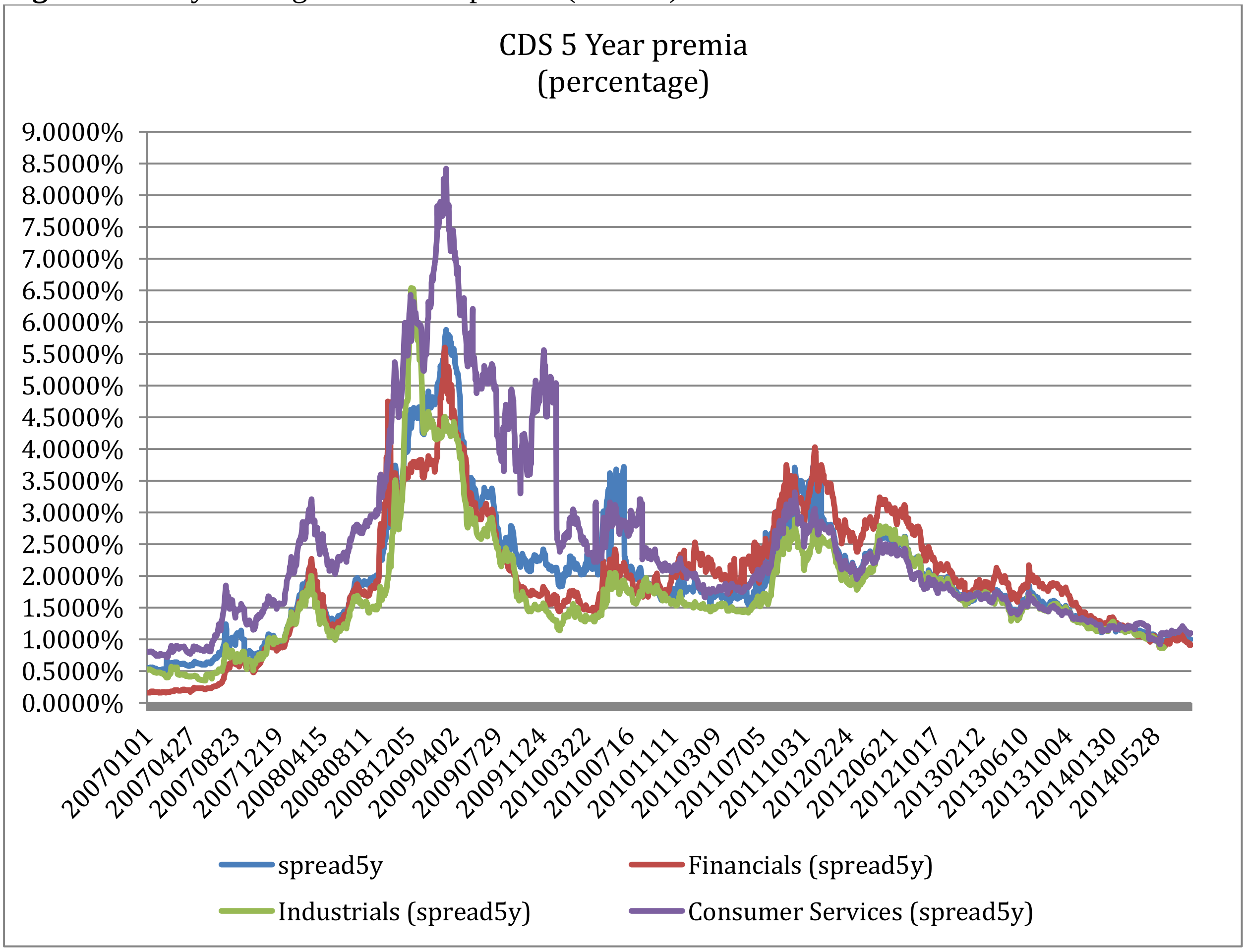
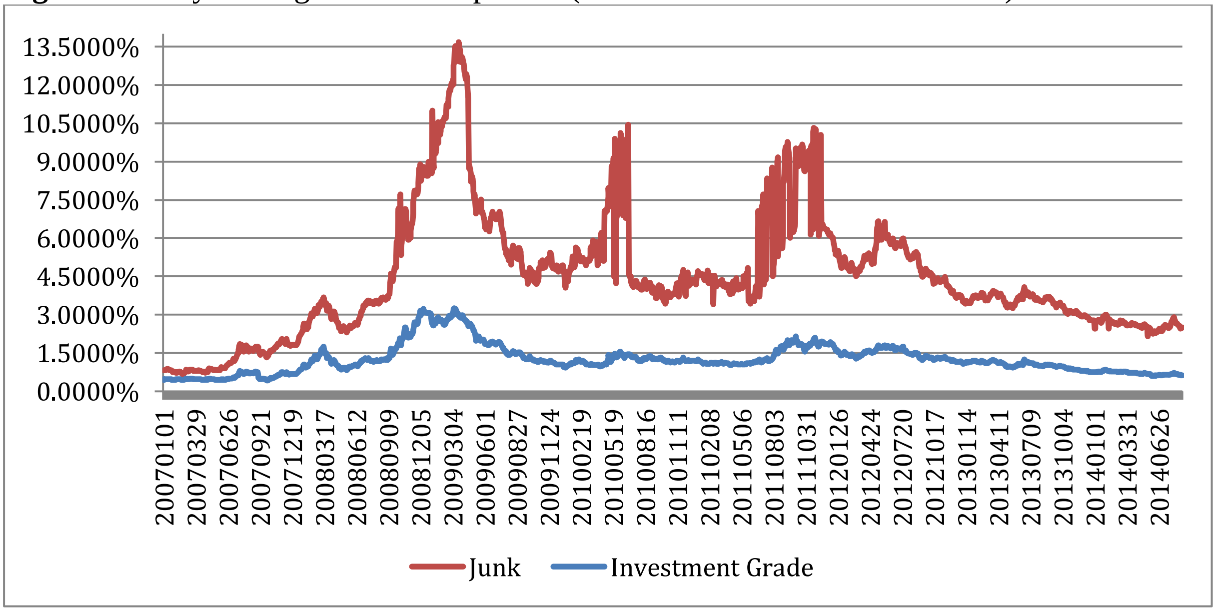


Figure 3: Daily Average CDS GBP premia (Investment Grade vs. Junk bonds)



It is observed that the levels of CDS premia are not constant across industries during the time period of 2007-2014. There are time periods when some sectors present higher spread than others, which might refer to some particularities of the industries, which is not the scope of this paper to analyse.

2.2 CDS and bond yields maturity matching

Various matching approaches have been applied to match CDS and bond data. Essentially financial literature offers two main techniques to match the data. The first approach is *'direct matching',* which focuses on finding a bond with the maturity as close as possible to the maturity of CDS contract. In the current case it is 5 years. (De Wit 2006, Hull, Predescu and White 2004) The other approach explores *'linear interpolation'* framework (Blanco et al., 2005, De Wit, 2006). In linear interpolation approach arithmetical mean is applied to construct a *'synthetic'* bond to be as close as possible to 5-year maturity. However, since CDS is similar to an insurance contract it provides protection against default solely for the exact maturity in most cases it is 5 years and it can be used to assure bonds with longer maturity for a time span of 5 years. An investor can buy a protection for a life span of debt at any stage of it. Thus, it makes sense to match each single 5-year CDS premia on a particular day with a bond with remaining maturity close to 5 years from that day. The remaining matching approach depends on data availability and the remaining maturity of a bond. As the sample research consists of more than 2,000 observations for CDS market it allows picking out a higher number of bonds with remaining maturity closer to 5-year. Remaining maturity approach differs from the previous studies presented in existing empirical literature for a couple of reasons. First, it is more pushed closer to financial conditions and more realistic than linear interpolation e.g. marketable approach. Second, it lets to match bonds not only with exactly restricted maturity of 5 years but bonds with longer maturity, where remaining maturity as close as possible to 5 years. The remaining maturity approach helps to cover a larger amount of data for sample selection.

In the current study CDS premia and bond yield spread are matched based on the '*remaining maturity*' approach. The logic of the approach is based on the assumption that CDS is an 'insurance' contract, which is obtained to protect debt buyer against default and in the case of 5 year CDS to protect a bondholder against a risk of default, which can occur during these five years of remaining maturity. Thus, to analyse CDS bond relationship it is essential to find a sound approach to merge the data. According to the approach the initial CDS sample will be matched with bond yield spread data, collection of which determines the approach itself.

The process of bond spread collection is organised in three steps. First, for each single reference entity of CDS transaction a date of remaining maturity is set. Second, the reference entity is searched in *Datastream* database, and the matching approach is applied to select an appropriate bond for a particular transaction e.g. for each CDS transaction, a respectively bond with a remaining maturity close to 5 years is collected. The approach is yearly based. For example, for a CDS contract starting in 2007, a 5-year to maturity bond is selected, which expires in 2012. For a CDS transaction starting in 2008, a bond with a maturity date in 2013 is sampled and so on for each year until the last one of the defined period. Therefore, there are CDS premia with five years maturity starting from 2007, 2008 and so on until 2014 and matched bond yield spreads with the maturity dates from 2012 to 2019 for most of the observations. However, there are some deviations in matching the samples[8]. In Table 4 the summary statistics of the remaining maturity approach for matched CDS premia and bond spread is presented. According to the table starting from 2010 for bonds denominated in EUR but less for ones in GBP the average and the median number of years of remaining maturity declines as it gets closer to 5-year maturity. The method of remaining maturity is new, and it makes the study unique and different from other empirical research.

Table 4: Bonds remaining maturity per sample year

Year	GBP		EUR	
	Remaining Maturity		Remaining Maturity	
	Mean	Median	Mean	Median
2007	11,63	9,58	8.70	8.48
2008	11,63	9,41	7.91	7.57
2009	11,23	8,64	7.20	6.70
2010	10,61	8,00	6.29	5.89
2011	10,76	7,64	5.72	5.19
2012	10,05	7,32	6.08	5.04
2013	9,50	7,21	5.71	4.90
2014	9,08	7,39	5.81	5.14

8 As an example AB SKF with a CDS issued in 2007 is merged with a bond the maturity of which expires on December 13, 2013

Corporate and government bond yields are collected daily from *Datastream* for the period 1 January 2007 to 30 September 2014. Bond yield spread is calculated daily and equal to corporate bond minus government bond yields in the denominated currency. The annual allocation of unique reference entities and daily observations for bonds per sector denominated in GBP and EUR are presented in Table 5.

Overall there are 116 and 147 unique reference entities for bonds denominated in GBP and EUR, respectively. [9]The number of entities increases in the course of time and peaks in 2014 for GBP currency (108 unique reference entities) and for EUR currency (127 unique reference entities). Financials and Consumer Services play the leading role in the sample of GBP and EUR bonds, while Technology is absent for GBP bonds equals to zero. For EUR bonds the least presented are Government, Healthcare and Technology.

[9] Coupon and zero-coupon bonds are employed in the research.

Table 5: Unique reference entities/daily observations for bonds denominated in GBP and EUR per year and sector

GBP						EUR					
Years		**Unique Reference Entities**	**Sectors**	**Observations**	**Unique Reference Entities**	**Years**	**Observations**	**Unique Reference Entities**	**Sectors**	**Observations**	**Unique Reference Entities**
2007	17,959	73	Basic Materials	2,806	2	2007	8,924	35	Basic Materials	12,845	12
2008	17559	71	Consumer Goods	15,673	13	2008	9,545	40	Consumer Goods	12,906	14
2009	19654	87	Consumer Services	34,658	23	2009	13,562	74	Consumer Services	22,442	20
2010	23,250	99	Energy	1,328	1	2010	20,159	94	Energy	4,225	5
2011	25,459	100	Financials	53,829	36	2011	26,937	111	Financials	57,763	53
2012	26,702	105	Government	2,986	2	2012	26,661	111	Government	4,176	3
2013	26,525	102	Healthcare	3,738	2	2013	29,518	121	Healthcare	1,538	3
2014	18,110	108	Industrials	13,772	9	2014	21,219	127	Industrials	16,016	14
TOTAL	**175,218**	**116**	Technology	0	0	**TOTAL**	**156,525**	**147**	Technology	1,191	2
			Telecommunications Services	11,835	7				Telecommunications Services	9,403	11
			Utilities	34,593	21				Utilities	14,020	10
			TOTAL	**175,218**	**116**				**TOTAL**	**156,525**	**147**

The summary statistics by country (reference entities and daily observations) are presented in Table 6 for GBP and EUR currency

Table 6: Unique reference entities/daily observations for bonds denominated in GBP and EUR per country

GBP			*EUR*		
Countries	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique Reference Entities**
Australia	985	1	Australia	435	1
Cayman Islands	1,970	1	Austria	2,746	4
Denmark	2,054	2	Belgium	3,699	3
France	8,999	5	Cayman Islands	1,328	1
Germany	5,176	6	Denmark	1,192	1
Ireland	1,610	2	Finland	1,979	2
Italy	10,819	6	France	38,758	35
Jersey	1,039	1	Germany	26,884	27
Luxembourg	985	1	Greece	2,266	2
Netherlands	6,948	4	Ireland	5,897	4
Norway	1,328	1	Italy	10,465	9
Sweden	3,131	2	Japan	695	1
United Arab Emirates	1936	1	Luxembourg	4,804	6
United Kingdom	114,681	76	Netherlands	13,004	11
United States	13,557	7	Netherlands Antilles	1,293	1
			Norway	2,442	2
			Panama	1,305	1
			Portugal	3,332	5
			Spain	10,680	7
			Sweden	5,114	7
			Switzerland	710	1
			Ukraine	174	1
			United Kingdom	9,434	7
			United States	7,889	8
TOTAL	**175,218**	**116**	**TOTAL**	**156,525**	**147**

As expected UK dominates in the GBP sample (76 reference entities out of 116), while EUR bonds are mostly presented by Germany and France (35 and 27 references out of 147). Hence, most of the reference entities and trading dates cover the Europe region and *financial sector* in particular. Furthermore, we report in Tables 7 reference entities and daily observation per region for GBP and EUR currency respectively.

As a result of the*" remaining maturity approach"* matching process the number of companies/reference entities decreased due to unavailability of bonds. Tables 8 and 9 present the final sample constituted by 193 unique entities. It also reports the number of daily observations per year, sector and country.

The final merged sample consists of 99 and 94 pairs of CDS premia and bond spread, which are denominated in GBP and EUR currency.[10] The highest number of companies in the sample is observed in 2010 and equals to 75 for CDS bond pairs denominated in GBP and in 2013 and 2014 for CDS in GBP and bond in EUR and the figures are equal to 66. Moreover, financial sector dominates in the final sample covers more than quarter of the sample.

The summary of country statistics for the merged sample (reference entities and daily observations) is presented in Tables 8 and 9 for GBP and GBP/EUR currency respectively. As in the bond samples in the merged samples the United Kingdom dominates in the pairs of CDS and bond spreads denominated in GBP and equals to 65 unique reference entities that cover 76,379. Germany and France are presented by 20 and 26 unique reference entities respectively and cover 15,960 and 20,453 trading days.

[10] Bond spreads quoted in Euro are adjusted by currency when the bonds were matched them with CDSs in GBP.

Table 7: Unique reference entities/daily observations for bonds denominated in GBP and EUR per sector and region

Currency	Region	Obs.	Unique Reference Entities	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Government	Healthcare	Industrials	Technology	Telecommunications Services	Utilities
GBP	Europe	156,770	106	2	11	20	1	32	2	2	9	---	7	20
	Middle East	1,936	1	---	---	1	---	---	---	---	---	---	---	---
	North America	13,557	7	---	2	2	---	3	---	---	---	---	---	
	Oceania	985	1	---	---	---	---	1	---	---	---	---	---	---
	Off-Shore	1,970	1	---	---	---	---	---	---	---	---	---	---	1
	TOTAL	**175,218**	**116**	**2**	**13**	**23**	**1**	**36**	**2**	**2**	**9**	**---**	**7**	**21**
EUR	Asia	695	1	---	---	---	---	1	---	---	---	---	---	---
	Eastern Europe	174	1	---	---	---	---	---	1	---	---	---	---	---
	Europe	144,699	134	11	13	20	4	47	2	2	13	2	10	10
	Latin America	1,305	1	---	---	---	1	---	---	---	---	---	---	---
	North America	7,889	8	1	1	---	---	4	---	1	1	---	---	---
	Oceania	435	1	---	---	---	---	1	---	---	---	---	---	---
	Off-Shore	1,328	1	---	---	---	---	---	---	---	---	---	1	---
	TOTAL	**156,525**	**147**	**12**	**14**	**20**	**5**	**53**	**3**	**3**	**14**	**2**	**11**	**10**

Table 8: Unique reference entities/daily observations for the merged CDS premia and bond spread denominated in GBP per year, sector and country

Years	Observations	Unique Reference Entities	Sectors	Observations	Unique Reference Entities	Countries	Obs.	Unique Reference Entities
2007	12,823	58	Basic Materials	2,804	2	Cayman Islands	917	1
2008	13,851	57	Consumer Goods	9,548	12	Denmark	1,944	2
2009	15,057	70	Consumer Services	22,641	20	France	7,274	5
2010	16,130	75	Energy	---	---	Germany	4,232	3
2011	14,522	62	Financials	31,520	26	Ireland	811	2
2012	16,569	71	Government	949	1	Italy	10,349	6
2013	17,171	68	Healthcare	3,501	2	Jersey	491	1
2014	11,605	71	Industrials	11,111	8	Netherlands	6,228	4
TOTAL	**117,728**	**99**	Technology	---	---	Sweden	2,658	2
			Telecommunications Services	10,108	7	United Arab Emirates	878	1
			Utilities	25,546	21	United Kingdom	76,379	65
			TOTAL	**117,728**	**99**	United States	5,567	7
						TOTAL	**117,728**	**99**

Table 9: Unique reference entities/daily observations for the merged CDS premia and bond spread, where CDS is denominated in GBP and bond is denominated in EUR per year, sector and country

Years	Observations	Unique Reference Entities	Sectors	Observations	Unique Reference Entities	Country	Observations	Unique Reference Entities
2007	4,398	20	Basic Materials	8,646	9	Austria	413	1
2008	5,562	27	Consumer Goods	8,821	10	Belgium	1,563	1
2009	8,137	47	Consumer Services	13,714	17	Cayman Islands	541	1
2010	10,715	54	Energy	1,759	2	Denmark	1,188	1
2011	11,831	56	Financials	21,081	25	Finland	1,478	1
2012	13,575	57	Government	926	1	France	20,453	26
2013	14,651	66	Healthcare	1,148	3	Germany	15,960	20
2014	10,566	66	Industrials	8,407	11	Greece	229	1
			Technology	1,292	2	Ireland	2,661	4
			Telecommunications Services	7,122	9	Italy	6,140	5
			Utilities	6,519	5	Luxembourg	1,175	3
						Netherlands	8,191	8
						Norway	2,429	2
						Portugal	1,918	2
						Spain	6,654	6
						Sweden	2,740	4
						Switzerland	113	1
						United Kingdom	4,980	4
						United States	609	3
TOTAL	**79,435**	**94**	**TOTAL**	**79,435**	**94**	**TOTAL**	**79,435**	**94**

3. Methodology

In this section, the methodology used in the first part of the research is introduced. The main focus is to analyse the relationship between CDS premia and bond yield spread. Different tests presented in previous papers will be used to study whether CDS premia lead lags bond yield spread or the inverse will apply. For all examinations, the time period is sub-divided into two. The first one is before the financial crisis and the second one is the period after the crisis. The breaking point is defined by Zivot-Andrews test described further in the paragraph. Therefore, first, data is tested on existence of stationarity. Second, causality of the markets is analysed and, finally, the marginal effect of CDS change in bond spread is researched as well as influence of market and firm specific variables is presented.

3.1 Time series stationarity tests and preliminary results

As the first step in our analysis, the test of time series stationarity is performed, in other words, to test whether the data sample of CDS premia and matched bond yield spread is stationary or non-stationary. According to De Wit (2006) *"A stationary series follows a process which has a constant mean, variance, and autocovariance structure through time."* If data is found to be non-stationary a series must be differenced once before it becomes stationary. The reason why stationary data is required is that most statistical forecasting methods are based on the assumption that the time series can be rendered approximately stationary. Another reason for trying to stationaries a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables.

The previous research employs augmented Dickey-Fuller test (hereafter ADF test) (Palladini and Porters, 2011; Bühler and Trapp, 2012; Gyntelberg et al., 2013; Fontana and Scheicher, 2016 and Garcia, Valle and Marin, 2014) to find if time series has unit-root. Palladini and Porters (2011) indicate the presence of a unit root at the 0.05 level for sovereigns for 2004-2010. However, Bühler and Trapp (2012) found that the augmented Dickey-Fuller test could reject a unit root at 10% level for contracts during 2001 to 2007 years. Gyntelberg et al. (2013) found evidence of existing of unit root for sovereigns and non-stationary of the data. Fontana and Scheicher (2016) apply the test to Sovereign CDS and bond spread series. The results do not reject the null hypothesis of unit root existence for levels, but it does for all series in their first differences. Garcia, Valle and Marin (2014) stated that the data of sovereigns for 2004-2012 has unit root and data is non-stationary and it follows a random walk pattern.

A unit root is a feature, which can cause problems in statistical implication. If a unit root is observed in a linear stochastic process, such a process is non-stationary. Hence if a process does not have a unit root, it is stationary. Alternatively, Phillips-Perron test (hereafter PP) could be run (Bühler and Trapp, 2012; Lien and Shrestha, 2014 and Gyntelberg et al. 2013). Lien and Shrestha (2014) use PP unit root tests on the level of the series and its first difference and state that PP and ADF tests lead to identical conclusions. It is concluded that all the series are non-stationary with single unit-root. Dotz (2007) also report the existence of unit-root by running PP for 1, 5 and 10 percent levels. In our analysis, we apply two methods for testing unit roots and stationarity in the CDS time-series: the Augmented Dickey-Fuller (ADF) and. The Phillips-Perron (PP) tests.

First, CDS premia for every single company in the sample is tested with the null hypothesis that unit-root does exist either rejected (in this case data reported to be stationary) or not rejected (in this case data is non-stationary). After the time series levels are tested there are two possible outcomes either it is stationary or non-stationary. If the time series is found to be non-stationary the next step is to first-difference it and test for stationarity again. The same approach is applied to the first difference of testing every company of existence of stationarity for both tests.

The following equation analyse whether there is unit root in time series for CDS premia sample. ADF is run for every single entity.

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{j=1}^{p} (\delta_j \Delta Y_{t-j}) + \varepsilon_t \qquad (2)$$

In equation (2) *t* is the time index, γ is the coefficient presenting process root, i.e. the focus of testing, *p* is the lag order of the first-differences autoregressive process, ε_t is an independent identically distributes residual term. The outcomes supposed to show whether the coefficient γ equals to zero, meaning that $Y_1 \dots Y_n$ process has a unit root and is non-stationary. If γ is not equal to zero, the process is stationary, and there is no unit root.

Hence the null hypothesis of the research is γ=0. The null hypothesis is tested against the alternative hypothesis γ < 0 of stationarity.

$$H_0\text{: } Y_t = 0$$
$$H_1\text{: } Y_t < 0 \qquad (3)$$

Equation (3) shows the decision criteria where the null hypothesis, which is a random walk, is rejected or accepted. The ADF test ensures that the null hypothesis is accepted unless there is strong evidence against it to reject in favour of the alternative stationarity hypothesis. The method described above is applied for levels of CDS premia for 1, 5 and 10 percent levels of significance considering drift and lag equal to zero days.

Alternatively, Phillips-Perron test can also be applied with the same approach for CDS premia and bond spread.

$$\Delta X_t = \beta Y_{t-1} + \sum_{j=1}^{p}(\delta_j \Delta X_{t-j}) + e_t \qquad (4)$$

In equation (4) t is the time index, β is the coefficient presenting process root, i.e. the focus of testing, p is the lag order of the first-differences autoregressive process, e_t is an independent identically distributed residual term. The outcomes supposed to show whether the coefficient β equals to zero, meaning that $X_1 \dots X_n$ process has a unit root and is non-stationary. If β is not equal to zero, the process is stationary, and there is no unit root. According to Brooks (2002), the two tests tend to give similar results. Nevertheless, both tests are conducted in this research. For Philips-Perron Newey-West lags approach is applied, including a trend.

There are therefore two possible outcomes. First, when unit root exists, and data is non-stationary, (which has been found in some empirical studies before), the analysis is preceded by testing of cointegration (long run relationship between variables). If there is no unit root and data is stationary Granger Causality approach can be applied. If data was found non-stationary for CDS premia (levels), we apply the first-difference technique to stationaries the data. The differenced series is the change between consecutive observations in the original series, and can be written as the following equation:

$$y_t' = y_t - y_{t-1} \tag{5}$$

Equation (5) shows the first-order differencing process, which will be applied to the time series in the research. Hence, to make a time series stationary — compute the differences between consecutive observations. Differencing can help to stabilize the mean of a time series by removing changes in the level of a time series, and so eliminating trend and seasonality.

After the first-difference technique is applied to the levels, the data is tested on stationarity one more time with the application of ADF and PP tests. If data is now stationary, we can implement the Granger Causality method, which is described next.

3.1.1 Augmented Dickey-Fuller and Phillips-Perron results

To determine further research methods the preliminary results of the unit-root tests will be described in this section based on the assumption that if the data, either it is levels or first-difference, is found to be stationary Granger Causality is applied next. Table 10 provides the results of ADF tests and states that that for the CDS levels the time series data is stationary, as 501 out of 685 time series is found stationary, which equals 73.12 % comparing to 184 time series or 26.86% that is non-stationary. By testing with different levels of significance, it is possible to conclude that most of the data is stationary for 5 percent level. This is equal to 233 time series out of 685. Table 10 provides the information of 130 and 138 time series that are stationary for 10 and 1 percent level of significance respectively.

Table 10: Dickey-Fuller Unit root tests for CDS levels and first difference.

Dickey Fuller Results		**TOTAL**	**10 percent**	**5 percent**	**1 percent**
Levels	Non-Stationary	184/26.86%	---	---	---
	Stationary	501/73.12%	130	233	138
First Differences	Non-Stationary	2/0.29%	---	---	---
	Stationary	683/99.71%	2	5	676

For *pvalues* higher than 10% the null hypothesis of unit-root presence cannot be rejected, hence the data is non-stationary

After the time series are first differenced the percentage of stationarity cases substantially increases. Indeed, for the first difference unit root absence result is perceived in 683 time series out of 685 time series, which is in relative value is higher than the total percent of stationarity for levels by 26.59% (99.71%-73.12%). Only 2 time series are non-stationary, which is equal to 0.29% of the whole sample. For the first difference, the highest percent of time series is found to be stationary with 1% significance level, which equals to 676 time series out of 685, or in 99.71% cases. For 5 and 10 percent significance level, the results are neglect.

Additionally, Table 11 reports the results of PP tests showing the presence of unit root in the time series of 82.34%, which is 564 time series out of 685, comparing to 17.6% or 121 time series, which does not have a unit root and is reported to be stationary. Hence, comparing to ADF approach, PP test results suggest that data is more likely to be non-stationary. For significance levels of 1, 5 and 10 percent the time series levels that have a unit root and are non-stationary are equal to 33, 37 and 51 respectively. However, after the first difference is applied the time series turn stationary. First differences are presented to be stationary in 677 time series out of 685, which is 98.83% comparing with 1.17% of non-stationary cases. The highest number of stationary time series is reported for 1% significance level, which is similar to ADF result.

Table 11: Phillips-Perron Unit root tests for CDS levels and first difference.

Philips Perron Results		**TOTAL**	**10 percent**	**5 percent**	**1 percent**
Levels	Non-Stationary	564/ 82.34%	---	---	---
	Stationary	121/17.66%	51	37	33
First Differences	Non-Stationary	8/1.17%	---	---	---
	Stationary	677/98.83%	1	2	674

For *pvalues* higher than 10% the null hypothesis of unit-root presence cannot be rejected, hence the data is non-stationary

As the time series sample is found to be stationary by both tests for the first differences and the level of stationary is higher for the first difference the next steps that are Granger Causality testing and linear regression model (LRM) approach are applied to first difference time series.

3.2. Causality testing of CDS premia and bond yield spread

Granger causality approach aims to test how events in the past can *cause* events to happen today or in the future. The test is used to examine whether CDS premia "causes" bond spread or vice-versa. If a time series is a stationary process, the test is performed using the level values of two variables. If the variables are non-stationary, then the test is done using first differences or higher. In the current sample, the stationarity is found for both levels and first difference of time series. However, Table 10 shows that stationarity is stronger by 26.59% for first differenced data comparing to levels, when ADF test is applied and by 81.17% when PP test is applied. In both cases first differences are stationary in almost 100%. Hence it is decided to proceed with the first difference time series and test it for "causality" purpose by employing Granger causality.

The test whether bond yield causes CDS premia or vice versa leads to the null alternative hypothesis as below:

H_0= The bond spreads do not Granger causes CDS premia
H_1= The CDS premia does not Granger causes bond spreads (6)

$$CDS_t=\sum_{j=1}^{k} \alpha_i \, BYS_{t-j}+\sum_{j=1}^{k} \beta_j \, CDS_{t-j}+u_{1t}$$

$$BYS_t=\sum_{j=1}^{k} \lambda_i \, BYS_{t-j}+\sum_{j=1}^{k} \delta_j \, CDS_{t-j}+u_{2t} \quad (7)$$

where *CDS* refers to the premia changes; *BYS* refers to bond yield spread change. Where u_1 and u_2 are uncorrelated prediction errors. In the equation (7) j is the number of lags and t is a point of time. The null hypothesis is rejected for 10% critical value.

3.3 Regression Analysis

Granger causality test presented previously allows to establish the relationship direction between CDS premia and bond yield spread. After doing so we will apply panel data regression model to assess the magnitude of the marginal effect. The model is specified below for the case that CDS *premia* explains bond yield spread.

$$BYS_{i,t} = \alpha + \beta CDS_{i,t-1} + \varepsilon_{i,t} \quad (8)$$

In equation (8) $\mathrm{BYS_{it}}$ is the bond yield spread (dependent variable) and $\mathrm{CDS_{it-1}}$, is CDS premia (explanatory variable) and is one day lagged. The dependent variable is determined by two components: by non-random/structural component α or coefficient or intercept, that measures the value where the regression line crosses y-axis and β or coefficient or slope that measures the steepness of the regressing line. The second component is the random component called disturbance or error term epsilon *i*. Thus, based on the equation (8) it is possible to conclude how bond yield spread changes when CDS premia increases or decreases by 1 basis point (bp.) and to conclude how the markets are correlated. Subsequently, the model is applied to daily time-series from the two currency markets (GBP, EUR). The regression coefficient β of $\mathrm{CDS_i}$ the coefficient equals to the covariance between $\mathrm{BYS_i}$ and $\mathrm{CDS_i}$ divided by variance of $\mathrm{CDS_i}$. Another variable, which embedded in the equation, is the spread investment variable.

$$BYS_{i,t} = \alpha + \beta CDS_{i,t-1} + INV_{i,t}\varepsilon_{i,t} \qquad (9)$$

In equation (9) $INV_{i,t}$ is spread investment variable, calculated as the interaction among CDS_{i-1} and a binary variable equal to one if the bond is *Investment Grade* (AAA, AA-high quality; A and BBB-medium quality) and zero otherwise (*junk bonds*). Moreover, the data is divided into two sub-periods (before and after the financial crisis). However, since it is not obvious how to split the data for the periods during and after the financial crisis a Zivot-Andrews unit-root test (1992) is employed. The breakpoint is defined by applying the test. Zivot Andrews has a null hypothesis of a unit root process with drift that excludes exogenous structural change. If the null hypothesis is rejected in favour of a trend stationary process that allows for a one-time break in the level. According to Waheed, Alam and Ghauri (2006), the null hypothesis can be described by three equations. The models describe, first, one-time change in the level of the series, second, which allows for a one-time change in the slope of the trend function and, third, which combines one-time changes in the level and the slope of the trend function of the series.

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \gamma DU_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DT_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DU_t + \gamma DT_t \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

(10)

DU_t is an indicator dummy variable for a mean shift occurring at each possible break-date, while DT_t is corresponding trend shift variable.

4. Results

This section presents the empirical results based on the discussion in the methodology section. First, unit-root test results using Augmented Dickey-Fuller and Phillips-Perron are presented to assess if CDS premia series and bond spread are stationary. We address both levels and first differences in the stationarity tests. Next, Granger Causality approach is applied to analyse whether CDS premia causes bond yield spread or whether the relationship is the inverse. Finally, regression analysis is conducted to analyse how bond spread changes with the change of CDS premia.

4.1. Augmented Dickey-Fuller and Phillips-Perron Unit Root tests

The first step to investigate the link between CDS premia and bond spread is to check whether time series of CDS premia is stationary. To check whether it is non-stationary or stationary or whether it has a unit root or not Augmented Dickey-Fuller (thereafter ADF) and Phillips-Perron (thereafter PP) tests are employed, and it is run for levels of every entity separately. The results of the tests are reported in the previous section as *preliminary results*, and it is concluded that even data is found to be stationary for levels the stationarity is much stronger and almost equal to 100% of data that is first differences. Hence, it is decided to proceed with the first difference time series and test it for "causality" purpose by employing Granger causality. The first differencing approach is important, because, according to Brooks (2002), a stationary time series is characterised by a constant mean, variance, and autocovariance structure through time. To test for a unit root, we use the augmented Dickey-Fuller test.

4.2 Testing for Granger Causality

After the time series of CDS premia series is found stationary for both levels and first difference and stationarity also confirmed to be stronger after the series is first differenced the existence of the temporal relationship is examined. Granger causality method is employed to infer the relationship between CDS and bond. First difference approach calculates the difference between CDS premia of day t and the previous day (t-1).

The Granger causality makes it possible to test for different lags. In this study causality for 1, 3 and 5 days is performed, indicating the link for 1, 3 and 5 days between CDS and bond transactions. Granger Causality test with different lags has been employed. For example, O'Kane (2012) performs tests for 1 lag and Palladini and Porters (2011) for 2 lags. However, the maximum of 5 lags is optimum choice, as more than 10 lags were never found to be a significant choice and no results are based on a lag number greater than 10 (Berggren and Mattsson, 2008). However, Garcia, Valle and Marin (2014) test causality for up to 20 lags.

Overall, 99 pairs of CDS premia and bond spread denominated in GBP and 94 pairs of CDS premia denominated in GBP and bond spread denominated in EUR are tested for 10 percent level of significance. There can be 4 possible outcomes: bond spread causes CDS premia, CDS premia cause bond spread, feedback between bond spread and CDS premia and causality between spread and CDS premia does not exist. (Garcia, Valle and Marin, 2014)

4.2.1. CDS Bond GBP relationship

In this section, the Granger Causality is run for the data of first difference time series of CDS premia and bond spreads. Table 12 presents the evidence that it can be deduced that the premia of the CDS causes the spreads for the majority of the cases.

Table 12: Granger causality CDS 5-year (GBP)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of CDS premia and bond spread. The results show the summary of outcomes when the null hypothesis is rejected.

GBP			EUR		
Lags (days)	Bond Spread do not cause CDS Spreads	CDS Spread do not cause Bond Spreads	Lags (days)	Bond Spread do not cause CDS Spreads	CDS Spread do not cause Bond Spreads
1	28/28.28%	65/65.66%	1	30/31.91%	58/61.70%
3	20/20.20%	37/37.37%	3	23/24.47%	27/28.72%
5	27/27.27%	34/34.34%	5	10/10.64%	17/18.09%

One-lag analysis shows that only in 28 cases out of 99 bond spread Granger causes CDS premia, when CDS premia does not cause bond spread. In this case, the null hypothesis that Bond Spread does not cause CDS Spreads is rejected. If the null hypothesis is rejected, hence, in this case, a bond is determined to lead CDS spread. In 23 cases both CDS premia and bond spread leads to price discovery, and in 29 cases causality between spread and CDS premia does not exist. Overall, for 66% the hypothesis that CDS Spread does not cause Bond Spreads is rejected for a lag of 1 day. For 3 and 5 days, the hypothesis is rejected for 37.37% and 34.34%. Moreover, for a lag of 3 days only in 20 pairs bond spread causes CDS premia. In 8 cases both lead to price discovery. The number cases increases to 49 for the relationship when none of the instruments causes each other. In 5-lag analysis bond spread causes CDS premia in 27 cases, while there is feedback between CDS and bond spread leads in 36 cases and no causality is observed in 47 cases.

Comparing to previous empirical papers the results overlap with the current results. Delis and Mylonidis (2011) state that CDS almost uniformly Granger-cause spread for Greece, Portugal, Spain, and Italy. However, no relationship is detected CDS-bond relationship for Italy for 2004 -2010 time period. However, CDS with 10 years to maturity is assessed. Regarding the existing empirical literature on the topic O'Kane (2012) concludes CDS leading role for Greece and Spain, but converse relationship for Italy and France and bidirectional relationship for Portugal and Ireland during 2008-2011. This means that different results can be caused by such factors as state-dependence or industry-dependence. Palladini and Porters (2011) report that in 61% of cases over the whole sample CDS market plays a leadership role in the Eurozone countries they study. Arce, Mayordomo and Peña (2011) also confirm country-dependence for 2004-2010. Regarding the analysis of the UK companies the null hypothesis is rejected for both scenarios (CDS causes Bond and Bond causes CDS, Berggren and Mattsson, 2008). However, when data for Barclays PLC is analysed for different time-periods, it is concluded that CDS leads to price discovery before, during and after the financial crisis from 2005 to 2011. Moreover, the causality between CDS premia and bond spread is concluded to be country-dependable, and it is stated that bond spread leads to price discovery for Germany, France, Netherlands, Austria and Belgium. However, the relationship is inverse for Italy, Ireland, Spain, Portugal and Greece for 2008-2010 time period (Fontana and Scheicher, 2016). For the time span of 2004 for six Euro area countries, CDS premia helps to forecast bond spread (Palladini and Portes, 2011). A research that mostly focuses on the UK market is conducted by states that the hypothesis that the premia of the CDS do not cause the spreads of the bonds cannot be rejected for 5 10 and 20 days with a significance level of 95, 90 and 95% respectively. However, bond spread leads to price discovery for 10 days lag with a significance level of 95%. (Garcia et al., 2014). Since the UK market is obscured and all existing empirical literature tends to assess Eurozone market, the above comparison matches CDS premia and bond spread denominated in EURO currency pairs.

Hence, in summary, CDS market leads the bond market, as in a higher number of cases the null hypothesis that Bond Spread does not cause CDS Spreads is rejected. Moreover, the relationship is stronger for 1ag of 1 day comparing to 3 and 5 lags analysis.

4.2.2 CDS Bond EUR relationship

According to the Table 12, which reports the number of cases where bond spread grange CDS premia and vice versa only in 30 cases out of 94 bond spread causes CDS premia for lag of 1 day, while in 20 pairs both CDS and bond lead to price discovery and no relationship found in 26 cases. Thus, for CDS-Bond EUR sample CDS premia lags bond spread for 61.70%. With the increase of lags the number of cases where bond spread causes CDS premia slightly changes to 23 for 3 days and 10 for 5 days. Hence the hypothesis that CDS Spread does not cause Bond Spreads is rejected for 28.72% and 18.09% for 3 and 5 days respectively. Both CDS and bond spreads are found to granger in 9 cases out of 94 for 3 days and 3 cases out of 94 for 5 days. Both hypotheses are not rejected, and hence, in 3 lags analysis bonds do not Granger CDS, and CDS does not Granger bonds as well in 52 cases, and in 69 cases for 5 lags. Thus CDS leads in more cases for a lag of 5 days comparing to 3 and 5 days in CDS-Bond GBP example. Hence for bonds denominated in GBP currency CDS premia lags bond spread earlier in more cases. This means that in a higher number of cases CDS premia reacts to the flow information faster for GBP.

Overall, new information seems to be incorporated faster to CDS premia than to bond spread. However, bonds denominated in EUR currency causes credit default swaps in more cases comparing to GBP sample. Moreover, leading bond role is more significant for the time lag of 1 day for GBP and 5 days for EUR. The causality relationship shows that CDS premia precede the risk spreads of bonds and according to Garcia, Valle and Marin (2014) in this case CDS contract is a better instrument to measure credit risk since CDS premia moves before bond spread and reacts faster to changes in the market. The results intersect with other conclusions. For example, Garcia, Valle and Marin (2014) found that CDS become leading rather than a lagging market in 2004-2008 for sovereign bonds. Chan-Lau and Kim (2004), who also conclude the leading role of CDS in pricing discovery for 2001-2003, point-out the CDS domination to the price discovery for a one-day horizon. Moreover, the current result reveals the absence of causality link between CDS premia and bond spread that confirms the results reported by Mora-Jensen (2013) for sovereign CDS premia and currency exchange spreads. One of the first studies to test the no-arbitrage relationship between CDS and bond credit premia discussed above is Blanco et al. (2005), who use a cointegration methodology to study corporate bond and CDS markets. For a sample of 33 investment grade U.S. and European firms, they find an equilibrium long-run relation between the pricing in the two markets for the majority of firms.

4.3 CDS bond spread – Regression Analysis

In this section, multiple linear regression model is used to evaluate the data and to assist in finding the significance for the regression coefficients. Linear regression of spreads is conducted to explain bond spread change with a lag of 1 day by changing of CDS premia during 8 years period from 2007 to 2014. Using Zivot-Andrews unit root test, (aimed to find a break point in the time series) we divide time series into two sub-periods (breakpoint found on 09/07/2010 indicating statistically the end of the financial crisis period. Bond spread of first difference is a dependent variable in the regression, while CDS premia lagged first difference lagged one day (to address the situation that on average CDS granger bonds) is an independent one. The regression also includes CDS premia multiplied by investment grade, where investment grade is equal to one if Investment Grade, AAA, AA (high quality), A and BBB (medium quality) and zero otherwise (Junk bonds grade others, low credit quality). The model is performed in 6 different specifications. Model 1 indicates how first difference CDS premia influences change of bond spread. Model 2 employs the same approach but includes spread investment variable. Model 3 and 4 tests the relationship for time periods of 1 January 2007 to 9 July 2010 included and from 10 July 2010 until 1 September 2014. Models 5 and 6 employ the same approach but includes spread investment variable for both periods of time.

4.3.1 CDS Bond GBP regression analysis

To investigate the relationship between CDS premia and bond spread denominated in GBP the model is performed in 6 different specifications. Model 1 shows that first differenced CDS premia with 1 day lag as a positive effect on a bond spread. This means that with increase/decrease in CDS premia the next day bond spread goes up/down (statistically significant for 1 percent level). A change of CDS premia by 1 percent the bond spread changes by 40 basis point, on average. An increase/decrease in CDS premium (more/less probability of default) increase/decrease bond spread (more/less probability of default), with a decrease/increase in average bond prices (capital losses/gains). In Model 2 CDS premia is also positively correlated with CDS premia. The model includes the spread investment variable defined previously. However, the variable is not statistically significant. Model 3 to 6 test crisis and post-crisis periods with a breakpoint on 9th July 2010. During the crisis and after the crisis the spreads are positively correlated. However, the influence of a change in 1 day lagged CDS premia after the crisis is stronger, comparing to the crisis period. The coefficients are 0.0194 and 0.1333 respectively. The spread investment variable is not included in these models. However, models 5 and 6 also show a positive correlation with the same degree of influence, but they include spread investment variable. The obtained results also show positive correlation where independent variable moves from 0.0193 to 0.1333 from crisis to post-crisis timespan with 1% significance level. Models 5 and 6 include spread investment variable. However, the variable is also not statistically significant. The results mean that the influence of investment grade bonds on change of bond spread is neglected for bonds denominated in GBP.

4.3.2 CDS Bond EUR regression analysis

To investigate the relation among CDS premia and bond spread denominated in EUR the same regression models are employed. According to model one, the correlation is also positive, but it is less strong comparing to the GBP sample. Model 2 concludes the positive correlation as well, however, spread investment variable is positive, and it indicates that the overall impact on bond spread give a change in CDS.

Table 13: Regression Analysis GBP/GBP Pair

Results for Equations 8 and 9 are presented for pairs of CDS premia denominated in GBP currency and bond spread denominated in GBP currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test.

GBP	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Spread (-1)	0.0400***	0.0399 ***	0.0193***	0.1325***	0.01929***	0.1326***
	(8.11)	(9.01)	(6.05)	(9.38)	(6.05)	(9.38)
Spread_investment	---	-0.00010	---		-0.0001	-0.0001
		(-0.82)			(-0.29)	(-0.44)
Constant	-0.0000	0.0000	0.0000	-0.000	0.0000	0.000
	(-0.02)	(0.81)	(0.88)	(-0.08)	(0.41)	(0.43)
CDS/Bonds pair	99	99	80	89	80	89
Observations	117,629	117,629	50,872	66,757	50,872	66,757

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Table 14: Regression Analysis GBP/EURO Pair

Results for Equations 8 and 9 are presented for pairs of CDS premia denominated in GBP currency and bond spread denominated in EURO currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test.

EUR	(1) RE	(2) RE	(3) ≤20100709	(4) >20100709	(5) ≤20100709	(6) >20100709
Spread (-1)	0.0101***	0.0100***	0.0151***	0.0097***	0.0149***	0.0096***
	(6.74)	(6.66)	(2.59)	(6.25)	(2.55)	(6.17)
Spread_investment	---	-0.0001***	---	---	-0.0000	-0.0002***
		(-3.52)			(-1.55)	(-3.27)
Constant	-0.0000	0.0000***	0.0000	-0.0000	0.0000	0.000***
	(-0.40)	(3.35)	(0.44)	(-0.76)	(1.57)	(3.06)

CDS/Bonds pair	94	94	56	89	56	89
Observations	79,341	79,341	24,220	55,121	24,220	55,121

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

premium is higher for investment grade bonds. For investment grade bonds the impact is considered to be statistically insignificant, while for junk bonds it is equal to 0.0099. Model 3 to 6 test timespans before and after 9th July 2010. During the turmoil and after it the spreads are positively correlated. However, the influence of a change in 1 day lagged CDS premia after the crisis is less strong, comparing to the crisis period. The coefficients are 0.0151 and 0.0097 respectively with 1 percent level of significance. The spread investment variable is not included in these models. However, models 5 and 6 also show a positive correlation with the same degree of influence, but they include spread investment variable. The obtained results also show positive correlation where independent variable decreases from 0.0149 to 0.0096 from crisis to post-crisis timespan with 1% significance level. Model 5 and 6 include spread investment variable. The negative sign of this variable shows that the overall impact on bond spread give a change in CDS premium is less for investment grade bonds. For investment grade bonds the impact is (0.0096-0.00016=0.0094) where to junk bonds is 0.0096. These effects are marginal effects. This effect is valid after the crisis, however, during the crisis, the effect is not statistically significant. The results confirm preceding finding. Norden and Weber (2009) find positive coefficient between lagged CDS premia and bond spread, which is equal to 0.08 for 1000 reference entities (Corporates, Financials, and Sovereigns) for the time period starting from July 2, 1998, to December 2, 2002. More recent research focuses on regression of determinants. Zawadowski and Oehmke (2016) regress including hedging proxies and size controls. Tables 15 and 16 report the results with control for industry effect by running independent regressions per sector for GBP/GBP and GBP/EUR pairs.

Table 15: Regression Analysis GBP/GBP Pair

CDS premia denominated in GBP currency and bond spread denominated in GBP currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0. Model 2 and 3 report regression for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test. Additionally, the table contains sector dummy variable equal to 1 for each sector.

GBP	Model 1	Model 2	Model 3
Spread (-1)	0.039952***	0.0192891 ***	0.1325751***
	(8.11)	(6.05)	(9.39)
Basic materials	-0.0000273	-0.0000826	-9.58e-06
	(-0.49)	(-1.25)	(-0.05)
Consumer Goods	-1.12e-06	-6.05e-07	-2.61e-06
	(-0.03)	(-0.02)	(-0.02)
Consumer Services	-0.0000138	-1.84e-06	-0.0000581
	(-0.54)	(-0.08)	(-0.62)
Financials	6.54e-06	9.04e-06	0.0000345
	(0.28)	(-0.43)	(0.42)
Government	1.29e-06	-1.38e-06	8.61e-06
	(0.01)	(-0.02)	(0.01)
Healthcare	-5.13e-06	-3.76e-06	-6.23e-06
	(-0.10)	(-0.09)	(-0.03)
Industrials	-0.0000119	-1.72e-06	-0.0000157
	(-0.38)	(-0.06)	(-0.15)
Telecommunications	-3.47e-06	-6.44e-09	-5.23e-06
	(-0.11)	(-0.00)	(-0.05)
Constant	0.000	0.000	0.000
	(0.18)	(0.35)	(0.02)
CDS/Bonds pair	99	80	89
Observations	117,629	50,872	66,757

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Table 16: Regression Analysis GBP/EUR Pair

CDS premia denominated in GBP currency and bond spread denominated in EUR currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0. Model 2 and 3 report regression for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test. Additionally, the table contains sector dummy variable equal to 1 for each sector.

GBP	Model 1	Model 2	Model 3
Spread (-1)	0.0100846***	0.0150774**	0.0097496***
	(6.74)	(2.58)	(6.25)
Basic materials	-0.0000156	-0.0000283	-0.0000115
	(-0.43)	(-0.43)	(-0.25)
Consumer Goods	-1.83e-06	0.0000357	-0.0000195
	(-0.05)	(0.63)	(-0.41)
Consumer Services	-8.59e-06	-0.0000149	-5.13e-06
	(-0.26)	(-0.29)	(-0.12)
Energy	-4.61e-06	-0.0000164	-4.21e-07
	(-0.08)	(-0.14)	(-0.01)
Financials	0.000019	0.0000159	0.0000211
	(0.60)	(0.34)	(0.49)
Government	0.0000202	0.0000236	-0.0001404
	(0.26)	(0.29)	(0.34)
Healthcare	-0.0000156	-0.0000259	-9.49e-06
	(-0.22)	(-0.23)	(-0.10)
Industrials	-1.16e-06	0.0000213	-9.14e-06
	(-0.33)	(0.36)	(-0.19)
Technology	-0.000066		-0.0000644
	(-0.97)		(-0.88)
Telecommunications	-5.75e-06	9.92e-06	-8.37e-06
	(-0.15)	(0.14)	(-0.17)
Constant	0.000	0.000	0.000
	(-0.11)	(-0.02)	(-0.12)
CDS/Bonds pair	94	56	89
Observations	79,341	24,220	55,121

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

5. Conclusions

The aim of this paper is to investigate the link between CDS premia and bond yield spread during the time period starting from 1 January 2007 to 1 September 2014. The necessary data collection for CDS premia and bond yield spread are from Markit and Datastream sources, respectively; we match the CDS premia with bond yield spread of the same reference entity by applying what we called *"remaining maturity"* approach, described earlier, adopting appropriate methodology to test data stationarity and causality among CDS premia and bond yield spread. The sample consists of 5-year CDS premia for a set of reference entities/corporations that covers different countries, regions, and industries.

The results of a stationary analysis, Granger Causality test and panel data regressions leads to the main conclusions that CDS premia changes cause Bond yield spread changes. This means that during 2007-2014 CDS premia has been reacting faster to information flow to the markets. Regression analysis also includes investment grade variable, which shows that overall impact on bond spread give a change in CDS premium is less for investment grade bonds.

The results of Augmented Dickey-Fuller and Phillip-Perron tests applied shows that first difference of CDS premia is a better option for Granger causality and regression analysis. Granger causality indicates that in most cases CDS premia causes bond denominated in GBP and EUR for all significance levels from 1 to 10 percent. Though CDS is found to lead to price discovery process, a bond spread is noticed to cause CDS premia in 28 cases out of 99 for a lag of 1 day and 20 and 27 cases for GBP with lags of 5 and 10 days. Bond spread denominated in EUR is found to lead CDS premia only in 30 cases out of 94 for a lag of 1 day and 23 and 10 cases for lags of 3 and 5 days respectively. Hence, the causality of CDS is stronger for the pairs, where bonds are denominated in GBP currency. After it is concluded that CDS premia tends to lead to price discovery for both time series its influence on the bond spread is specified. Regression analysis shows that for the whole time period the CDS premia is positively correlated with bond spread denominated in GBP and EUR. If the model includes an investment spread variable no difference was found among investment grade and junk bonds on the effect of CDS premia and Bond yield.

This paper brings new light to the price discovery process and implements a new approach in data matching that we called “remaining maturity” approach.
This empirical paper can be developed further by including more CDS/bonds reference entities matching in the sample. The present data sample is denominated only in two currencies GBP and EUR. To develop the paper Swiss franc, US, Hong Kong, Canadian Dollar and Australian Dollar as well as Japanese yen will be included in the sample.

The outcomes of this paper can be useful for all market participants as traders, risk managers, and regulators. Price discovery helps to understand how CDS premia and bond spread react to information flow at the markets. The concept of positive and negative basis may bring arbitrage opportunity and understanding of it drivers helps to gain from arbitrage opportunities. To manage default risk the influence of credit rating announcements should lead to a conception of its relationship with CDS premia and predictable opportunity.

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CHAPTER 3: Global Financial Crisis and Price Discovery: the case of EUR denominated credit default swaps

Abstract

This paper analyses the relationships between credit default swap (CDS) premia and bond yield spread. The relationship is analysed by employing daily data for CDS premia and bond yield spread from the 1st January 2007 to 1st September 2014. Initially, we collected 1,826,061 daily observations for 2,509 entities for CDS premia denominated in Euros (EUR). After the data was matched with bond spreads, we received the final sample with 152 entities for CDS and bond spreads denominated in EUR, and 269 entities for CDS in EUR and bond spreads denominated in USD.

The paper extends previous research by employing data for CDS denominated in Euro currency. The paper contributes to the empirical financial literature by employing an extended data sample that covers various sectors, markets and regions, by analysing the period before and after the financial crisis. We provide a comprehensive empirical analysis of the CDS-Bond relationship and its implications for price discovery process and market efficiency, employing causality and regression analysis.

The results show that first CDS premia leads to price discovery for CDS bond denominated in EUR during the whole assessed period. Second, before the Financial Crisis, the impact of lagged CDS premia on bond yield spread remained similar to the impact after it. Third, the investment grade variable influence on EUR/USD pairs before the financial crisis indicates that, for investment grade bonds, the change of lagged CDS premia effects bond yield a spread, but the influence is lower.

Keywords: Credit Default Swap, bonds, financial crisis, price discovery, market efficiency.

JEL Classification: G01, G14, G15

1. Introduction and background

A Credit Default Swap (CDS) is a financial instrument that protects lenders in the event of default on the part of the borrower by transferring the associated credit risk in return for periodic income payments. The 'default' here is the failure to pay interest and principal on a loan or security when due.

The CDS market has existed for the last two decades since it was created by the Bankers Trust, later acquired by Deutsche Bank, and JP Morgan as insurance that banks could use to protect themselves against their exposure to large corporate loans they made to their clients. The size of the market was in the low hundreds of billions by the late 1990s. However, the market swelled during the nineties and in 2011, its gross notional was close to $28 trillion (£17 trillion) (Wilson, 2017). Before the financial crisis of 2008, CDSs were traded with an assumption that the buyer of a CDS contract held the underlying credit asset - the market was equal to 900 billion USD (Zabel, 2017). Hence, by the beginning of the crisis, the CDS market had a notional value of $45 trillion, although the corporate bond, municipal bond and structured investment vehicles market totalled less than $25 trillion. The conclusion could then be drawn that a minimum of $20 trillion were speculative 'bets' on the possibility of a credit event of a specific credit asset not owned by either party to the CDS contract.

CDS contracts are traded over-the-counter (OTC) and regulated by the *International Swaps and Derivatives Association* (ISDA). They are measured by spread, or premia the premia that CDS buyer pays to protect obtained debt against default, and the premia is measured in basis points or percentage. The size and impact of the CDS market differs according to the region and country. In this study, we are going to analyse CDS contracts denominated in the Euro currency.

Since the 2008 financial crisis, the gross notional value of CDS contracts written for Euro countries has been trending upward. Increases in the net notional values[11] in France, Germany, State and the UK CDS have levelled off for the euro-area aggregate since the beginning of 2010 and went from 400 billion EUR to 800 billion EUR. (Europa, 2012) Kalbaska and Gątkowski (2012) have analysed the influence of the Greek crisis on the derivative markets and contagion effect of CDS

[11] Notional values are the par amount of credit protection bought or sold, and gross notional values represent the sum of CDS contracts bought or equivalently sold.

markets. The main conclusion is that sovereign risk is mainly concentrated in Eurozone countries.

It is Spain and Ireland in particular that have the biggest effect on the CDS market while since August 2007, the UK CDS market has not caused a big distress in Eurozone because the UK market has most immune to shocks. This paper focuses on the dynamics of CDS market before and after Greek bailout to conclude that the highest CDS spread is determined for Portugal from March 2010 to September 2010, while the lowest was for Germany, France and the UK. Before the financial crisis, the CDS spreads of different countries were growing simultaneously, but the UK CDS spread did not grow dramatically comparing to the Greek, Portuguese and Irish spreads.

The relationship between CDS and bond markets has been a new fascinating topic for research into financial empirical studies. Studies have focused on price discovery and causality link between the markets. The reason why *price discovery process* is important is that derivatives are highly dependable on information flow as they are traded OTC. Hence, understanding what market leads to price discovery can help to understand the informational efficiency of the market.

The empirical literature on the topic of CDS bond relationship in the Eurozone market is not as limited as the empirical analysis estimating the UK market. The overall consensus is that the CDS market leads to price discovery before the financial crisis and the crisis fuels the relationship (Blanco, Brennan and March, 2005; Gomes and Brandi, 2005; Ammer and Cai, 2011; Fontana and Scheicher, 2016). However, according to some academics the results are found to be country dependable (O'Kane, 2012 and Arce, Mayordomo and Pena, 2013). 'Country dependable' indicates the manner in which market leads to price discovery depends on a country. For the European market, Kolstad (2013) has been notable for researching 5-year CDS spread denoted in Euros from March 2003 until January 2012. This author concludes that a general price discovery rule as to which market leads the other cannot be found. Nonetheless, for several countries the CDS market has become more active indicated by a leading role. In France, Greece and Spain, the CDS market leads the bond market. In the period before the financial crisis, a cointegrating relationship is found suggesting a trending behaviour between the two markets over time. In Germany, Italy and Portugal the bond market is the significant driver, where the CDS market adjusts to new information about the bond market. Before the crisis, the two markets trended together in Germany to form a relationship of equilibrium.

Blanco, Brennan and March (2005) have assessed European and American companies from 1999 to 2008 to conclude that, before the financial crisis, CDS premia tended to lead bond spread for sovereigns and financial institutions. Akdoğu (2012) continues to confirm what most of the studies agree that bond spreads are mainly driven by the credit default swaps. This study has analysed data for Italy, Portugal, Spain, Greece and Ireland. For Spain, Austria, Belgium, Greece, Ireland, Italy and Portugal from 30th January 2004 to 11th March 2011, the CDS market leads in price discovery because changes in CDS prices affect the fundamentals driving the prices of the underlying bonds. The study reports the results that the CDS market moves ahead of the bond market regarding price discovery. The Granger Causality Test further supports the outcomes. For most sovereigns in the sample, the past values of CDS spreads can predict bond yield spreads.

Garcia, Valle and Marin (2014) conclude that CDS reacts more rapidly to changes in the market for Spain, France, Italy and the UK over 2004-2011. However, Palladini and Portes (2011) have studied Austria, Belgium, Greece, Ireland, Italy and Portugal developed economies in Europe from 30th January 2004 through 11th March 2011 to conclude that CDS prices lead in the price discovery process. Arce, Mayordomo and Pena (2011) have employed CDS spreads from Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Portugal, and Spain from January 2004 to October 2011. They conclude that the price-discovery process is clearly state-dependent.

During the financial crisis, CDS premia tended to lead to price discovery and its leading role increases during the crisis for sovereigns and corporate companies (Alexopoulou, Andersson and Georgescu, 2009; Fontana and Scheicher, 2016). The results are confirmed by Delis and Mylonidis (2011) for daily data on 10-year government yield spreads for Greece, Portugal and Spain between 9th July 2004 and 25th May 2010.

Alexopoulou et al. (2009) have examined firm-specific, common factors and liquidity influences on CDS premia movements and the long-term equilibrium relationship between CDS premia and bond spread for European financial and non-financial firms over the period January 2004 to October 2008. Here, the authors found the CDS market playing a strong leading role, and this role was strengthened by the onset of financial turmoil.

Fontana and Scheicher (2016) have analyse the 2008-2010 crisis period. The study employs weekly CDS spreads and benchmark bond yields for 10-year CDS denominated in US dollars for Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. The relationship is found to be state-dependent, because CDS spread leads in 50% of cases, while the bond spread leads in the other half of the sample. O'Kane (2012) confirms the results for 2009-2011, stating that the CDS spread causes bond spread for Greece and Spain. They found the reverse relationship for France and Italy and a feedback relationship for Ireland and Portugal.

Finally, Andraz, Viegas and Norte (2016) conclude that the CDS market performed a leading role in price determination in short- and long-run before the crisis, but the role of the bond spread as a credit risk information has increased during the crisis.

This study aims to analyse the relationship between CDS premia denominated in the Euro currency and bond yield spread before and after the financial crisis through the application of stationary tests. The Granger Causality analysis and linear regression model are intended to present a comprehensive picture, whose market leads to price discovery and determination of the correlation between the CDS and bond markets.

The research employs a data sample, which consists of 5-year CDS premia, as the most liquid one (Coudert and Gex, 2010). We match the CDS premia with bond yield spread for every single reference entity of a CDS contract. The period researched covers the 2007-8 global financial crisis and the period following it. In addition, the data will be divided into two sub-periods. The first one from January 2007 - December 2008 and the second from December 2008 to September 2014. To match a bond yield spread with a corresponding CDS premia, *'the remaining maturity'* approach is applied for every year for every single reference entity. The approach is described in detail in the *'Sample'* section.

This study contributes to CDS market literature by examining the relationship between securities of derivative (CDS) and debt market (bond) denominated in both the EUR and USD currency. The current study contributes into three directions. First, it employs extended data analysis comparing to previous empirical papers, which use limited data of European and the US financial and non-financial institutions (Berggren and Mattsson, 2008; Alexopoulou, Andersson and Georgescu, 2009; and Buhler and Trap 2012) and sovereigns (Fontana and Scheicher, 2016; Garcia, Mayordome and Pena, 2013; O'Kane, 2012; Lehtonen 2012 and Gyntelberg et al., 2013).

This paper is notable for employing daily observations for 2,509 unique reference entities, which include both companies from different industries and sovereign entities. Secondly, this study analyses data for an extended period including the pre-crisis and the post-crisis period as well as the crisis period itself, then applying break point analysis to determine the date of financial distress. Finally, the study employs a rating factor to examine the difference in the influence of CDS premia on the bond spread for investment grade and junk bonds.

This research will provide the results destined to describe price discovery process between CDS and bond markets, demonstrating which one responds faster to new information in the market and which one is more efficient. In summary, the results show that CDS premia leads to price discovery in CDS bond relationship during the whole assessed period. In the second place, the findings show that, before the financial crisis, the impact of lagged CDS premia on bond yield spread is almost equivalent to the impact it had after it. Third, for investment grade bonds the change of lagged CDS premia effected the bond yield spread for EUR/USD pairs before the financial crisis, but the influence is lower.

The remainder of the chapter is organised as follows. First, we will outline the data sources and samples, as well as the data collection process and matching approach. Second, the methodology will be given, describing the tests that will be implemented to obtain the results. Finally, the results of the empirical analysis will be discussed and a conclusion provided based on the results.

2. Data sources, sample and matching procedure

2.1 Data source and sample

To investigate the relationship between CDS premia and bond yield spreads we collect the necessary data from *Markit* and *Datastream* databases. The databases are chosen due to the fact of specific nature of required information.

Markit collects and gathers CDS information directly from traders. It provides daily reports for a set of CDS transactions, which consists of CDS premia, ticker and short name, recovery rate, currency, type of CDS, called '*DocClause*' which describes collateral, rating, and a number of providers of information, called '*CompositeDepth5y*', sector, region and country.[12] The CDS sample is selected based on the criteria as follows. It is a major derivative database, which provides verified reference data to the credit derivatives market in particular. *DataStream* database was selected to obtain bond yield spreads. This database provides up to date as well as historical international data on stocks, indices, bonds, commodities, futures, options, etc. being one of the major databases for corporate bond collection. The CDS sample is selected based on the criteria as follows.

First, the sample covers the time period before, during and after the financial crisis and starts from 01 January 2007 to 01 September 2014. *Second*, the final CDS sample is filtered and selected based on CDS currency. The currency is specified to be Euro (EUR).[13] The currency is selected as the one of the most traded one. The sectors defined include Basic Materials, which means mining and refining of metals, chemical producers and forestry products and usually sensitive to changes in the business cycle, Consumer Goods, which contains clothing, food, automobiles and jewellery. The sample also includes Consumer Service, Energy, Government, Industry, Technology, Telecommunication Service and Utilities. The annual allocation of unique reference entities and daily observations for CDS and per sector denominated in EUR are presented in Table 1. The largest number of daily observations and unique reference entities is reported for 2007 prior to the financial crisis, and the lowest figures were spotted in 2013. The sample begins with 2,016

[12] Daily data is chosen because given the information technology has developed enormously, and markets react almost instantaneously, the use of daily data will capture better the linkage among CDS and bond markets.

[13] As for the 1st of January 2007 there are 2,685 unique reference entities, which are quoted in 31 difference currencies including such currencies as Australian Dollars, Euro, GBP, Japanese Yen and USD. The weight of GBP is equal to 849 unique reference entities, which is equal to 31.6%. The USD weight is equal to 96.7% and Euro is equal to 82.9%.

unique reference entities in 2007 that provide 400,543 observations. In 2008 the number of reference entities decreases by 43 companies and 316,310 observations are collected for the year. During 2009 and 2010 the number of entities presented in the sample declined respectively to 1,376 and 1,142 entities, comparing to 1,973 in 2008. The number of reference entities and observations continues to fall and are equal to 792 in 2011 with 173,272 observations, 793 for 2012 with 175,145 observations. In 2013 the number of entities and observations decreased dramatically to 350 and 171,145 respectively. However, it increases again in 2014 and equals to 712 entities with 111,913. The total number of observations for the whole period is 1,826,061 for 2,509 unique reference entities. The general trend shows that after the financial crisis of 2008 the number of CDS contracts in our sample started to decline.

Table 1: Unique reference entities/daily observations for CDS with 5-year maturity denominated in EUR per year and sector

Year	**Observations**	**Unique Reference Entities**	**Sectors**	**Observations**	**Unique Reference Entities**
2007	400,543	2,016	Basic Materials	119,333	180
2008	316,310	1,973	Consumer Goods	196,694	243
2009	260,935	1,376	Consumer Services	215,759	301
2010	216,798	1,142	Energy	74,189	136
2011	173,272	792	Financials	550,743	695
2012	175,145	793	Government	101,546	156
2013	171,145	350	Healthcare	52,570	91
2014	111,913	712	Industrials	200,063	274
TOTAL	**1,826,061**	**2,509**	Technology	42,863	79
			Telecommunications Services	102,338	135
			Utilities	169,963	219
			TOTAL	**1,826,061**	**2,509**

Financial and Consumer Service industries are dominant in the sample while Healthcare and Technology are less presented in the derivative market. Financial sector reaches 27.7% of all 2,509 unique entities of the sample, which is equal to 695 entities and covers 550,743 daily observations. The share of the Healthcare and Technology sectors is small and equal to 3.6% and 3.1% respectively.

Third, the collateral type is defined. *Modified-Modified* (MM) is.[14] MM is introduced with a maturity limit of 60 months for restructured obligations and 30 months for all other obligations. The reason for choosing MM collateral type is that it used mostly in Europe. We also collect CDS implied rating provided by *Markit* for

[14] Collateral criteria covers 96% of European Restructuring Clauses.

risk proxy.[15] The summary of country statistics for CDS sample (reference entities and daily observations) is presented in Table 2. Concerning country diversification the largest number of unique reference entities and daily observations for CDS market is collected for Germany, France, Netherlands and mostly for the United States and the United Kingdom. The US market provides data for 853 entities out of 2,516, which is 33.9% of the market and covers 360,633 daily observations. In contrast Algeria, Bulgaria, Colombia, Croatia, Dominican Republic, Ecuador, El Salvador, Estonia, Panama, Tunisia, Curacao, Latvia, Iraq, Jamaica, Kuwait, Lebanon, Liberia, Lithuania, Malta, Marshall Islands, Morocco, Pakistan, Peru, Serbia, Slovakia, Slovenia, Trinidad and Tobago and Uruguay provide data only for one unique reference entity. Moreover, some CDS contracts are traded in multiple countries.

Furthermore, we report in Table 3 reference entities and daily observation per region (Asia, Eastern Europe, Europe, Latin America, Middle East, North America, Oceania and Offshore) and sector. Europe and North America prevalent in the sample, compared to insignificant Eastern Europe. In particular, in Europe CDS is traded mainly in the financial sector and is represented by 1,150 reference entities and by 185 for the North American region. Moreover, some CDS contracts are traded in multiple regions.

Figure 1 presents a daily average of 5-year CDS premia from 2007 to 2014. It shows that the CDS premia increases dramatically at the time of the financial crisis from 1.38% to 7.04% in 2008 and returns at 2.43% at the end of 2009. Moreover, there is an interesting observation that CDS premia of 1 and 3-year maturity exceeds 5-year CDS during the crisis, while the tendency is opposite at the normal financial period. It can be explained by higher demand for short maturity insurance during abnormal periods. The trend is also discernible for industry analysis, which was performed only for the sectors with many observations. While it is widely accepted that financial sector suffered above all other industries during the crisis, Figure 2 contradicts that evidence. It shows that the highest premia for a daily average of CDS premia with 5-year maturity premia is observed in consumer service sector. In figure 3 we also report interesting results regarding the CDS daily average premia dividing between Investment grade and junk bonds. We can observe a similar pattern across

[15] Calculated on a weekly basis by comparing the issuer's 5-year senior standard trading convention spread to the 5-year spreads of the sector curves and applying the rating of the logarithmically nearest rating curve unique to that sector.

the time, but the financial crisis and periods of increased uncertainty are amplified in junk bonds CDS than their counterpart.

Table 2: Unique reference entities/daily observations for CDS with 5-year maturity denominated in EUR per country

Countries	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities
Algeria	147	1	Mexico	4,782	9
Argentina	493	2	Netherlands	110,312	123
Australia	21,251	52	Netherlands Antilles	268	3
Austria	24,789	24	New Zealand	1,010	18
Bahrain	2,550	5	Norway	18,825	7
Belgium	21,441	19	Panama	2,191	1
Bermuda	7,593	18	Philippines	1,141	4
Brazil	3,467	8	Poland	3,936	6
Bulgaria	949	1	Portugal	17,875	13
Canada	21,604	55	Puerto Rico	1,035	2
Cayman Islands	10,570	22	Qatar	1,749	5
Channel Isl	552	3	Romania	1,327	2
Chile	2,888	6	Russian Federation	26,768	32
China	2,449	8	Singapore	3,887	13
Colombia	190	1	South Africa	11,069	16
Croatia	949	1	Spain	52,220	43
Cyprus	1,261	3	Supra National	7,548	11
Czech Republic	4,305	6	Sweden	53,845	40
Denmark	21,021	23	Switzerland	43,686	45
Dominican Republic	190	1	Taiwan Province of China	2,334	11
Ecuador	190	1	Thailand	1,125	6
Egypt	1,594	2	Tunisia	949	1
El Salvador	190	1	Turkey	1,098	3
Estonia	949	1	Ukraine	3,950	8
Finland	22,219	17	United Arab Emirates	8,577	12
France	159,751	124	United Kingdom	341,018	315
Germany	158,972	149	United States	360,633	853
Greece	16,056	12	British Virgin Islands	898	2
Guernsey	2,467	3	Curacao	2,001	1
Hong Kong	7,735	21	Latvia	949	1
Hungary	5,151	5	Lebanon	949	1
Iceland	2,621	6	Liberia	1,282	1
India	6,872	22	Lithuania	949	1

Indonesia	743	2	Malta	935	1
Iraq	949	1	Marshall Islands	83	1
Ireland	27,144	31	Morocco	948	1
Israel	5,946	4	Pakistan	190	1
Italy	76,724	84	Peru	210	1
Jamaica	947	1	Saudi Arabia	5,457	7
Japan	21,111	34	Serbia	949	1
Jersey	2,706	4	Slovakia	949	1
Kazakhstan	6,553	10	Slovenia	949	1
Korea (Republic of)	9,601	29	Trinidad and Tobago	482	1
Kuwait	742	1	Uruguay	188	1
Luxembourg	33,228	52	Venezuela	584	2
Malaysia	4,131	12	**TOTAL**	**1,826,061**	**2,509**

Table 3: Unique reference entities/daily observations for CDS with 5-year maturity denominated in EUR per sector and region

Region/Industry	**Obs.**	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Government	Healthcare	Industrials	Technology	Utilities	**Unique Reference Entities**
Africa	15,989	2	2	6	1	-	6	-	1	-	2	22
Asia	54,257	2	14	4	8	45	18	-	12	17	10	140
Caribbean	5,553	-	-	1	2	1	3	1	-	-	-	8
E.Eur	59,582	3	-	1	7	31	25	-	-	-	2	77
Europe	1,209,116	85	112	142	28	378	51	29	135	20	105	1,152
India	7,062	2	2	1	-	4	3	3	3	1	3	23
Lat.Amer	15,373	4	-	3	4	4	14	-	1	-	2	34
MiddleEast	28,017	-	-	1	2	17	13	1	2	-	2	39
N.Amer	389,830	76	108	133	79	185	13	55	110	40	87	926
Oceania	22,344	6	5	9	2	19	1	2	8	-	2	57
OffShore	11,390	-	1	-	4	12	-	-	2	2	4	26
Supra	7,548	-	-	-	-	1	9	-	1	-	-	11
TOTAL	**1,826,061**	180	244	301	137	697	156	91	275	80	219	**2,509**

Figure 1: Daily Average CDS EUR premia (Maturity)

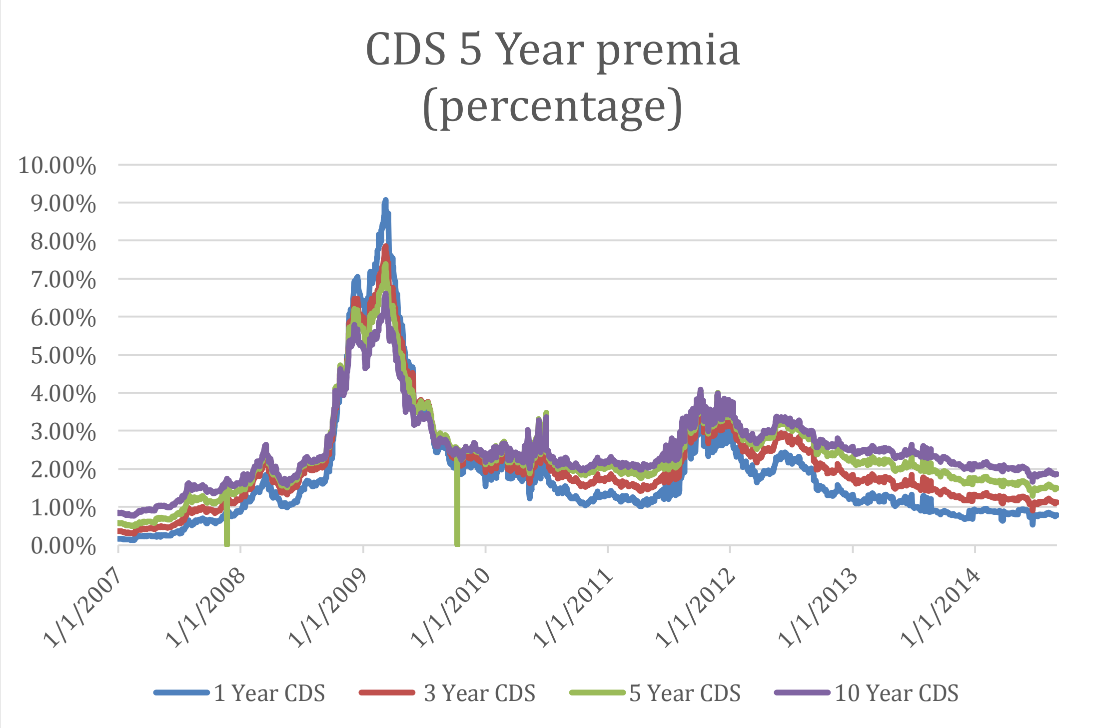


Figure 2: Daily Average CDS EUR premia (Sectors)

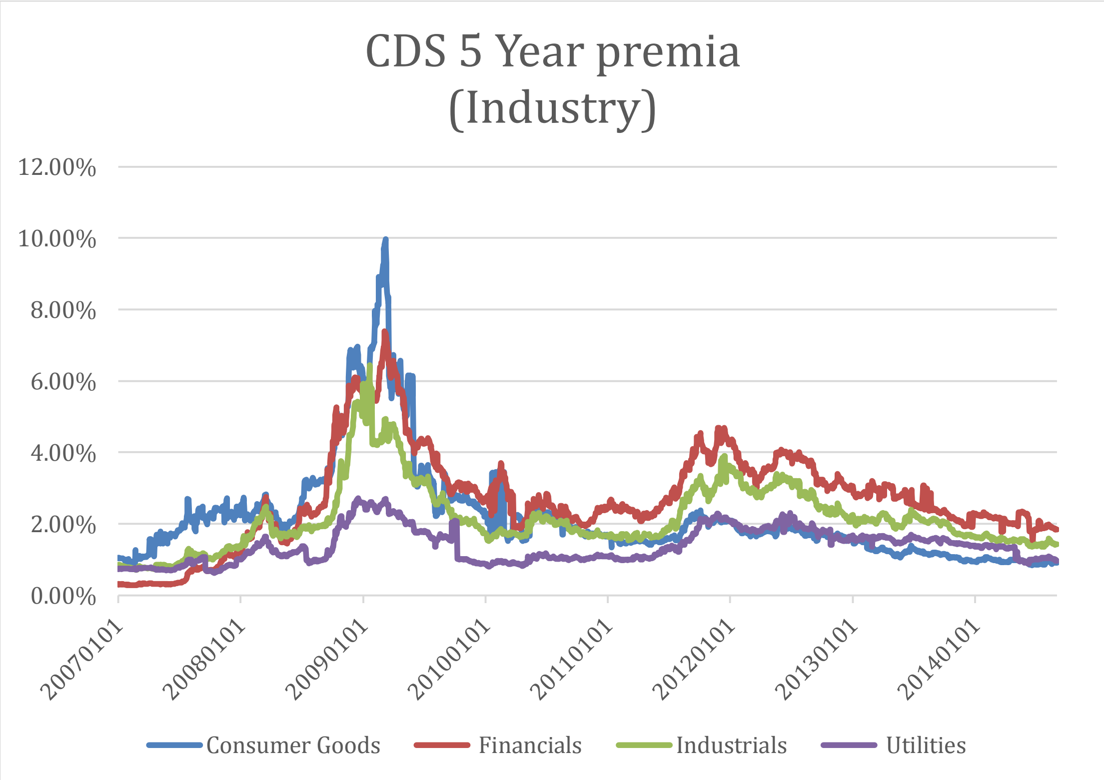
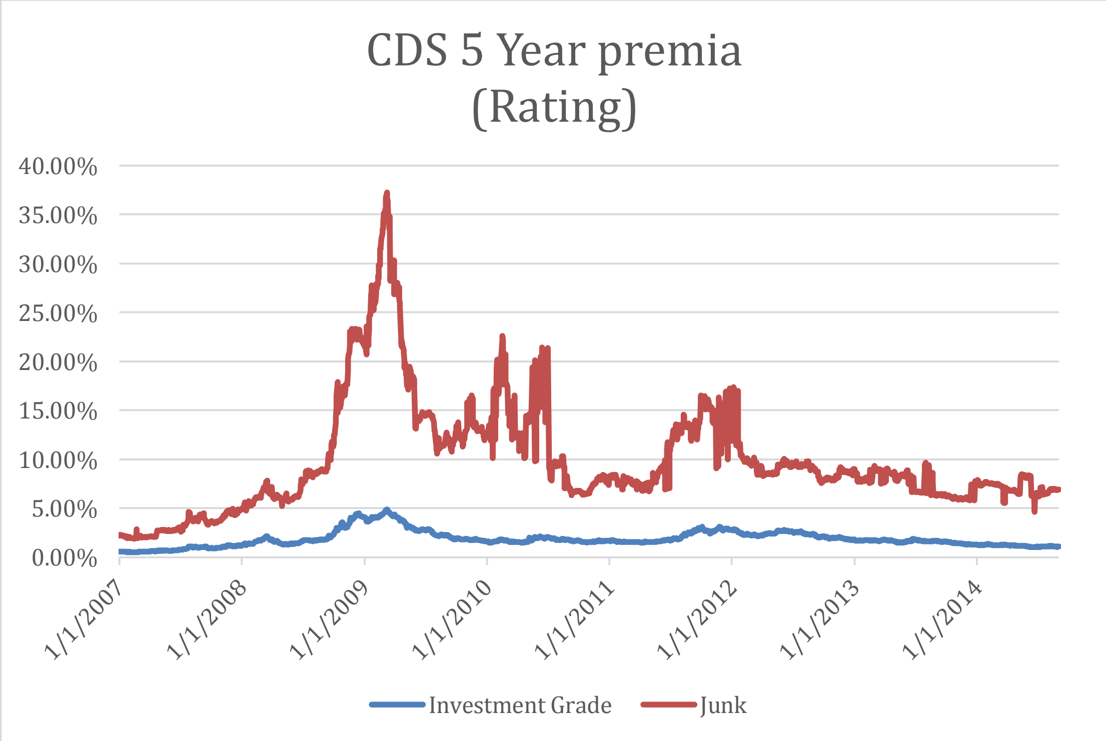


Figure 3: Daily Average CDS EUR premia (Investment Grade vs Junk bonds)



Overall, we observe that the levels of CDS premia is not constant across industries during the time period of 2007-2014. There are time periods when some sectors present higher spread than others, which might refer to some particularities of the industries, which is not the scope of this paper to analyse.

2.2 CDS and bond yields maturity matching

The existing empirical literature offers various matching approaches to match CDS and bond data. Essentially two main techniques to match the data are discussed. The first approach is *'direct matching'*, which focuses on finding a bond with the maturity as close as possible to the maturity of CDS contract. In the current case it is 5 years. (De Wit, 2006 and Hull, Predescu and White 2004) The other approach explores *'linear interpolation'* framework (Blanco et al., 2005 and De Wit, 2006). In linear interpolation approach arithmetical mean is applied to construct a 'synthetic' bond to be as close as possible to 5-year maturity. However, since CDS is similar to an insurance contract it protects against default solely for the exact maturity in most cases it is 5 years, and it can be used to assure bonds with longer maturity for a time span of 5 years. An investor can buy a protection for a life span of debt at any stage of it. Thus, it makes sense to match each single 5-year CDS premia on a particular day with a bond with remaining maturity close to 5 years from that day. The remaining matching approach depends on data availability and the remaining maturity of a bond. As the sample research consists of more than 2,000 observations for CDS market it allows picking out a higher number of bonds with remaining maturity closer to 5-year. Remaining maturity approach differs from the previous studies presented in existing empirical literature for a couple of reasons. First, it is more pushed closer to financial conditions and more realistic than linear interpolation. Second, it lets to match bonds not only with the exactly restricted maturity of 5 years but bonds with longer maturity, where remaining maturity as close as possible to 5 years. The remaining maturity approach helps to cover the bigger amount of data for sample selection.

In the current study CDS premia and bond yield spread are matched based on the *'remaining maturity'* approach. The logic of the approach is based on the assumption that CDS is an 'insurance' contract, which is obtained to protect debt buyer against default and in the case of 5 year CDS to protect a bondholder against a risk of default, which can occur during these five years of remaining maturity. Thus, to analyse CDS bond relationship it is essential to find a sound approach to merge the data. According to the approach, the initial CDS sample will be matched with bond yield spread data, collection of which determines the approach itself.

The process of bond spread collection is organised in three steps. First, for each single reference entity of CDS transaction a date of remaining maturity is set. Second, the reference entity is searched in Datastream database, and the matching approach is applied to select an appropriate bond for a particular transaction e.g. for each CDS transaction, a respectively bond with a remaining maturity close to 5 years is collected. The approach is yearly based. For example, for a CDS contract starting in 2007, a 5-year to maturity bond is selected, which expires in 2012. For a CDS transaction starting in 2008, a bond with a maturity date in 2013 is sampled and so on for each year until the last one of the defined period. Therefore, there are CDS premia with five years maturity starting from 2007, 2008 and so on until 2014 and matched bond yield spreads with the maturity dates from 2012 to 2019 for most of the observations. However, there are some deviations in matching the samples.[16] In Table 4 the summary statistics of the remaining maturity approach for matched CDS premia and bond spread is presented. According to the table, the median of remaining maturity is closer to 5 years for bond denominated in EUR. The method of remaining maturity is new, and it makes the study unique and different from other empirical research.

Table 4: Bonds remaining maturity per sample year

	EUR			USD	
	mean	median		mean	median
2007	6.88	5. 81	2007	10.6	8.78
2008	6.86	5.82	2008	10.56	8.77
2009	6.87	5.85	2009	10.54	8.77
2010	6.87	5.85	2010	10.49	8.73
2011	6.87	5.85	2011	10.53	8.79
2012	6.87	5.85	2012	10.54	8.8
2013	6.86	5.84	2013	10.49	8.78
2014	6.86	5.83	2014	10.46	8.76

Corporate and sovereign bond spreads are collected via *DataStream* for the time period from 1 January 2007 to 1 September 2014 and are denominated in EUR and USD. Bond yield spread is calculated daily and equal to corporate bond minus government bond yields in the denominated currency.

The annual allocation of unique reference entities and daily observations for bonds per sector denominated in EUR and USD are presented in Tables 5.

[16] As an example AB SKF with a CDS issued in 2007 is merged with a bond the maturity of which expires on December 13, 2013

Table 5: Unique reference entities/daily observations for bonds denominated in EUR and USD per year and sector

EUR						USD					
Year	**Obs.**	**Unique Reference Entities**	**Sectors**	**Obs.**	**Unique Reference Entities**	**Year**	**Obs.**	**Unique Reference Entities**	**Sector**	**Obs.**	**Unique Reference Entities**
2007	11,450	47	Basic Materials	12,261	18	2007	71,343	281	Basic Materials	62,651	44
2008	11,261	53	Consumer Goods	22,799	24	2008	73,131	285	Consumer Goods	72,894	50
2009	14,760	79	Consumer Services	19,713	27	2009	77,759	322	Consumer Services	97,987	67
2010	23,313	110	Energy	3,177	4	2010	84,548	347	Energy	73,091	50
2011	31,759	134	Financials	56,021	56	2011	92,738	375	Financials	103,582	81
2012	36,089	158	Government	21,801	18	2012	97,231	393	Government	11,152	11
2013	44,482	185	Healthcare	4,369	4	2013	104,517	422	Healthcare	39,513	25
2014	32,286	191	Industrials	30,891	34	2014	73,946	439	Industrials	90,450	67
TOTAL	**205,400**	**221**	Technology	4,360	5	**TOTAL**	**675,213**	**481**	Technology	33,476	24
			Telecommunications Services	14,972	15				Telecommunications Services	35,258	25
			Utilities	15,036	16				Utilities	55,159	37
			TOTAL	**205,400**	**221**				**TOTAL**	**675,213**	**481**

Overall, the bond spreads denominated in EUR and USD are collected for 221 and 481 unique reference entities respectively.[17] The number of entities increases in the course of time and peaks in 2014 for both EUR and USD. The main industries that cover bonds in EUR are Financials and Industrials. Bond spreads in USD are presented mainly for Financials, Industrials and Consumer services. The summary statistics by country (reference entities and daily observations) are presented in Table 6 for EUR and USD currency

[17] Coupon and zero-coupon bonds are employed in the research.

Table 6: Unique reference entities/daily observations for bonds denominated in EUR and USD per country

EUR						USD					
Countries	**Obs.**	**Unique Reference Entities**	**Country**	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique Reference Entities**
Australia	2,613	3	Korea (Republic of)	1,328	1	Argentina	221	1	Marshall Islands	1,160	1
Austria	5,510	6	Latvia	781	1	Australia	6,711	6	Mexico	5,690	4
Belgium	4,645	3	Lebanon	261	1	Austria	2,001	1	Netherlands	3,480	4
Bermuda	1,181	1	Luxembourg	9,001	11	Bermuda	6,753	5	New Zealand	2,001	1
Brazil	1,161	1	Netherlands	23,863	21	Canada	23,837	15	Norway	2,697	2
Cayman Islands	1,328	1	Netherlands Antilles	985	1	Cayman Islands	10,540	6	Pakistan	102	1
Croatia	615	1	Norway	1,002	2	Chile	4,786	3	Panama	296	1
Czech Republic	1,291	2	Portugal	3,033	4	China	26	1	Philippines	3,329	2
Denmark	2,362	3	Russian Federation	505	1	France	5,573	5	Portugal	174	1
Finland	1,778	3	Slovakia	2,001	1	Germany	2,001	1	Qatar	2,001	1
France	42,692	41	Slovenia	2,001	1	Greece	956	1	Russian Federation	2,205	2
Germany	36,595	38	Spain	12,477	10	Hong Kong	1,934	3	Singapore	1,636	3
Greece	1,907	3	Sweden	4,666	8	India	6,847	6	Supra National	1,327	1
Hungary	1,231	1	Switzerland	3,044	3	Iraq	2,001	1	Sweden	1,903	1
India	444	1	Ukraine	1,041	1	Ireland	2,001	1	Switzerland	1,619	1
Ireland	3,608	3	United Kingdom	7,050	11	Jamaica	1,328	1	Thailand	760	2
Italy	16,482	20	United States	6,398	11	Japan	3,931	3	Ukraine	1,920	1
Japan	520	1	**TOTAL**	**205,400**	**221**	Kazakhstan	866	1	United Arab Emirates	2,733	2
						Korea (Republic of)	2,448	5	United Kingdom	22,855	20

Lebanon	538	1	United States	521,265	351
Liberia	2,001	1	Venezuela	2,638	2
Luxembourg	4,006	7	**TOTAL**	**675,213**	**481**
Malaysia	2,116	2			

The highest number of observations and unique reference entities are reported for the countries of the Eurozone region for bond spreads denominated in EUR. (France, Germany, Netherlands and Italy) All together they cover more than half of the sample. For the bonds denominated in USD 351 unique reference entities with 521,265 daily observations are collected for the United States.

Table 7 provides an overview of reference entities and daily observation per region for bonds in EUR and USD.

Table 7: Unique reference entities/daily observations for bonds denominated in EUR and USD per sector and region

Currency	**Region/Sector**	**Unique Reference Entities**	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Government	Healthcare	Industrials	Technology	Telecommunications Services	Utilities	**Obs.**
EUR	Asia	2	520	-	-	-	-	-	-	1,328	-	-	-	1,848
	E.Eur	9	-	615	-	505	1,041	5,089	-	-	-	1,231	985	9,466
	Europe	190	10,135	21,488	19,168	2,672	50,655	14,885	2,576	28,461	3,705	11,919	14,051	179,715
	India	1	-	-	-	-	-	-	444	-	-	-	-	444
	Lat.Amer	1	1,161	-	-	-	-	-	-	-	-	-	-	1,161
	MiddleEast	1	-	-	-	-	-	261	-	-	-	-	-	261
	N.Amer	12	445	696	-	-	2,012	1,566	1,349	196	655	660	-	7,579
	Oceania	3	-	-	545	-	-	-	-	906	-	1,162	-	2,613
	OffShore	2	-	-	-	-	2,313	-	-	-	-	-	-	2,313

	TOTAL	**221**	12,261	22,799	19,713	3,177	56,021	21,801	4,369	30,891	4,360	14,972	15,036	**205,400**
USD	Africa	1	-	-	2,001	-	-	-	-	-	-	-	-	2,001
	Asia	21	-	1,143	1,673	639	3,073	1,354	-	275	2,057	4,661	1,305	16,180
	Caribbean	1	-	-	-	-	-	1,328	-	-	-	-	-	1,328
	E.Eur	4	-	-	-	-	2,786	2,205	-	-	-	-	-	4,991
	Europe	45	4,202	5,383	6,433	4,002	8,834	-	-	14,079	-	2,994	3,339	49,266
	India	7	2,001	-	-	-	873	102	-	644	-	-	3,329	6,949
	Lat.Amer	11	3,458	-	2,001	858	-	2,297	-	-	-	3,689	1,328	13,631
	MiddleEast	5	-	-	-	2,001	2,733	2,539	-	-	-	-	-	7,273
	N.Amer	371	52,990	64,367	84,847	61,919	79,825	-	39,513	72,070	29,418	23,914	42,992	551,855
	Oceania	8	-	2,001	1,032	-	1,456	-	-	3,382	-	-	2,001	9,872
	OffShore	6	-	-	-	3,672	4,002	-	-	-	2,001	-	865	10,540
	Supra	1	-	-	-	-	-	1,327	-	-	-	-	-	1,327
	TOTAL	**481**	62,651	72,894	97,987	73,091	103,582	11,152	39,513	90,450	33,476	35,258	55,159	**675,213**

As a result of the*” remaining maturity approach”* matching process the number of companies/reference entities decreased due to unavailability of bonds. Tables 8 and 9 present the final sample constituted by 421 unique entities. It also reports the number of daily observations per year, sector and country.

The final merged sample consists of 152 and 269 pairs of CDS premia and bond spread, which are denominated in EUR and USD currency respectively. The highest number of companies in the sample is observed in 2014 and equals to 114 for CDS bond pairs denominated in EUR and in 2007 and 2008 for CDS in EUR and bond in USD and the figures are equal to 225 and 226 respectively. Moreover, financial sector, consumer service and industrials dominate in the final sample covers.

The summary of country statistics for the merged sample (reference entities and daily observations) is presented in Tables 8 and 9 for EUR/EUR and EUR/USD currency pairs respectively. As in the bond samples in the merged samples France, Germany, Italy and Netherlands dominate in the pairs of CDS and bond spreads denominated in EUR. The United States is presented by 198 unique reference entities and cover 88,042 trading days.

Table 8: Unique reference entities/daily observations for the merged CDS premia and bond spread denominated in EUR per year, sector and country

Year	Obs.	Unique Reference Entities	Sector	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities		Obs.	Unique Reference Entities
2007	7,499	34	Basic Materials	5,469	9	Australia	1,162	1	Luxembourg	4,016	8
2008	7,323	37	Consumer Goods	14,693	16	Austria	2,949	4	Netherlands	14,174	16
2009	9,762	54	Consumer Services	9,915	18	Belgium	2,871	3	Norway	528	1
2010	13,661	74	Energy	269	2	Bermuda	871	1	Portugal	1,897	4
2011	16,654	81	Financials	30,207	40	Czech Republic	983	1	Slovakia	949	1
2012	18,940	91	Government	7,770	11	Denmark	2,152	2	Slovenia	949	1
2013	23,854	105	Healthcare	2,371	3	Finland	500	1	Spain	8,868	10
2014	17,726	114	Industrials	19,205	23	France	30,255	35	Sweden	4,284	8
TOTAL	**115,419**	**152**	Technology	2,793	4	Germany	20,274	27	Switzerland	2,854	3
			Telecommunications Services	10,689	11	Greece	442	1	Ukraine	187	1
			Utilities	12,038	15	India	146	1	United Kingdom	4,014	6
			TOTAL	**115,419**	**152**	Ireland	949	1	United States	371	1
						Italy	8,774	14	**TOTAL**	**115,419**	**152**

Table 9: Unique reference entities/daily observations for the merged CDS premia and bond spread, where CDS is denominated in EUR and bond is denominated in USD per year, sector and country

Year	**Obs.**	**Unique Reference Entities**	**Sector**	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique ref. entities**		**Obs.**	**Unique ref. entities**
2007	45,220	225	Basic Materials	11,548	27	Australia	784	1	Netherlands	586	1
2008	27,428	226	Consumer Goods	14,126	29	Austria	1,368	1	New Zealand	362	1
2009	19,676	130	Consumer Services	26,336	45	Bermuda	712	2	Norway	1,241	2
2010	12,933	76	Energy	13,670	29	Canada	4,457	10	Philippines	190	1
2011	5,814	31	Financials	15,736	37	Cayman Islands	2,140	5	Portugal	174	1
2012	7,885	36	Government	2,825	5	Chile	222	1	Qatar	276	1
2013	9,005	40	Healthcare	5,718	13	France	2,388	4	Russian Federation	887	1
2014	6,343	38	Industrials	25,043	40	Germany	2,001	1	Singapore	190	1
TOTAL	**134,304**	**269**	Technology	4,335	11	Hong Kong	229	1	Supra National	173	1
			Telecommunications Services	8,540	14	India	892	3	Sweden	1,903	1
			Utilities	6,427	19	Iraq	949	1	Ukraine	697	1
			TOTAL	**134,304**	**269**	Jamaica	275	1	United Arab Emirates	872	1
						Liberia	1,282	1	United Kingdom	17,870	19
						Luxembourg	1,837	4	United States	88,042	198
						Malaysia	574	1	Venezuela	541	1
						Mexico	190	1	**TOTAL**	**134,304**	**269**

3. Methodology

In this section, the methodology used in the first part of the research is introduced. The main focus is to analyse the relationship between CDS premia and bond yield spread. Different tests presented in previous papers will be used to study whether CDS premia lead lags bond yield spread or the inverse will apply. For all examinations, the time period is sub-divided into two. The first one is before the financial crisis and the second one is the period after the crisis. The breaking point is defined by Zivot-Andrews test described further in the paragraph. Moreover, to test the impact of one market on the other one the spreads will be regressed together with market and firm specific factors. Therefore, first, data is tested on the existence of stationarity. Second, the causality of the markets is analysed and, finally, the marginal effect of CDS change in the bond spread is researched as well as the influence of market and firm specific variables is presented.

3.1 Time series stationarity tests and preliminary results

As the first step in our analysis, the test of time series stationarity is performed, in other words, to check whether the data sample of CDS premia and matched bond yield spread is stationary or non-stationary. According to De Wit (2006) *"A stationary series follows a process which has a constant mean, variance and autocovariance structure through time."* If data is found to be non-stationary, a series must be differenced once before it becomes stationary. The reason why stationary data is required is that most statistical forecasting methods are based on the assumption that the time series can be rendered approximately stationary. Another reason for trying to stationaries a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables.

Previous research employs augmented Dickey-Fuller test (hereafter ADF test) (Palladini and Porters 2011, Bühler and Trapp 2012, Gyntelberg et al. 2013, Fontana and Scheicher 2016, Garcia, Valle and Marin, 2014) to find if time series has unit-root. Palladini and Porters (2011) indicate the presence of a unit root at the 0.05 level for sovereigns for 2004-2010. Bühler and Trapp (2012) found that the augmented Dickey-Fuller test could reject a unit root at 10% level for contracts during 2001 to 2007 years. Gyntelberg et al. (2013) found evidence of existing of a unit root for sovereigns and non-stationary of the data. Fontana and Scheicher (2016) apply the test to Sovereign CDS and bond spread series. The results do not reject the null hypothesis of unit root existence for levels, but it does for all series in their first differences. Garcia, Valle and Marin (2014) stated that the data of sovereigns for 2004-2012 has unit root and data is non-stationary and it follows a random walk pattern.

A unit root is a feature, which can cause problems in statistical implication. If a unit root is observed in a linear stochastic process, such a process is non-stationary. Hence if a process doesn't have a unit root, it is stationary. Alternatively, Phillips-Perron test (hereafter PP) could be run (Bühler and Trapp, 2012; Lien and Shrestha, 2014 and Gyntelberg et al., 2013). Lien and Shrestha (2014) use PP unit root tests on the level of the series and its first difference and state that PP and ADF tests lead to identical conclusions. It is concluded that all the series are non-stationary with single unit-root. Dotz (2007) also report the existence of unit-root by running PP for 1, 5 and 10 percent levels. In our analysis two methods have employed a test for unit roots and stationarity in the CDS time-series, the Augmented Dickey-Fuller (ADF) and The Phillips-Perron (PP) tests.

First, CDS premia for every single company in the sample is tested with the null hypothesis that unit-root does exist either rejected (in this case data reported to be stationary) or not rejected (in this case data is non-stationary). After the time series levels are tested there are two possible outcomes either it is stationary or non-stationary. If the time series is found to be non-stationary the next step is to first-difference it and test for stationarity again. The same approach is applied to the first difference of testing every company of existence of stationarity for both tests.

The following equation analyses whether there is unit root in time series for CDS premia sample. ADF is run for every single entity.

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{j=1}^{p} (\delta_j \Delta Y_{t-j}) + \varepsilon_t \qquad (1)$$

In equation (1) *t* is the time index, γ is the coefficient presenting process root, i.e. the focus of testing, *p* is the lag order of the first-differences autoregressive process, ε_t is an independent identically distributes residual term. The outcomes supposed to show whether the coefficient γ equals to zero, meaning that $Y_1 \ldots Y_n$ process has a unit root and is non-stationary. If γ is not equal to zero, the process is stationary, and there is no unit root.

Hence the null hypothesis of the research is γ=0. The null hypothesis is tested against the alternative hypothesis γ < 0 of stationarity.

$$H_0: Y_t = 0$$
$$H_1: Y_t < 0 \qquad (2)$$

Equation (2) shows the decision criteria where the null hypothesis, which is a random walk, is rejected or accepted. The ADF test ensures that the null hypothesis is accepted unless there is strong evidence against it to reject in favour of the alternative stationarity hypothesis. The method described above is applied for levels of CDS premia for 1, 5 and 10 percent levels of significance considering drift and lag equal to zero days.
Alternatively, Phillips-Perron test can also be applied with the same approach for CDS premia and bond spread.

$$\Delta X_t = \beta Y_{t-1} + \sum_{j=1}^{p}(\delta_j \Delta X_{t-j}) + e_t \qquad (3)$$

In equation (3) t is the time index, β is the coefficient presenting process root, i.e. the focus of testing, p is the lag order of the first-differences autoregressive process, e_t is an independent identically distributed residual term. The outcomes supposed to show whether the coefficient β equals to zero, meaning that $X_1 \dots X_n$ process has a unit root and is non-stationary. If β is not equal to zero, the process is stationary, and there is no unit root. According to Brooks (2002), the two tests tend to give similar results. Nevertheless both tests are conducted in this research. For Philips-Perron Newey-West lags approach is applied, including a trend.

There are therefore two possible outcomes. First, when unit root exists, and data is non-stationary, (which has been found in some empirical studies before), the analysis is preceded by testing of cointegration (long run relationship between variables). If there is no unit root and data is stationary Granger Causality approach can be applied. If data was found non-stationary for CDS premia (levels), we apply the first-difference technique to stationary the data. The differenced series is the change between consecutive observations in the original series, and can be written as the following equation:

$$y_t' = y_t - y_{t-1} \quad (4)$$

Equation (4) shows the first-order differencing process, which will be applied to the time series in the research. Hence, to make a time series stationary — compute the differences between consecutive observations. Differencing can help stabilize the mean of a time series by removing changes in the level of a time series, and so it eliminates trend and seasonality.

After the first-difference technique is applied to the levels, the data is tested on stationary one more time with the application of ADF and PP tests. If data is now stationary, we can implement the Granger Causality method, which is described next.

3.1.1 Augmented Dickey-Fuller and Phillips-Perron results

To determine further research methods the preliminary results of the unit-root tests will be described in this section based on the assumption that if the data, either it is levels or first-difference, is found to be stationary Granger Causality is applied next. Table 10 provides the results of ADF tests and states that that for the CDS levels the time series data is non-stationary as 123 out of 416 time series is found stationary, which equals 29.57 % comparing to 293 time series or 70.43% that is non-stationary. By testing with different levels of significance, it is possible to conclude that most of the data is stationary for 10 percent level. This is equal to 56 time series out of 416.

Table 10: Dickey-Fuller Unit root tests for CDS levels and first difference

Dickey Fuller Results		**TOTAL**	**10 percent**	**5 percent**	**1 percent**
Levels	Non-Stationary	293/70.43%	---	---	---
	Stationary	123/29.57%	56	43	24
First Differences	Non-Stationary	1/0.24%	---	---	---
	Stationary	415/99.76%	415	415	415

For *pvalues* higher than 10% the null hypothesis of unit-root presence cannot be rejected, hence the data is non-stationary

After the time series are first differenced the percentage of stationarity cases substantially increases. Indeed, for the first difference unit root absence result is perceived in 415 time series out of 416 time series, which is in relative value is higher than the total percent of stationarity for levels by 70.19% (99.76%-29.57%). Only 1 time series is non-stationary, which is equal to 0.24% of the whole sample.

Additionally, Table 11 reports the results of PP tests showing the presence of unit root in the time series. We cannot reject the null hypothesis for 72.83% cases, which is 303 time series out of 416, comparing to 27.16% or 113 time series, which does not have a unit root and is reported to be stationary. However, after the first difference is applied the time series turn stationary. First differences are presented to be stationary in 416 time series out of 416, which is 100%.

Table 11: Phillips-Perron Unit root tests for CDS levels and first difference

Philips Perron Results		**TOTAL**	**10 percent**	**5 percent**	**1 percent**
Levels	Non-Stationary	303/72.83%	---	---	---
	Stationary	113/27.16%	52	37	24
First Differences	Non-Stationary	0/0%	---	---	---
	Stationary	416/100%	416	416	416

For *pvalues* higher than 10% the null hypothesis of unit-root presence cannot be rejected, hence the data is non-stationary

As the time series of the sampled are found to be stationary by both tests for the first differences and the level of stationary is higher for the first difference the next steps that are Granger Causality testing and linear regression model (LRM) approach are applied to first difference time series.

3.2 Causality testing of CDS premia and bond yield spread

Granger causality approach aims to test how events in the past can *cause* events to happen today or in the future. The test is used to examine whether CDS premia "causes" bond spread or vice-versa. If a time series is a stationary process, the test is performed using the level values of two variables. If the variables are non-stationary, then the test is done using first differences or higher. In the current sample, the stationarity is found for first difference of time series. However, Table 10 shows that stationarity is stronger by 70.19% for first differenced data comparing to levels, when ADF test is applied and the data is found to be stationary for 100% when PP test is applied. In both cases first differences are stationary in almost 100%. Hence it is decided to proceed with the first difference time series and test it for "causality" purpose by employing Granger causality.

The test whether bond yield causes CDS premia or vice versa leads to the null alternative hypothesis as below:

H_0= The bond spreads do not Granger causes CDS premia
H_1= The CDS premia does not Granger causes bond spreads (5)

$$CDS_t = \sum_{j=1}^{k} \alpha_i \, BYS_{t-j} + \sum_{j=1}^{k} \beta_j \, CDS_{t-j} + u_{1t}$$

$$BYS_t = \sum_{j=1}^{k} \lambda_i \, BYS_{t-j} + \sum_{j=1}^{k} \delta_j \, CDS_{t-j} + u_{2t} \quad (6)$$

where *CDS* refers to the premia changes; *BYS* refers to bond yield spread change. Where u_1 and u_2 are uncorrelated prediction errors. In the equation (6) j is the number of lags and t is a point of time. The null hypothesis is rejected for 10% critical value.

3.3 Regression analysis

Granger causality test presented previously allows to establish the relationship direction between CDS premia and bond yield spread. After doing so we will apply panel data regression model to assess the magnitude of the marginal effect. The model is specified below for the case that CDS *premia* explains bond yield spread.

$$BYS_{i,t} = \alpha + \beta CDS_{i,t-1} + \varepsilon_{i,t} \qquad (7)$$

In equation (7) BYS_{it} is the bond yield spread (dependent variable) and CDS_{it-1}, is CDS premia (explanatory variable) and is one day lagged. The dependent variable is determined by two components: by non-random/structural component α or coefficient or intercept, that measures the value where the regression line crosses y-axis and β or coefficient or slope that measures the steepness of the regressing line. The second component is the random component called disturbance or error term epsilon i. Thus, based on the equation (7) it is possible to conclude how bond yield spread changes when CDS premia increases or decreases by 1 basis point (bp.) and to conclude how the markets are correlated. Subsequently, the model is applied to daily time-series from the two currency markets (EUR, USD). The regression coefficient β of CDS_i the coefficient equals to the covariance between $BYS_i$and CDS_i divided by variance of CDS_i. Another variable, which embedded in the equation, is the spread investment variable.

$$BYS_{i,t} = \alpha + \beta CDS_{i,t-1} + INV_{i,t}\varepsilon_{i,t} \qquad (8)$$

In equation (8) $INV_{i,t}$ is spread investment variable, calculated as the interaction among $CDS_{i-1}$and a binary variable equal to one if the bond is *Investment Grade* (AAA, AA-high quality; A and BBB-medium quality) and zero otherwise (*junk bonds*). Moreover, the data is divided into two sub-periods. However, since it is not obvious how to divide the data into the periods during and after the financial crisis a Zivot-Andrews unit-root test (1992) is employed. The breakpoint is defined by applying the test. Zivot Andrews has a null hypothesis of a unit root process with drift that excludes exogenous structural change. If the null hypothesis is rejected in favour of a trend stationary process that allows for a one time break in the level. According to Waheed, Alam and Ghauri (2006) the null hypothesis can be described by three equations. The models describe, first, one-time change in the level of the series, second, which allows for a one-time change in the slope of the trend function and, third, which combines one-time changes in the level and the slope of the trend function of the series.

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \gamma DU_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DT_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DU_t + \gamma DT_t \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

(9)

DU_t is an indicator dummy variable for a mean shift occurring at each possible break-date, while DT_t is corresponding trend shift variable.

4.4 One regression

For the whole sample combined of 5-year CDS spreads denominated in GBP and EUR matched with bond spreads denominated in GBP, EUR and USD a regression model includes a currency dummy variable, which indicates CDS premia of what currency has a stronger influence on bond yield spread.

$$BYS_{i,t} = \alpha + \beta CDS_{i,t-1} + INV_{i,t}\varepsilon_i + Currency_{i,t}\varepsilon_i$$

(10)

In equation (10) $Currency_{i,t}$ is a currency variable, calculated as the interaction among $CDS_{i,t-1}$and a binary variable equal to one if CDS premia is denominated in GBP and to 0 when CDS premia is denominated in EUR currency.

4. Results

This section presents the empirical results based on the discussion in the methodology section. First, unit-root test results using Augmented Dickey-Fuller and Phillips- Perron are presented to assess if CDS premia series and bond spread are stationary. We address both levels and first differences in the stationarity tests. Next, Granger Causality approach is applied to analyse whether CDS premia causes bond yield spread or whether the relationship is the inverse. Finally, regression analysis is conducted to analyse how bond spread changes with the change of CDS premia.

4.1Augmented Dickey-Fuller and Phillips-Perron Unit Root tests

First, we analyse the link between CDS premia and bond spread to check whether time series of CDS premia is stationary. To check whether it is non-stationary or stationary or whether it has a unit root or not Augmented Dickey-Fuller (thereafter ADF) and Phillips-Perron (thereafter PP) tests are employed, and it is run for levels of every entity separately. The results of the tests are reported in the previous section as *preliminary results*, and it is concluded that even data is found to be stationary for levels the stationarity is much stronger and almost equal to 100% of data that is first differences. Hence, it is decided to proceed with the first difference time series and test it for "causality" purpose by employing Granger causality. The first differencing approach is important, because, according to Brooks (2002), a stationary time series is characterised by a constant mean, variance, and autocovariance structure through time. To test for a unit root, we use the augmented Dickey-Fuller test.

4.2 Testing for Granger Causality

After the time series of CDS premia series is found stationary for both levels and first difference and stationarity also confirmed to be stronger after the series is first differenced the existence of the temporal relationship is examined. Granger causality method is employed to infer the relationship between CDS and bond. First difference approach calculates the difference between CDS premia of day t and the previous day (t-1).

The Granger causality makes it possible to test for different lags. In the study causality for 1, 3 and 5 days is performed, indicating the link for 1, 3 and 5 days between CDS and bond transactions. Financial academics employ Granger Causality test with different lags. For instance, O'Kane (2012) performs tests for 1 lag and Palladini and Porters (2011) for 2 lags. However, the maximum of 5 lags is optimum choice, as more than 10 lags were never found to be a significant choice and no results are based on a lag number greater than 10 (Berggren and Mattsson, 2008). However, Garcia, Valle and Marin (2014) test causality for up to 20 lags.

Overall, 152 pairs of CDS premia and bond spread denominated in EUR and 269 pairs of CDS premia denominated in EUR and bond spread denominated in USD are tested for 10 percent level of significance. According to Garcia, Valle and Marin (2014), there can be 4 possible outcomes: bond spread causes CDS premia, CDS premia causes bond spread, feedback between bond spread and CDS premia and causality between spread and CDS premia does not exist.

4.2.1. CDS Bond EUR relationship

In this section, the Granger Causality is run for the data of first difference time series of CDS premia and bond spreads. Based on the results presented in Table 12 we can conclude that the CDS premia causes the spreads for the majority of the cases.

Table 12: Granger causality CDS 5-year (EUR)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of CDS premia and bond spread. The results show the summary of outcomes when the null hypothesis is rejected.

EUR			USD		
Lags (days)	Bond Spread do not cause CDS Spreads	CDS Spread do not cause Bond Spreads	Lags (days)	Bond Spread do not cause CDS Spreads	CDS Spread do not cause Bond Spreads
1	56/36.84%	92/60.53%	1	91/33.83%	88/32.71%
3	33/21.71%	43/28.29%	3	49/18.22%	63/23.42%
5	17/11.18%	32/21.05%	5	38/14.13%	51/18.96%

The one-lag analysis shows that only in 56 cases out of 152 bonds spread Granger causes CDS premia when CDS premia does not cause bond spread. In this case, the null hypothesis that bond spread does not cause CDS Spreads is rejected. If the null hypothesis is rejected, hence, in this case, a bond is determined to lead CDS spread. In 36 cases both CDS premia and bond spread leads to price discovery, and in 38 cases causality between spread and CDS premia does not exist. Overall, for 61% the hypothesis that CDS Spread does not cause bond spreads is rejected for a lag of 1 day. For 3 and 5 days the hypothesis is rejected for 21.71% and 11.18%. Moreover, for a lag of 3 days only in 33 pairs bond spread causes CDS premia. In 9 cases both lead to price discovery. The number cases increase to 83 for the relationship when none of the instruments causes each other. CDS premia leads to price discovery in 43 pairs. In 5-lag analysis bond spread causes CDS premia in only 17 cases, while there is feedback between CDS and bond spread leads in 3 cases and no causality is observed in 104 cases. The conclusion can be made that for 1 day lag CDS premia leads bond spread in the most cases, despite, for 3 and 5 days the tendency stays the same, but it is more likely that there is no relationship between the markets due to lower percentages among the pairs when CDS premia leads to price discover comparing to 1 day lag analysis.

The outcomes of the previous empirical studies overlap the current results. Delis and Mylonidis (2011), who analyse CDS with 10 years to maturity state that CDS almost uniformly Granger-cause spread for Greece, Portugal, Spain, and Italy. However, no relationship is detected for CDS-bond relationship for Italy for 2004 - 2010 time period. O'Kane (2012) analyses causality link between the markets and concludes CDS leading role for Greece and Spain, but the converse relationship for Italy and France and bidirectional relationship for Portugal and Ireland during 2009-2011. This means that different results can be caused by such factors as state-dependence or industry-dependence. Palladini and Porters (2011) claim that in 61% of cases for sovereign CDSs over the whole sample CDS market plays a leadership role in the Eurozone countries during 2004-2011 and helps to forecast bond spread. The state-dependent outcomes for Euro area are confirmed by Arce, Mayordomo and Peña (2011) for 2004-2011. Fontana and Scheicher (2016) confirm that the causality link is state-dependent. For instance, CDS spread causes bond spread for the whole sample of Belgium, Greece, Ireland, Italy, and Portugal. However, the null hypothesis is not rejected for Austria. Indeed, in Austria bond spread causes CDS premia. Moreover, the causality between CDS premia and bond spread is concluded to be country-dependable, and it is stated that bond spread leads to price discovery for Germany, France, Netherlands, Austria and Belgium. However, the relationship is inverse for Italy, Ireland, Spain, Portugal and Greece for 2008-2010 time period. Research that mostly focuses on the French and Italian markets states that causality, in general, is manifested more for the CDS. (Garcia et al., 2014)

Hence, in summary, CDS market leads the bond market, as in a higher number of cases the null hypothesis that bond Spread does not cause CDS Spreads is rejected. Moreover, the relationship is stronger for 1ag of 1 day comparing to 3 and 5 lags analysis.

4.2.2 CDS Bond USD relationship

According to the Table 12, which reports the number of cases where bond spread Grange CDS premia and vice versa only in 91 cases out of 269 we can reject the hypothesis that bond spread does not cause CDS premia for a lag of 1 day, while in 39 pairs both CDS and bond lead to price discovery, and no relationship found in 129 cases. Thus, for CDS-Bond USD sample CDS premia lags bond spread for 32.71%. With an increase of lags, the number of cases where bond spread causes CDS premia slightly changes to 49 for 3 days and 38 for 5 days. Hence the hypothesis that CDS spread does not cause bond spreads is rejected for only 18.22% and 14.13% for 3 and 5 days respectively. Both CDS and bond spreads are found to granger in 15 cases out of 269 for 3 days and 12 cases out of 269 for 5 days. Both hypotheses are not rejected, and hence, in 3 lags analysis bonds do not Granger CDS premia and CDS does not Granger bonds as well in 172 cases, and in 192 cases for 5 lags. Thus CDS leads in more cases for a lag of 3 days comparing to 1 and 5 days in CDS-Bond USD example. Indeed, even CDS leads to price discovery for one day lag the percentage of cases is less comparing to bond spread leading role by 1.12%. However, the causality link reverse to since the number of lags increases to 3. Moreover, it can be resolved that CDS price discovery role is much higher for all lags for pairs CDS premia and bond spread both denominated in EUR comparing to CDS premia in EUR and bond spread in USD. This means that in higher number of cases CDS premia reacts to the flow information faster for EUR.

Overall, new information seems to be incorporated faster to CDS premia than to bond spread in EUR. Moreover, the results are mixed for CDS premia denominated in EUR and bond spread denominated in USD.

The results of the analysis keep pace with the outcomes of the previous studies. Gonzalez-Hermosillo (2014) continues concluding that during March 2009–September 2012 CDS premia for sovereigns adjust faster for Hungary, Poland, and the UK. However, bond spread adjusts faster for Greece, Portugal, and Ireland. Moreover, the current result reveals the absence of causality link between CDS premia and bond spread that confirms the results reported by Mora-Jensen (2013) for sovereign CDS premia and currency exchange spreads for 2005-2010. One of the first studies to test the no-arbitrage relationship between CDS and bond credit premia discussed above is Blanco et al. (2005), who study corporate bond and CDS markets. For a sample of 33 investment-grade U.S. and European firms, they find an equilibrium long-run relation between the pricing in the two markets for the majority of European companies.

4.3 CDS bond spread – Regression Analysis

In this section, multiple linear regression model is used to evaluate the data and to assist in finding the significance for the regression coefficients. Linear regression of spreads is conducted to explain bond spread change with a lag of 1 day by changing of CDS premia during 8 years period from 2007 to 2014. Using Zivot-Andrews unit root test, (aimed to find a break point in the time series) we divide time series into two sub-periods (breakpoint found on 03/12/2008) indicating statistically the end of the financial crisis period). Bond spread of first difference is a dependent variable in the regression, while CDS premia first difference lagged one day (to address the situation that on average CDS granger bonds) is an independent one. The regression also includes CDS premia multiplied by investment grade, where investment grade is equal to one if Investment Grade, AAA, AA (high quality), A and BBB (medium quality) and zero otherwise (Junk bonds grade others, low credit quality). The model is performed in 6 different specifications. Model 1 indicates how first difference CDS premia influences change of bond spread. Model 2 employs the same approach but includes spread investment variable. Model 3 and 4 tests the relationship for time periods of 1 January 2007 to 3 December 2008 included and from 4 December 2008 until 1 September 2014. Models 5 and 6 employ the same approach but includes spread investment variable for both periods of time.

4.3.1 CDS Bond EUR regression analysis

To investigate the relationship between CDS premia and bond spread denominated in EUR the model is performed in 6 different specifications. All models show a positive correlation between CDS premia and bond yield spread, meaning that an increase in 1 day lagged CDS premia leads to increase in bond spread. More specifically, Model 3 reports the results before the financial crisis and shows that before the financial crisis if CDS premia increases/ decreases by 1% the next day bond yield spread increases/decreases by 38 basis point.

Table 13: Regression Analysis EUR/EUR Pair

Results for Equations 7 and 8 are presented for pairs of CDS premia denominated in EUR currency and bond spread denominated in EUR currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test.

EUR	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Spread (-1)	0.0144975	0.0145227	0.0038405**	0.0194673	0.0038407**	0.0194866
	(1.30)	(1.30)	(2.16)	(1.38)	(2.16)	(1.38)
Spread_investment	---	0.000267	---		0.0000375	0.0000238
		(0.13)			(0.18)	(0.04)
Constant	0.000	0.000	0.000***	0.000	0.0000	0.000
	(1.03)	(0.14)	(6.72)	(0.93)	(0.07)	(0.56)
CDS/Bonds pair	152	152	39	149	39	149
Observations	115,266	115,266	14,245	101,021	14,245	101,021

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

4.3.2 CDS Bond USD regression analysis

The results of the relationship between CDS premi denominated in EUR and bond yield spread denominated in USD are presented in Table 14.

Table 14: Regression Analysis EUR/USD Pair

Results for Equations 7 and 8 are presented for pairs of CDS premia denominated in EUR currency and bond spread denominated in USD currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test.

USD	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Spread (-1)	0.0209536 **	0.0208883**	0.0132822 ***	0.0237999	0.0132456***	0.0238017
	(1.67)	(1.67)	(10.87)	(1.09)	(10.84)	(1.09)
Spread_investment	---	-0.0001247	---	---	-0.0000556 **	0.0005436
		(-0.38)			(-2.21)	(0.09)
Constant	-0.0000	0.0000	0.0000 ***	0.000	0.000 ***	0.000
	(-0.81)	(0.21)	(15.38)	(0.55)	(5.25)	(0.08)

CDS/Bonds pair	269	269	232	158	232	158
Observations	134,034	134,034	70,447	63,587	70,447	63, 587

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

According to Model 1 CDS premia is positively correlated with bond yield spread and increase/decrease of 1 day lagged CDS premia by 1% causes increase/decrease in bond yield spread by 209 basis points. Model 3 to 6 test time spans before and after the 3rd of December 2008. During the turmoil and after it the spreads are positively correlated. Model 3 indicates that before the financial crisis CDS premia and bond yield spread are positively correlated, and the influence of CDS premia on bond yield spread is lower than for the whole period. Models 5 and 6 also show a positive correlation with the same degree of influence, but they include spread investment variable. The negative sign of this variable indicates that the overall impact on bond spread given by a change in CDS premium is less for investment grade bonds. However, the result is only significant before and during the financial crisis. For investment grade bonds the impact is (0.0132456-0.0000556 =0.01319) where to junk bonds is 0.0132456. The difference is minor but can show that if one day lagged CDS premia goes up investment grade bond spread goes up less than the spread of junk bonds.

The results confirm the preceding finding. Norden and Weber (2009) find positive coefficient between lagged CDS premia and bond spread, which is equal to 0.08 for 1000 reference entities (Corporates, Financials, and Sovereigns) for the time period starting from July 2, 1998 to December 2, 2002. The positive correlation is confirmed by Chan-Lau and Kim (2004).

4.3.3 One regression analysis

In this paragraph, a single regression employing and combining two data sets (the data consists of CDS premia denominated in GBP and CDS premia denominated in EUR) will be run. To investigate the relationship between CDS premia and bond spread the model is performed in 6 different specifications with the same approach as in the previous sections. Additionally, using Zivot-Andrews unit root test, (aimed to find a break point in the time series) we divide time series into two subperiods (breakpoint found on 26/01/2009) indicating statistically the end of the financial crisis period. Thus the whole sample for one regression analysis includes CDS premia denominated in EUR and GBP, bond spread denominated in EUR, GBP and USD.

Table 15: Regression Analysis GBP/EUR/USD Pair

Results for Equations 7 and 8 are presented for pairs of CDS premia denominated in GBP and EUR currency and bond spread denominated in GBP, EUR and USD currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (26.01.2009)-the breaking point calculated by Zivot-Andrews

TOTAL	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Spread (-1)	0.0284564***	0.0284241***	0.0355148***	0.0257786 **	0.0354964 ***	0.0257819 **
	(3.17)	(3.16)	(19.97)	(2.10)	(19.96)	(2.10)
Spread_investment	---	-0.4853554	---	---	-0.8781927**	0.2255203
		(-0.32)			(-1.95)	(0.03)
Constant	-0.1176792	0.349538	0.6920116***	5.901201	1.535354 ***	5.690668
	(-0.41)	(0.24)	(7.59)	(0.75)	(3.45)	(0.50)

CDS/Bonds pair	609	609	369	484	369	484
Observations	446,277	446,277	127,453	318,824	127,453	318,824

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Model 1 shows that first differenced CDS premia with 1 day lag has a positive effect on the bond spread, these results are statistically significant for 1%. The coefficient is equal to 0.0284. Model 3 to 6 test crisis and post-crisis periods with a breakpoint on the 26th January 2009. The both coefficient before and after the structural break are positive. However, after the crisis the influence on the bond spread by the CDS premia is slightly lower. Model 5 and 6 includes investment grade variable. For the time period before 26/01/2009 the investment grade variable is negative, showing that influence of CDS premia change on investment grade bond is more than on Junk bonds. (Table 15) Table 16 reports the result for the one regression assuming the influence of the currency of the CDS premia. The results show that CDS premia is positively correlated with bond yield spread. Moreover, the currency variable affects the relationship before the break point and indicates that, according to Model 3 and 5, the influence of CDS premia denominated in GBP on the whole sample is less than the influence of CDS premia denominated in EUR.

Tables 17 and 18 reports results for control for industry effect. The tables present how industry effect influence changes in bond spread.

Table 16: Regression Analysis GBP/EUR/USD Pair including currency variable

Results for Equations 7 and 10 are presented for pairs of CDS premia denominated in GBP and EUR currency and bond spread denominated in GBP, EUR and USD currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0 and currency variable- dummy variable equal to 1 for CDS premia denominated in GBP and 0 for CDS premia denominated in EUR (Model 2). Model 3,4,5, and 6 report regression for time periods before and after the financial crisis (26.01.2009)-the breaking point calculated by Zivot-Andrews

TOTAL	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Spread (-1)	0.028457 ***	0.028423***	0.0355242***	0.0257772***	0.0355044***	0.0257817***
	(3.17)	(3.16)	(19.98)	(2.10)	(19.97)	(2.10)
Spread_investment	---	-0.5135062	---	---	-0.8810548***	0.312207
		(-0.34)			(-2.01)	(0.04)
Currency	0.2106513	0.2202273	-0.9469056***	-9.589574	-0.9514234 ***	-9.604777
	(0.36)	(0.38)	(-4.77)	(-0.59)	(-4.79)	(-0.59)
Constant	-0.2106528	0.2794367	0.9469745***	9.58955	1.794525***	9.302593
	(-0.55)	(0.19)	(9.14)	(0.95)	(4.12)	(0.72)
CDS/Bonds pair	609	609	369	484	369	484
Observations	446,277	446,277	127,453	318,824	127,453	318,824

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Table 17: Regression Analysis EUR/EUR Pair

CDS premia denominated in EUR currency and bond spread denominated in EUR currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0. Model 2 and 3 report regression for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test. Additionally, the table contains sector dummy variable equal to 1 for each sector.

EUR	Model 1	Model 2	Model 3
Spread (-1)	0.0145316	0.0035215 ***	0.019478
	(1.31)	(1.99)	(1.38)
Basic materials	-0.0005355**	-0.0000802	-0.0044745**
	(-1.97)	(-0.09)	(-1.94)
Consumer Goods	-0.0005195***	0.0000607**	-0.004471***
	(-2.35)	(1.90)	(-2.32)
Consumer Services	-0.0005164***	0.0000178	-0.0044122***
	(-2.29)	(0.53)	(-2.29)
Energy	-0.0004591	0.0008774***	-0.0049542
	(-0.63)	(8.90)	(-1.20)
Financials	-0.000529***	-9.33e-06	-0.0044778***
	(-2.79)	(-0.36)	(-2.67)
Government	-0.0005326***	-0.000023	-0.0044867***
	(-2.17)	(-0.84)	(-2.06)
Healthcare	-0.0005722		-0.0045602
	(-1.42)		(-1.33)
Industrials	-0.0005374***	7.08e-06	-0.0044839***
	(-2.61)	(0.22)	(-2.46)
Technology	-0.0005547	0.0001983***	-0.0045091
	(-1.53)	(3.23)	(-1.48)
Telecommunications	-0.0005309***	0.0000352	-0.0044763***
	(-2.18)	(1.00)	(-2.06)
Constant	0.000***	0.000***	0.000***
	(3.29)	(1.78)	(3.00)
CDS/Bonds pair	152	39	149
Observations	115,266	14,245	101,021

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Table 18: Regression Analysis EUR/USD Pair

CDS premia denominated in EUR currency and bond spread denominated in USD currency for the whole time period from the 1st of January 2007 to the 1st of September 2014 (Model 1) including Investment grade variable –dummy variable for bonds with rating higher BBB equal to 1 and below to 0. Model 2 and 3 report regression for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test. Additionally, the table contains sector dummy variable equal to 1 for each sector.

EUR	Model 1	Model 2	Model 3
Spread (-1)	0.0208503*	0.0132468***	0.023776
	(1.67)	(10.84)	(1.09)
Basic materials	9.75e-06	7.23e-06	-9.40e-06
	(0.03)	(0.26)	(-0.00)
Consumer Goods	0.0000231	0.0000147	-0.0000213
	(0.06)	(0.57)	(-0.00)
Consumer Services	0.0000246	0.000033	0.0001627
	(0.07)	(1.33)	(0.02)
Energy	0.0000112	-0.0000125	0.0002581
	(0.03)	(-0.47)	(0.02)
Financials	0.0000954	7.18e-06	0.0098649
	(0.27)	(0.27)	(0.88)
Government	0.0000106	0.0001389***	-5.34e-06
	(0.02)	(3.10)	(-0.00)
Healthcare	0.0000102	-0.0000144	-0.0000404
	(0.02)	(-0.46)	(-0.00)
Industrials	-0.0004529	0.0000211	-0.0008395
	(-1.34)	(0.85)	(-0.08)
Technology	-6.70e-07	0.0000112	-0.0000908
	(-0.00)	(0.31)	(-0.01)
Telecommunications	4.11e-06	-0.000017	0.0000203
	(0.01)	(-0.56)	(0.00)
Constant	0.000	0.000***	0.000***
	(0.03)	(2.91)	(-0.00)
CDS/Bonds pair	269	232	158
Observations	134,034	70,447	63,587

Notes: Hausman test indicate the use of Random effects

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

5. Conclusions

This paper has aimed to investigate the causality link between CDS premia and bond spread in the period starting from 1st January 2007 to 1st September 2014. To collect the data required for the research, Markit and Datastream sources have been used for CDS and bond spreads, respectively. The *"remaining maturity"* approach that we described earlier has been employed to match CDS premia with the bond yield spread of the same reference entity. The sample consists of 5-year CDS premia matched with bond spread for a set of companies and sovereigns that covers different countries, regions and industries.

The outcomes of the Augmented Dickey–Fuller test, Phillips–Perron test, Granger Causality test and linear regressions leads to the main conclusions that CDS premia changes cause bond yield spread changes. We can conclude here that CDS premia incorporated new information faster over 2007-2014, but for CDS premia in EUR and bond spread in USD, the relationship is not as clear. CDS premia is found to be positively correlated with bond spread for both currencies. Moreover, regression analysis includes an investment grade variable, which shows that the overall impact on bond spread by a change in CDS premia is less for investment grade bonds before and during the financial crisis for CDS premia in EUR and the bond spread in USD.

More specifically, the data is found to be non-stationary for series levels. However, after Augmented Dickey-Fuller and Phillip-Perron tests are applied to first-differenced data, the stationarity is confirmed in almost 100%. The CDS premia leads bond spread denoted in EUR and the relationship is stronger for 1-day lagged CDS premia cases (CDS leads in 60.53%).

For the pairs of CDS in EUR and bond in USD, the results are mixed. Hence, the causality of CDS is stronger for the pairs, where bonds are denominated in EUR currency. Regression analysis is performed in 6 different specifications. We may conclude that for the whole period, CDS premia is positively correlated with bond spread denominated in EUR and USD. In addition, before 3rd December 2008 the bond spread was also positively correlated with CDS premia for EUR and USD bonds. However, the influence of lagged CDS premia is less for investment grade bonds comparing to junk bonds denoted in USD.

For one regression, the lagged CDS premia and investment grade are regressed for bond spread as a dependent variable, thus showing that the relationship is positive and entailing that if CDS premia increase/decrease, then the bond spread in the next day increases/decreases. Moreover, investment grade variable is significant only before the crisis, while decreasing the influence of CDS premia on bond spread for investment grade bonds comparing to junk bonds. The impact of CDS currency is also vital before and during the financial crisis. The results reveal the inclination shows a slightly stronger influence of CDS premia denominated in EUR on bond spread, compared to CDS premia in GBP.

All the market participants, such as traders, risk managers and regulators can use the results of this paper. The price discovery helps us to understand how CDS premia and bond spread react to information flow in the markets. The concept of positive and negative basis may bring arbitrage opportunity, while adequate understanding of its drivers helps arbitrage opportunities to be gain. The ability to predict opportunities the CDS market can be useful for risk managers.

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Chapter 4: Global Financial Crisis and the interaction of the CDS, Bond and Equity markets

Abstract

This paper investigates the price discovery process between derivatives (credit default swap), bond and equity markets from 1st January 2007 to 1st September 2014 for a matching sample of 370 unique reference entities. The paper contributes to the empirical financial literature by employing an extended data sample for 446,886 daily observations of the three markets and by analysing the impact of the 2007-8 global financial crisis on price discovery.

In this paper, we provide a comprehensive analysis of the relationship between CDS, bond and equity markets. The study contributes to the above, firstly by employing an extended data sample for both corporates and sovereigns, comparing these findings to previous limited research who only employ data for sovereign markets. (Chan-Lau and Kim, 2004' and Corzo, Gomez-Biscarri and Lazcano, 2012). Second, the data covers the time period before and after the financial crisis, in contrast to previous research that only analyses the markets before the crisis (Norden and Weber, 2009). Third, the study employs a set of factors to research how they explain the change in the markets.

The results show that the leading role of any specific market is not clear. However, linear regression shows that bond and CDS spreads are positively correlated, while equity return is negatively correlated with CDS premia. Moreover, explanatory variables indicate that market value and market return positively influence equity return and negatively CDS premia.

Market volatility affects the markets differently for different currencies and time periods. Before the 2007-8 Financial Crisis, the bond spread is more influenced by CDS premia in Euro. However, the CDS premia in GBP has affected bond spread after the crisis.

The influence of equity return on CDS and bond did not change with the onset of the financial crisis. The markets are negatively correlated, but the correlation is found to be positive for equity bond relationship for bonds denominated in US Dollars.

Keywords: Credit Default Swap, bonds, equity market, financial crisis, price discovery, market efficiency.
JEL Classification: G01, G14, G15

1. Introduction and background

The study of the interrelation between derivative, debt and equity markets is a crucial issue for market participants and regulators because the equity market is regarded as a crucial provider of information to ensure the soundness of a firm's. Moreover, correlation within the market for credit default swaps is also a very important aspect for market participants and supervisory authorities to consider, being that increasing correlations are often referred to contagion (Coudert and Gex, 2010). Indeed, CDS spreads are widely regarded as an important indicator of potential default risk; what is more, CDS spreads may be used as a complement to credit ratings. The Credit Default Swap (CDS) is a financial instrument, which is destined for risk diversification against credit events like downgrades or defaults by single-name or a basket of obligors.

From this point onwards, the fundamental question that this paper tends to answer is what market is more informational efficient. To answer this research question, the study will assess which market reacts faster to new information because the quicker and more precise the market is able to price securities, the more efficient it is said to be. Moreover, the study will describe how supervisory authorities and risk management practitioners can benefit from it.

This paper aims to disclose the causality link between CDS, equity and bond markets, showing which market is more informational efficient. Indeed, according to Belke and Gokus (2014), there are three variables that indicate the performance of an entity: stock price, bond yield spread, and credit derivatives. Hence, the conception of a market efficiency/inefficiency, or how a market reacts when new public or private information enters into the market, is important for market participants and regulators. Every market participant can benefit from awareness of how the markets are affected by new information. As many investors try to identify securities that are undervalued, they can benefit from determining what market leads and beat the market. Market interrelation serves regulators in terms of credit risk management. Early studies such as Downing et al. (2009) define informational efficiency, which is the degree to which market prices correctly and quickly reflect information in a market. Thus, the true value of an underlying asset, by information and how information is incorporated into security prices by examining the correlations between stock and bond returns.

Informational efficiency can be considered as evidence of a lead-lag relation in one direction or the other. Here, it has been interpreted as indicative of the activities of informed traders in the market where returns carry predictive content. Furthermore, according to Belke and Gokus (2014), there are three variables that determine the performance of an entity: stock price, bond yield spread, and credit derivatives. The relationship and price discovery between bond and stock market has been researched, but CDS market efficiency requires further comprehensive research as the relationship and price discovery should shed light on the efficiency of the respected market, while the current academic literature on the topic is very small. Hence, CDS market could be an important indicator of informational efficiency.

The CDS market has received special attention, as it should reflect the pure credit risk of borrowers. Berndt and Ostrovnaya (2014) have extended the research of the relationship between the three markets and state that a significant information flow is observed from CDS market to equity market. The analysis of Berndt and Ostrovnaya (2014) is based on daily CDS, options and equity data for 144 U.S. firms from nine industries and it covers the period from 8th January 2002 to 8th November 2006. There is no evidence here that bonds lead equity market and this conclusion is supported by research Zhu (2006), Acharya and Johnson (2007) and Cao et al. (2010). However, according to Longstaff et al. (2005), there is no evidence for a lead-lag relationship between CDS and equity markets.

Regarding the relationship between bond and equity markets, Downing et al. (2009) find that hourly stock returns lead bond returns for non-convertible junk- and BBB-rated bonds. Moreover, stock returns lead bond returns for convertible bonds in all rating classes concluding that the corporate bond market is less informational efficient than the stock market, notwithstanding the recent improvements in bond market transparency and associated reductions in corporate bond transaction costs for 2002-2005. This position is advocated by (Kwan 1996, Longstaff et al. 2005 and Norden and Weber 2009) justifying the postulates of higher efficiency in the stock markets. However, Hotchkiss and Ronen (2002) argue that stocks do not lead bonds. Hotchkiss and Ronen (2002) reach a different conclusion using daily and hourly high-yield bond transaction prices between 3rd January 1995 and 1st October 1995. The authors employ VAR and Granger Causality to obtain the results.

Overall, the conclusion may be drawn that, according to rigorous analysis, the CDS market leads bond and equity markets while the equity market tends to lead the bond market. However, some outcomes clash with the above conclusion. Norden and Weber (2009) claim that equity clearly leads CDS market for the period of 2nd July 1998 to 2nd December 2002, while the analysis here includes CDS quotes and additional contractual information for more than 1000 reference entities (Corporates, Financials and Sovereigns). By employing Augmented Dickey-Fuller test, Phillips-Perron test and Kwiatkowski-Phillips-Schmidt-Shin test to find that data for stock price, CDS premia and bond spread is found to be stationary, mostly for first-difference tests of the data.

By employing a three-dimensional vector autoregressive model, the authors find that weekly and daily stock returns are negatively associated with CDS and bond spread changes. The results are in line with Bystrom (2006) and Trutwein and Schiereck (2011), who state that equity market leads a single CDS for the daily CDS index spread for the seven sector indices in the iTraxx Europe and for 9 out of 13 financial institutions between 2007 and 2008 respectively. All the indices in the study are based on five-year-maturity CDS contracts and are denominated in EUR. Indeed, in consistency with the Merton Model (1974), CDS premia and equity price should move in opposite directions and Kwan (1996) indeed confirms a negative correlation between bond yield changes and equity returns. However, Alexander et al. (2000) argue that there is positive, but weak correlation between stock and bond returns. Hence, it can be concluded that if there is a relationship between stock return, bond yield and CDS premia, then the correlation between premia and return and yield and return should be negative; that is, returns increase the soundness of a company increases bond spread and cause the CDS premia fall in price. Indeed, Scheicher (2009) concludes a negative correlation between CDS premia and equity returns for 240 firms between 2003 and 2005.

Moreover, a significant increase in the absolute value of the correlations can be observed after the start of the subprime crisis. It means that the financial crisis triggers the contagion. It can be also concluded that credit market can be a better indicator of informational efficiency than rating agencies. The results are controversial due to the fact of the difference in data sets and time periods. Corzo, Gomez-Biscarri and Lazcano (2012) investigate the relationship between sovereign CDSs, Bonds and Equity for the European region. The leading role of equity markets is confirmed for the period 2008-2010, but there is significant evidence for the leading movement of sovereign CDS markets in 2010.

Zhang and Zhang (2013), who investigate positive and negative earnings surprises for 1000 companies over the period 2001-2005, conclude that negative earnings surprises are well anticipated in the CDS market in the month prior to the announcement, with both economically and statistically stronger reactions for speculative-grade firms than for investment-grade firms. On the announcement day, the CDS spread for speculative-grade firms presents abnormal changes for both positive and negative earnings surprises. Moreover, there is no post-earnings announcement drift in the CDS market, which is in direct contrast to the well-documented post-earnings drift in the stock market. The results support the efficiency of the CDS market.

Prior to the above conclusion (Zhang, 2008) assesses both CDS and stock market for the original dataset of daily quotes on CDS spreads for over 1,000 North American obligors from January 2001 to December 2005. Here, CDS and stock market reactions have been assessed for the various types of credit events. It is concluded that CDS price increases by 37% to 96% on a single day in response to credit event news that is related to economic distress, financial distress, SEC probe (Securities and Exchange Commission probe), M&A (mergers and acquisitions) or leverage buyout (LBO). Moreover, the stock price drops by 2% to 9% upon the first four types of credit news, but rises by 7% on hearing the LBO news, consistent with wealth transfer effects from bondholders to equity holders. The findings support the efficiency of the CDS market as the authors find the CDS price reaction is concentrated upon a single day for all five types of adverse credit events.

Furthermore, based on the reviewed literature it can be assumed that if a particular market leads then it can play a significant role in informational efficiency. The assumption is in line with research conducted by Amadori et al. (2014). A lead-lag relation is found between the CDS market and the other markets, in which changes in CDS spreads serve to forecast changes in stock prices and equity options' implied volatilities consistently, indicating how the fast-growing CDS market seems to play a special role in the price discovery process for 91 companies from 15th July 2005 to 30th September 2010 in European markets. The CDS-bond relationship has been studied earlier and the leading role of CDS premia is supported by evidence reported by Longstaff et al. (2005), Blanco et al. (2005), Zhu (2006) and Norden and Weber (2009).

To research the relationship between the three markets the current study will employ lead-lag analysis. If the data is found stationary, then the regression model can be applied. For instance, Berndt and Ostrovnaya (2014) apply Ordinary Least Square model to analyse the interrelation between the three markets. This methodology is in line with the methodology employed by Kwan (1996), Hotchkiss and Ronen (2002), Longstaff et al. (2005) and Byström (2005). In this research, the relationship between three markets will be assessed by application of a different approach to analyse the co-movements of the markets.

This study has assembled a data set that includes 193 CDS contracts with 197,163 daily observations for CDS contracts denominated in GBP and 416 CDS contracts denominated in EUR covering 249,723 daily observations. The sample covers the period starting from the 1st January to 1st September 2014. Moreover, apart from dependent and independent variables of CDS premia, bond yield spread and equity return the study employs explanatory variables that will explain changes in CDS, bond and equity market. The overall results suggest that, according to Granger Causality test, in most cases the results are mixed and there is no significant evidence of one's market leading role.

However, there is slight evidence that equity market tends to lead CDS market. The results of regression model indicate that CDS premia and equity return are negatively correlated, while CDS premia is positively correlated with bond yield spread. Market return and market value are hence strong explanatory variables for all dependent variables, while the investment grade variable does not have a significant explanatory power. The effect of market volatility differs according to the currency and time period.

The remainder of the chapter is organised as follows. First, the data sources and sample, as well as the data collection process and matching approach of equity prices to a sample of merged CDS premia and bond yield spread will be described. Secondly, the methodology section will describe the tests implemented to obtain the results. Finally, the results of the empirical analysis will be discussed and the conclusion based on the results provided.

2. Data sources, sample and matching procedure

2.1 Data sources and CDS/bond sample

To address the paper objectives the relationship between CDS premia, bond yield spread, and equity returns are studied. The sample employed in the research contains data collected from Markit and Datastream sources for 5-year to maturity CDS premia, bond spread with remaining maturity close to 5 years for the same entity and equity price. In the aftermath, equity price is recalculated into equity return. The databases are chosen due to the fact of specific nature of required information. CDS premia data is collected from Markit, a major derivative database which provides verified reference data to the credit derivatives market in particular. Earliest data is back to 2001 and disposes of daily quotes for over than 13 thousands reference entities. Besides CDS daily quotes Markit provides information regarding CDS maturity, transaction date, recovery rate, currency, type of CDS collateral, rating, and a number of providers of information, sector, region and country. DataStream database was selected to obtain bond yield spreads. This database provides up to date as well as historical international data on stocks, indices, bonds, commodities, futures, options, etc. being one of the major databases for corporate bond collection.

The collection process is organized in two phases. First, the bond yields spreads are collected for each reference entity and matched with an appropriate CDS premia of the reference entity. Second, equity prices are collected for each reference entity and matched with an appropriate CDS and already merged bond yield spread of the reference entity.

The merged sample of CDS and bond pairs is provided for this study. It is assumed that the data is collected and the yields are merged based on the following criteria. First, the sample covers the time period before, during and after the financial crisis and starts from 01 January 2007 to 01 September 2014. Second, the final CDS sample is filtered and selected based on CDS currency. The currency is specified to be British Pound Sterling (GBP) and Euro (EUR). The currency is selected as the one of the most traded ones. (Desjardins, 2017) Third, the collateral type is defined. *Modified-Modified* (MM) is.[18] MM is introduced with a maturity limit of 60 months for restructured obligations and 30 months for all other obligations. The reason for choosing MM collateral type is that it used mostly in Europe.

Ultimately, for the current research four initial merged datasets are provided. The first one consists of CDS premia denominated in GBP and bond yield spread denominated in GBP (pair GBP/GBP), the second one is CDS premia denominated in GBP and

[18] Collateral criteria covers 96% of European Restructuring Clauses.

bond yield spread denominated in EUR (pair GBP/EUR), the third one includes CDS premia denominated in EUR and bond yield spread denominated in EUR (pair EUR/EUR), and the last one consists of CDS premia denominated in EUR and bond yield spread denominated in USD (pair EUR/USD).
The annual allocation of unique reference entities and daily observations per sector and country for merged CDS and bond spreads denominated in GBP and EUR are presented in Tables 1 and 2 respectively. The annual allocation of unique reference entities and daily observations per sector and country for merged CDS and bond spreads denominated in EUR and USD are presented in Tables 3 and 4 respectively.

The final merged sample consists of 99 and 94 pairs of CDS premia and bond spread, which are denominated in GBP and EUR currency. The final merged sample for CDS in EUR consists of 152 and 269 pairs for bond spreads, which are denominated in EUR and USD currency. The United Kingdom dominates in the pairs of CDS and bond spreads denominated in GBP and equals to 65 unique reference entities that cover 76,379. Germany and France are presented by 20 and 26 unique reference entities respectively and cover 15,960 and 20,453 trading days. As in the bond samples in the merged samples the France and Germany dominate in the pairs of CDS and bond spreads denominated in EUR and is equal to 35 and 27 unique reference entities that cover 30,255 and 20,274 trading days respectively. The United States is presented by 198 unique reference entities and covers 88,042 observations.

Table 1: Unique reference entities/daily observations for the merged CDS premia and bond spread denominated in GBP per year, sector and country

Years	Observations	Unique Reference Entities	Sectors	Observations	Unique Reference Entities	Countries	Obs.	Unique Reference Entities
2007	12,823	58	Basic Materials	2,804	2	Cayman Islands	917	1
2008	13,851	57	Consumer Goods	9,548	12	Denmark	1,944	2
2009	15,057	70	Consumer Services	22,641	20	France	7,274	5
2010	16,130	75	Energy	---	---	Germany	4,232	3
2011	14,522	62	Financials	31,520	26	Ireland	811	2
2012	16,569	71	Government	949	1	Italy	10,349	6
2013	17,171	68	Healthcare	3,501	2	Jersey	491	1
2014	11,605	71	Industrials	11,111	8	Netherlands	6,228	4
TOTAL	**117,728**	**99**	Technology	---	---	Sweden	2,658	2
			Telecommunications Services	10,108	7	United Arab Emirates	878	1
			Utilities	25,546	21	United Kingdom	76,379	65
			TOTAL	**117,728**	**99**	United States	5,567	7
						TOTAL	**117,728**	**99**

Table 2: Unique reference entities/daily observations for the merged CDS premia and bond spread, where CDS is denominated in GBP and bond is denominated in EUR per year, sector and country

Years	Observations	Unique Reference Entities	Sectors	Observations	Unique Reference Entities	Country	Observations	Unique Reference Entities
2007	4,398	20	Basic Materials	8,646	9	Austria	413	1
2008	5,562	27	Consumer Goods	8,821	10	Belgium	1,563	1
2009	8,137	47	Consumer Services	13,714	17	Cayman Islands	541	1
2010	10,715	54	Energy	1,759	2	Denmark	1,188	1
2011	11,831	56	Financials	21,081	25	Finland	1,478	1
2012	13,575	57	Government	926	1	France	20,453	26
2013	14,651	66	Healthcare	1,148	3	Germany	15,960	20
2014	10,566	66	Industrials	8,407	11	Greece	229	1
			Technology	1,292	2	Ireland	2,661	4
			Telecommunications Services	7,122	9	Italy	6,140	5
			Utilities	6,519	5	Luxembourg	1,175	3
						Netherlands	8,191	8
						Norway	2,429	2
						Portugal	1,918	2
						Spain	6,654	6
						Sweden	2,740	4
						Switzerland	113	1
						United Kingdom	4,980	4
						United States	609	3
TOTAL	**79,435**	**94**	**TOTAL**	**79,435**	**94**	**TOTAL**	**79,435**	**94**

Table 3: Unique reference entities/daily observations for the merged CDS premia and bond spread denominated in EUR per year, sector and country

Year	Obs.	Unique Reference Entities	Sector	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities		Obs.	Unique Reference Entities
2007	7,499	34	Basic Materials	5,469	9	Australia	1,162	1	Luxembourg	4,016	8
2008	7,323	37	Consumer Goods	14,693	16	Austria	2,949	4	Netherlands	14,174	16
2009	9,762	54	Consumer Services	9,915	18	Belgium	2,871	3	Norway	528	1
2010	13,661	74	Energy	269	2	Bermuda	871	1	Portugal	1,897	4
2011	16,654	81	Financials	30,207	40	Czech Republic	983	1	Slovakia	949	1
2012	18,940	91	Government	7,770	11	Denmark	2,152	2	Slovenia	949	1
2013	23,854	105	Healthcare	2,371	3	Finland	500	1	Spain	8,868	10
2014	17,726	114	Industrials	19,205	23	France	30,255	35	Sweden	4,284	8
TOTAL	**115,419**	**152**	Technology	2,793	4	Germany	20,274	27	Switzerland	2,854	3
			Telecommunications Services	10,689	11	Greece	442	1	Ukraine	187	1
			Utilities	12,038	15	India	146	1	United Kingdom	4,014	6
			TOTAL	**115,419**	**152**	Ireland	949	1	United States	371	1
						Italy	8,774	14	**TOTAL**	**115,419**	**152**

Table 4: Unique reference entities/daily observations for the merged CDS premia and bond spread, where CDS is denominated in EUR and bond is denominated in USD per year, sector and country

Year	**Obs.**	**Unique Reference Entities**	**Sector**	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique ref. entities**		**Obs.**	**Unique ref. entities**
2007	45,220	225	Basic Materials	11,548	27	Australia	784	1	Netherlands	586	1
2008	27,428	226	Consumer Goods	14,126	29	Austria	1,368	1	New Zealand	362	1
2009	19,676	130	Consumer Services	26,336	45	Bermuda	712	2	Norway	1,241	2
2010	12,933	76	Energy	13,670	29	Canada	4,457	10	Philippines	190	1
2011	5,814	31	Financials	15,736	37	Cayman Islands	2,140	5	Portugal	174	1
2012	7,885	36	Government	2,825	5	Chile	222	1	Qatar	276	1
2013	9,005	40	Healthcare	5,718	13	France	2,388	4	Russian Federation	887	1
2014	6,343	38	Industrials	25,043	40	Germany	2,001	1	Singapore	190	1
TOTAL	**134,304**	**269**	Technology	4,335	11	Hong Kong	229	1	Supra National	173	1
			Telecommunications Services	8,540	14	India	892	3	Sweden	1,903	1
			Utilities	6,427	19	Iraq	949	1	Ukraine	697	1
			TOTAL	**134,304**	**269**	Jamaica	275	1	United Arab Emirates	872	1
						Liberia	1,282	1	United Kingdom	17,870	19
						Luxembourg	1,837	4	United States	88,042	198
						Malaysia	574	1	Venezuela	541	1
						Mexico	190	1	**TOTAL**	**134,304**	**269**

2.2 Equity data sample

2.2.1 Equity data for EUR/EUR/USD pairs

In this section the data for equity prices for CDS premia sample denominated in EUR and bond yield spread in EUR and USD (pair EUR/EUR and pair EUR/USD) is described. For each reference entity of the merged sample of CDS premia denominated in EUR and bond yield spread denominated in EUR and USD, we have collected equity prices for each trading day of the sample. Table 5 summarizes the number of daily observations and unique reference entities by years and sectors over the whole time period.

Table 5: Unique reference entities/daily observations of equity data for pairs EUR/EUR/USD per year and sector

Year	**Observations**	**Unique Reference Entities**	**Sector**	**Observations**	**Unique Reference entities**
2007	69,138	268	Basic Materials	52,680	22
2008	69,954	267	Consumer Goods	83,978	35
2009	70,144	271	Consumer Services	109,131	45
2010	70,731	271	Energy	59,476	25
2011	71,445	276	Financials	112,332	47
2012	72,449	278	Government	3,633	2
2013	72,803	280	Healthcare	39,824	16
2014	73,265	281	Industrials	92,305	38
2015	73,613	283	Technology	31,239	13
2016	40,439	285	Telecommunications Services	39,899	16
TOTAL	**683,981**	**285**	Utilities	59,484	26
			TOTAL	**683,981**	**285**

The equity prices are collected started from 1st of January 2007 up to 2016. The largest number of daily observations and entities is spotted for 2016 at the end of our time-span and the lowest one- in 2008 during the financial crisis. The number of unique reference entities starts to grow since 2010 up to the end of the time-span. The increase is equal to 14 entities. The whole number of observations collected is equal to 683,981 and 285 reference entities.

Financial and consumer service industries are dominant in the sample while Government and Technology are less presented in the stock market. Financial sector reaches 16.49% of all 285 unique entities of the sample, which is equal to 47 entities and covers 112,332 daily observations. The share of the Government and Technology sector is small and equal to 0.7% and 5.6% respectively.

Concerning country and region diversification the largest number of unique reference entities and daily observations for equity market is collected from the United States, France, Germany and the United Kingdom. (Table 6) The United Kingdom market provides data for 17 entities out of 285, which is 5.96% of the market and covers 41,623 daily observations. The United States is presented by 155 unique reference entities, while France and Germany by 27 and 17 respectively. In contrast for Belgium, Chez Republic, Finland, Greece, Hong Kong, India, Republic of Korea, Liberia, Malaysia, Mexico, New Zealand, Norway, Philippines and Russian Federation provide data only for 1 entity.

Table 6: Unique reference entities/daily observations of equity data for pairs EUR/EUR/USD per country

Countries	Observations	Unique Reference Entities
Australia	4,993	2
Austria	7,488	3
Belgium	2,494	1
Bermuda	7,486	3
Canada	14,956	6
Cayman Islands	4,992	2
Czech Republic	2,491	1
Denmark	2,527	2
Finland	2,493	1
France	64,534	27
Germany	38,528	17
Greece	2,494	1
Hong Kong	2,494	1
India	7,464	3
Israel	2,497	1
Italy	19,867	8
Korea (Republic of)	2,493	1
Liberia	2,496	1
Luxembourg	4,776	2
Malaysia	2,497	1
Mexico	2,494	1
Netherlands	21,375	9
New Zealand	2,475	1
Norway	2,497	1
Philippines	2,497	1
Portugal	4,964	2
Russian Federation	2,497	1
Spain	16,165	7
Sweden	7,072	4
Switzerland	4,972	2

United Kingdom	41,623	17
United States	375,290	155
TOTAL	**683,981**	**285**

Table 7 confirms that equity market is prevalent in Europe in Financial Sector and North America for Consumer Service.

Table 7: Daily observations of equity data for pairs EUR/EUR/USD per region/sector

Region/Sector	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Government	Healthcare	Industrials	Technology	Telecommunications Services	Utilities	**TOTAL**
Africa	-	-	2,496	-	-	-	-	-	-	-	-	**2,496**
Asia	-	-	2,494	2,493	-	-	-	-	-	4,994	-	**9,981**
E.Eur	-	-	-	-	-	2,497	-	-	-	-	2,491	**4,988**
Europe	12,825	35,225	26,309	7,488	62,777	-	4,994	37,463	9,930	24,918	21,940	**243,869**
India	2,497	-	-	-	-	-	2,470	-	-	-	2,497	**7,464**
Lat.Amer	-	-	2,494	-	-	-	-	-	-	-	-	**2,494**
MiddleEast	-	-	-	-	-	-	2,497	-	-	-	-	**2,497**
N.Amer	37,358	46,278	75,338	47,000	49,555	1,136	29,863	52,346	18,812	7,490	32,556	**397,732**
Oceania	-	2,475	-	-	-	-	-	2,496	-	2,497	-	**7,468**
OffShore	-	-	-	2,495	-	-	-	-	2,497	-	-	**4,992**
Grand Total												**683,981**

In particular, in Europe stock is traded mainly in the financial sector and is represented by 62,777 observations. The North America region with 49,555 observations takes the second place.

Moreover, for the equity market, Table 8 provides the descriptive statistics for currency. The most popular currencies are EUR and the US dollars with 76 and 158 unique reference entities respectively.

Table 8: Unique reference entities/daily observations of equity data for pairs EUR/EUR/USD per currency

Currency	Observations	Unique Reference Entities
£	36,861	15
A$	9,983	4
C$	12,459	5
CK	2,491	1
DK	2,527	2
E	181,016	76
I£	2,497	1
IR	16,090	7
K$	2,494	1
M$	2,497	1
MP	2,494	1
NK	2,497	1
PP	2,497	1
R	2,494	1
RI	2,495	1
S$	4,986	2
SF	2,795	2
SK	4,994	2
U$	382,351	158
UR	2,497	1
Y	2,491	1
Z$	2,475	1
TOTAL	**683,981**	**285**

2.2.1 Equity data for GBP/GBP/EUR pairs

In this section, equity prices are collected for a merged sample of and CDS premia denominated in *British Pounds* and bond yield spread in GBP and EUR (pair GBP/GBP and pair GBP/EUR). In this section, the data is considered and analysed by countries, regions, and sectors. The data is also collected for the time period starting from 2007 up to 2016.

As it can be seen from Table 9 there are 484,565 daily observations for 205 reference entities for the whole period. Data availability stipulates the size of the equity sample. As equity prices are matched with CDS premia and bond spread, Datastream does not dispose of all available bonds for the CDS-bond sample.

Table 9: Unique reference entities/daily observations of equity data for pairs GBP/GBP/EUR per year and sector

Years	Observations	Unique Reference Entities	Industry	Observations	Unique Reference Entities
2007	50,879	196	Basic Materials	29,849	13
2008	51,484	197	Consumer Goods	43,872	19
2009	51,417	197	Consumer Services	84,524	36
2010	51,829	200	Energy	12,117	5
2011	51,983	200	Financials	172,135	72
2012	52,200	200	Healthcare	12,118	5
2013	52,627	204	Industrials	46,065	19
2014	53,244	204	Technology	4,842	2
2015	53,366	205	Telecommunications Services	35,369	16
2016	15,536	205	Utilities	43,674	18
TOTAL	**484,565**	**205**	**TOTAL**	**484,565**	**205**

The highest number of observations and entities is spotted in 2015 and 2016. The lowest number was observed in 2007. The quantity of reference entities included in the sample is 196, 197 and 197 for 2007, 2008 and 2009, which includes 50,879, 51,484 and 51,417 daily observations, respectively. From 2010, 2011 and 2012 the number of reference equities is higher and equal to 200. The number of unique reference entities became to be equal to 204 in 2013 and 2014 and increase by 1 during 2015 and 2016. Equities are traded mostly at financial and consumer services markets. The financial sector is presented by 72 reference entities and consumer services by 36 reference entities. Comparing to equity market of EURO sample the dispersion of observation across sectors is analogous. Government and Technology sectors are represented only by 2 and 13 reference entities respectively.

Considering country analysis (Table 10) equities are mostly located in the United Kingdom and European countries. The UK market has 63 reference entities with 152,580 observations, and the European markets have 32 and 28 for French and German markets respectably.

Table 10: Unique reference entities/daily observations of equity data for pairs GBP/GBP/EUR per country

Countries	**Observations**	**Unique ref. entities**
Australia	4,853	2
Austria	7,266	3
Belgium	7,266	3
Denmark	4,849	2
Finland	4,843	2
France	75,643	32
Germany	62,292	28
Greece	4,844	2
Ireland	7,271	3
Italy	31,514	13
Japan	2,422	1
Jersey	2,429	1
Luxembourg	5,443	3
Netherlands	28,635	13
Norway	7,275	3
Portugal	9,686	4
Spain	12,109	5
Sweden	14,539	6
Switzerland	2,421	1
United Kingdom	152,580	63
United States	36,385	15
TOTAL	**484,565**	**205**

Considering industry region correspondence it is evident that financial and consumer service are prevalent in Europe, however, in American region prevails mostly financial sector and Consumer service and Industrials are presented mostly in Europe (Table 11). The number of observations presented in Financial Sector in Europe is equal to 147,883 daily observations. Moreover, among 4 markets of Asia, Europe, North America and Oceania Europe and North America is mostly illustrative.

Table 11: Unique reference entities/daily observations of equity data for pairs GBP/GBP/EUR per region and sector

Region/Sector	Basic Materials	Consumer Goods	Consumer Services	Energy	Financials	Healthcare	Industrials	Technology	Telecommunications Services	Utilities	**Unique Reference Entities**	**TOTAL**
Asia	-	-	-	-	2,422	-	-	-	-	-	1	2,422
Europe	27,427	36,590	79,664	12,117	147,883	9,696	43,643	4,842	35,369	43,674	187	440,905
N.Amer	2,422	7,282	4,860	-	16,977	2,422	2,422	-	-	-	15	36,385
Oceania	-	-	-	-	4,853	-	-	-	-	-	2	4,853
Grand Total	29,849	43,872	84,524	12,117	172,135	12,118	46,065	4,842	35,369	43,674	**205**	**484,565**

Finally, currency descriptive statistics report EUR and GBP as the most popular currencies in line with the US dollar that are equal to 234,041, 140,822 and 53,530 observations respectively. (Table 12)

Table 12: Unique reference entities/daily observations of equity data for pairs GBP/GBP/EUR per currency

Currency	Observations	Unique Reference Entities
£	140,822	58
A$	4,853	2
C	5,651	3
CX	2,038	1
DK	2,422	1
E	234,041	99
IR	4,844	2
K$	4,858	2
M$	2,427	1
NK	4,853	2
S$	2,422	1
SF	4,843	2
SK	14,539	6
U$	53,530	24
Y	2,422	1
TOTAL	**484,565**	**205**

2.3 Merging data for EUR/EUR/USD pairs

In this section the final sample of merged CDS premia denominated in EURO and bond yield spread denominated in EUR and USD will be matched with appropriate equity prices denominated GBP, EURO, Canadian dollar and USD. The matching approach for equity prices is more straightforward comparing to the matching approach of CDS premia and bond yield spread (remaining maturity approach). Basically, for each daily observation and each reference entity an appropriate daily equity price for a particular unique reference entity is searched and matched to an appropriate daily observation of CDS premia and bond spread yield. There are only reference entities with observations, the quantity of which exceeds 100 consecutive trading days, included in the sample. The sample includes assembly of data, which covers different industries, countries, and timespans. The initial sample consists of equity prices that are going to be recalculated into equity return before the analysis. In this section descriptive statistic will be presented for pair EUR/EUR/USD, which is divided by the currency of bond yield matched with CDS premia that are EUR and USD. The subsamples will be defined as pair EUR/EUR and pair EUR/USD and matched with equity sample with returns denominated in EUR, GBP, USD and Canadian Dollar.

Tables 13 and 14 report the number of observations and entities over the whole period of research by year, sector, country and equity currency for pairs EUR/EUR and EUR/USD respectively. There are 72 reference entities with 58,941 observations for the whole time period for pairs EUR/EUR. For pairs EUR/USD there are 161 reference entities with 84,226 observations for the whole time period. It can be concluded that pair EUR/USD is presented by a higher number of observations and unique reference entities. Moreover, the number of observations and unique reference entities accelerate with the time for pairs EUR/EUR and decelerate in most of the cases for pairs EUR/USD.

Regarding the comparison between the samples denominated in different currencies in Euro sample a number of equities traded in the financial sector is the highest and higher by 2 unique reference entities observations comparing to USD market and it is equal to 16,788 observations comparing to 8,333 observations for USD sample. Consumer service and Industrials are the most prevalent sectors for the sub-sample of USD currency (pairs EUR/USD) and include 33 and 25 reference entities respectively out of 161.

Country statistics show that French and German equity market for pairs EUR/EUR is better established comparing to pairs EUR/USD, where the most prevalent markets are the UK and the US ones. Moreover, Germany and France are among the most prevalent countries with 22 and 14 reference entities out of 72 for pairs EUR/EUR. The UK market is presented less for the pairs EUR/EUR (4 reference entities) while the US market is not presented at all in the sample. However, for pairs EUR/USD there are 134 unique reference entities for the US market and 14 for the UK out of 162.

For pair EUR/EUR Euro currency is presented by 64 reference entities out of 72 pairs EUR/USD consists of 136 unique reference entities for the USD currency out of 172.

Table 13: Unique reference entities/daily observations of equity data for pairs EUR/EUR per year, sector country and currency

Year	Obs.	Unique Reference Entities	Sector	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities	Currency	Obs.	Unique ref. entities
2007	2,928	13	Basic Materials	2,945	5	Austria	2,000	3	£	1,971	4
2008	3,199	14	Consumer Goods	10,440	11	Belgium	1,997	1	E	52,428	64
2009	3,907	20	Consumer Services	4,116	8	Finland	500	1	U$	4,542	4
2010	5,975	31	Energy	119	1	France	20,081	22	**TOTAL**	**58,941**	**72**
2011	9,172	42	Financials	16,788	20	Germany	9,594	14			
2012	10,708	50	Healthcare	819	1	Greece	442	1			
2013	13,324	57	Industrials	6,709	10	Italy	5,872	8			
2014	9,709	60	Technology	2,535	3	Luxembourg	1,320	2			
TOTAL	**58,941**	**72**	Telecommunications Services	6,755	6	Netherlands	9,119	7			
			Utilities	7,715	7	Portugal	426	2			
			TOTAL	**58,941**	**72**	Spain	4,657	6			
						Switzerland	962	1			
						United Kingdom	1,971	4			
						TOTAL	**58,941**	**72**			

Table 14: Unique reference entities/daily observations of equity data for pairs EUR/USD per year, sector country and currency

Year	**Obs.**	**Unique Reference Entities**	**Industry**	**Obs.**	**Unique Reference Entities**	**Countries**	**Obs.**	**Unique Reference Entities**	**Currency**	**Obs.**	**Unique ref. entities**
2007	27,398	133	Basic Materials	5,494	14	Canada	2,737	5	£	8,056	12
2008	16,585	135	Consumer Goods	9,999	20	Cayman Islands	577	2	C$	2,737	5
2009	12,359	84	Consumer Services	21,205	33	France	2,124	2	E	8,045	8
2010	7,884	46	Energy	9,847	19	Germany	2,001	1	U$	656,428	136
2011	3,851	21	Financials	8,333	18	Liberia	1,282	1	**TOTAL**	**84,266**	**161**
2012	5,417	25	Healthcare	3,923	8	Luxembourg	299	1			
2013	6,472	29	Industrials	14,913	25	Sweden	1,311	1			
2014	4,490	27	Technology	3,579	7	United Kingdom	11,113	14			
TOTAL	**84,226**	**161**	Telecommunications Services	3,780	6	United States	62,822	134			
			Utilities	3,193	11	**TOTAL**	**84,266**	**161**			
			TOTAL	**84,266**	**161**						

2.4 Merging data for GBP/GBP/EUR pairs

In this section the final sample of merged CDS premia denominated in GBP and bond yield spread denominated in GBP and EUR will be matched with appropriate equity prices denominated GBP, EUR, and USD. The matching approach for equity prices is more straightforward comparing to the matching approach of CDS premia and bond yield spread (remaining maturity approach). Basically, for each daily observation and each equity entity an appropriate daily equity price for a particular unique reference entity is searched and matched with an appropriate daily observation of CDS premia and bond yield spread. There are only reference entities with observations, the quantity of which exceeds 100 consecutive trading days, included in the sample. The sample includes assembly of data, which covers different industries, countries, and timespans. The initial sample consists of equity prices that are going to be recalculated into equity return before the analysis. In this section descriptive statistic will be presented for a sample of CDS premia denominated in GBP currency, which is divided by the currency of bond yield spread that are GBP (pair GBP/GBP) and EUR (GBP/EUR).

Tables 15 and 16 report the number of observations and entities by year, sector, country and equity currency over the whole period of research. There are 73 reference entities with 91,035 observations for the whole time period for pairs GBP/GBP. For pairs GBP/EUR there are 64 reference entities with 53,959 observations for the whole time period. It can be concluded that pair GBP/GBP is presented by a higher number of observations and unique reference entities. Moreover, the number of observations and unique reference entities accelerate with the time for the pairs. However, the number of unique reference entities and observations varies across the whole time period with the highest number in 2010 equal to 56 and the lowest one in 2007 equal to 43.

Regarding industry analysis both pairs GBP/GBP and GBP/EUR report the highest number of observations and unique reference entities for Consumer service and financial sector, which is equal to 18 and 19 entities, 20,173 and 22,460 observations for pair GBP/GBP and 12 and 18 entities, 9,505 and 16,266 observations for pair GBP/EUR for respectively for each currency. Basic material and healthcare are presented least for pair GBP/GBP and pair GBP/EUR.

Country statistics show that in the UK equity market for pair GBP/GBP is better established comparing to pair GBP/EUR, where the most prevalent markets are German and French ones. Moreover, Germany and France are among the most prevalent countries with 15 and 21 reference entities out of 64. The UK market is presented less for GBP/EUR pairs (3 reference entities). However, for pair GBP/GBP there are 48 unique reference entities the UK market out of 73.

For pair GBP/GBP GBP currency is presented by 45 reference entities out of 73, which is equal to 62%. Pairs GBP/EUR consists of 55 unique reference entities for the EUR currency out of 64, which is equal to 86%.

Table 15: Unique reference entities/daily observations of equity data for pairs GBP/GBP per year, sector, country and currency

Year	Obs.	Unique Reference Entities	Sector	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities	Currency	Obs.	Unique Reference Entities
2007	9,510	43	Basic Materials	2,804	2	France	6,058	4	£	54,501	45
2008	11,143	45	Consumer Goods	5,489	5	Germany	4,232	3	E	24,865	16
2009	11,471	53	Consumer Services	20,173	18	Ireland	563	1	U$	11,669	12
2010	12,252	56	Financials	22,460	19	Italy	9,360	5	**TOTAL**	**91,035**	**73**
2011	11,283	48	Healthcare	3,501	2	Jersey	491	1			
2012	12,500	53	Industrials	11,111	8	Netherlands	6,228	4			
2013	13,740	54	Telecommunications Services	10,108	7	United Kingdom	58,536	48			
2014	9,136	55	Utilities	15,389	12	United States	5,567	7			
TOTAL	**91,035**	**73**	**TOTAL**	**91,035**	**73**	**TOTAL**	**91,035**	**73**			

Table 16: Unique reference entities/daily observations of equity data for pairs GBP/EUR per year, sector, country and currency

Year	Obs.	Unique Reference Entities	Sector	Obs.	Unique Reference Entities	Countries	Obs.	Unique Reference Entities	Currency	Obs.	Unique Reference Entities
2007	2,721	12	Basic Materials	5,623	6	Austria	413	1	£	6,616	5
2008	3,271	17	Consumer Goods	6,479	8	Belgium	1,563	1	E	45,963	55
2009	4,998	29	Consumer Services	9,505	12	Finland	1,478	1	U$	1,380	4
2010	7,019	34	Energy	1,759	2	France	14,852	21	**TOTAL**	**53,959**	**64**
2011	8,035	39	Financials	16,266	18	Germany	10,892	15			
2012	9,383	39	Healthcare	681	1	Greece	229	1			
2013	10,462	50	Industrials	6,124	8	Ireland	1,280	2			
2014	8,070	50	Technology	1,292	2	Italy	6,140	5			
TOTAL	**53,959**	**64**	Telecommunications Services	2,014	4	Netherlands	6,650	7			
			Utilities	4,216	3	Norway	749	1			
			TOTAL	**53,959**	**64**	Spain	5,019	4			
						United Kingdom	4,439	3			
						United States	255	2			
						TOTAL	**53,959**	**64**			

3. Methodology

In this section the methodology used in the current study is introduced. The main focus is to analyse the relationship between three markets of CDS premia, bond yield spread and equity return. Different tests presented in previous papers will be used to study whether CDS premia lead lags equity return or the relationship inverses or whether lagged bond yield spread leads equity return or the relationship inverses.

3.1 Causality testing of CDS premia, bond yield spread and equity return

Granger causality approach aims to test how events in the past can cause events to happen today or in the future. The test is used to examine whether CDS premia "*causes*" equity return or vice-versa. Or whether bond yield spread causes equity return or vice-versa.

As in this paper three markets are analysed, hence two tests will be run to assess the causality link between the markets. First, a test whether CDS premia causes equity return will be run. Second, a test whether bond yield spread causes equity return will be applied. If a time series is a stationary process, the test is performed using the level values of two variables. If the variables are non-stationary, then the test is done using first differences or higher. In the current sample the stationarity is found for first difference of time series. Hence the first difference time series is tested for this "causality" purpose by employing Granger causality.

First, the test whether equity return causes CDS premia or vice versa leads to the null hypothesis 'The equity return do not Granger causes CDS premia'.

H_0= The equity return do not Granger causes CDS premia
H_1= The CDS premia do not Granger causes equity return (1)

$$CDS_t=\sum_{j=1}^{k} \alpha_i \, ER_{t-j}+\sum_{j=1}^{k} \beta_j \, CDS_{t-j}+u_{1t}$$

$$ER_t=\sum_{j=1}^{k} \lambda_i \, ER_{t-j}+\sum_{j=1}^{k} \delta_j \, CDS_{t-j}+u_{2t} \quad (2)$$

CDS refers to the premia changes; *ER* refers to equity return. Where u_1 and u_2 are uncorrelated prediction errors. In the equation (2) j is the number of lags. After the null hypothesis that H_0 is tested and if the F-statistic exceeds the 10% critical value, the null hypothesis of absence of Granger Causality cannot be rejected. If statistics is less than 10% critical value the null hypothesis is rejected.

Second, the test whether equity return causes bond yield spread or vice versa leads to the null hypothesis ‘The equity return do not Granger causes bond yield spread’.

H_0= The equity return do not Granger causes bond yield spread
H_1= The bond yield spread do not Granger causes equity return (3)

$$BYS_t=\sum_{j=1}^{k} \alpha_i \, ER_{t-j}+\sum_{j=1}^{k} \beta_j \, BYS_{t-j}+u_{1t}$$

$$ER_t=\sum_{j=1}^{k} \lambda_i \, ER_{t-j}+\sum_{j=1}^{k} \delta_j \, BYS_{t-j}+u_{2t} \quad (4)$$

BYS refers to the bond yield spread changes; *ER* refers to equity return. Where u_1 and u_2 are uncorrelated prediction errors. In the equation (4) *j* is the number of lags. After the null hypothesis that H_0 is tested and if the F-statistic exceeds the 10% critical value, the null hypothesis of absence of Granger Causality cannot be rejected. If statistics is less than 10% critical value the null hypothesis is rejected.

3.2 Regression analysis

To investigate the relationship between CDS premia, bond spread and equity return panel data regression model to assess the magnitude of the marginal effect. For the model data is specified as panel data also known as longitudinal data or in some disciplines as cross-sectional time series when there is an explicit time component. Panel datasets have the form x_{it}, where x_{it} is a vector of observations for unit i and time t.

$$CDS_{i,t} = \alpha + \beta Bond_{i,t-1} + \gamma Equity_{i,t-1} + \delta Market\ value_{i,t} + \theta Market\ return_t + \lambda Market\ volitality_t + \varphi iTraxx_t + \varepsilon_{it}$$

$$Bond_{i,t} =$$

$$\alpha + \beta CDS_{i,t-1} + \gamma Equity_{i,t-1} + \delta Market\ value_{i,t} + \theta Market\ return_t + \lambda Market\ volitality_t + \varphi iTraxx_t + \varepsilon_{i,t}$$

$$Equity_{i,t} = \alpha + \beta CDS_{i,t-1} + \delta Market\ value_i + \theta Market\ return_t + \lambda Market\ volitality_t + \varphi iTraxx_t + \varepsilon_{i,t}$$

$$Equity_{i,t} = \alpha + \beta Bond_{i,t-1} + \delta Market\ value_i + \theta Market\ return_t + \lambda Market\ volitality_t + \varphi iTraxx_t + \varepsilon_{i,t}$$

(5)

In equation (5) $CDS_{i,t}$, $Bond_{i,t}$ and $Equity_{i,t}$ are CDS premia, bond yield spread and equity return (dependent variable) and $CDS_{i,t-1}$, $Bond_{i,t-1}$ and $Equity_{i,t-1}$ are CDS premia, bond yield spread and equity return (explanatory variable) and are one day lagged. The dependent variable is determined by two components: by non-random/structural component α or coefficient or intercept, that measures the value where the regression line crosses y-axis and β ,γ, δ, θ, λ and φ or coefficient or slope that measures the steepness of the regressing line. The second component is the random component called disturbance or error term epsilon i.

Thus, based on the equation (5) it is possible to conclude how dependent variable changes when independent variable increases or decreases by 1 basis point (bp.) and to conclude how the variables are correlated. Subsequently, the model is applied to daily time-series from the two currency markets (GBP, EUR). Moreover, the equation includes explanatory variables: market value, market return, market volatility, iTraxx. The same approach is applied to the other dependent and independent variables. All models are tested for 1, and 10 percent significance level for the two sets of currency pairs: GBP and EUR. Moreover, the data is divided into two sub-periods. However, since it is not obvious how to split the data for the periods during and after the financial crisis a Zivot-Andrews unit-root test (1992) is employed. The breakpoint is defined by applying the test. Zivot Andrews has a null hypothesis of a unit root process with drift that excludes exogenous structural change.

If the null hypothesis is rejected in favour of a trend stationary process that allows for a one-time break in the level. According to Waheed, Alam and Ghauri (2006), the null hypothesis can be described by 3 equations. The models describe, first, one-time change in the level of the series, second, which allows for a one-time change in the slope of the trend function and, third, which combines one-time changes in the level and the slope of the trend function of the series.

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \gamma DU_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DT_t + \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = c + \propto y_{t-1} + \beta t + \theta DU_t + \gamma DT_t \sum_{j=1}^{k} d_j \, \Delta y_{t-j} + \varepsilon_t$$

(6)

DU_t is an indicator dummy variable for a mean shift occurring at each possible break-date, while DT_t is corresponding trend shift variable.

3.3 Variable description

In this sub-section set of variables considered in the study will be described in detail. In particular, we are going to discuss the dependent variable, the main explanatory variables and explanatory variable. A clear definition of each of them is provided.

3.3.1 Dependent variables

This paper analysis consists of three variables, which represent derivative, debt and equity markets and are CDS premia, bond yield spread and equity return respectively. A significant body of literature uses the first difference of CDS and bond yield spread. (Esen, Zeren and Simdi, 2015 and Eyssell, Fung and Zhang, 2013) Hence, following previous studies, CDS and bond spread is calculated as the first difference between current and previous day. There is no need to first difference equity return as it is the relative magnitude of equity price.

3.3.2 Independent variables

The independent variables according to the defined methodology are: one-day lagged CDS premia, one-day lagged bond yield spread and one-day lagged equity return. The choice of independent variables is based on the assumption that change in one market is determined by the change in another market on a previous day. Hence, there are three equations with three dependent variables determined above and independent variables for each of them. First, CDS premia is explained by lagged bond yield spread and equity return. Second, bond yield spread is regressed against lagged CDS premia and equity return. Third, equity return is explained by lagged CDS premia and bond yield spread.

3.3.3 Explanatory variable

In this subsection variables and their theoretical relation to CDS, bond spread and equity return changes are described. The variables are divided into two groups. The first group is firm specific variables: market value and implied rating. The second one is market variable: market return, market volatility and CDS index.

3.3.3.1 Firm-specific variables

Implied rating: Default probability is a key risk element of the debt market. High probability of default decreases the rating of an entity. Hence, a company's rating determines the soundness of the company and the risk to invest in its securities. Hence, the higher the rating the lower is the spread. In the current study rating is a binary variable equal to one if the bond is Investment Grade (AAA, AA-high quality; A and BBB-medium quality) and zero otherwise (junk bonds).

Market value: A company's market value is a good indication of investors' perceptions of its business prospects. Market value represents market capitalisation and is determined by a number of securities by its price. The data is collected for each entity and matched on a daily basis for the period of 2007-2014.

3.3.3.2 Market factors

Market return: The business climate affects companies' performance. Market indexes can be good indicators for investors. For our analysis we collected data for 4 major indexes of the UK (FTSE 100), US (S&P 500), Canada (S&P/TSX 60) and Europe (STOXX EUROPE 60). Market return is adjusted by currency.

Market volatility (VIX): For measuring market volatility, we follow Collin-Dufrense et al. (2001) and use the VIX index, which represents option-implied volatility based on S&P 500 index options for the US currency, FTSE 100 for Sterling and VSTOXX for Euro currency. As with firm-specific volatility, we expect a positive relation between market volatility and CDS spreads.

CDS index: A benchmark for the CDS market is determined by the iTraxx index. For the current paper we employ ITraxx Europe with 5 year maturity.

4. Results

This section summarises the empirical results based on the discussion in the methodology section. First, Granger Causality approach is applied to analyse first, whether CDS premia causes equity return or whether the relationship is the inverse and second, whether bond yield spread causes equity return or whether the relationship is inverse. Finally, regression analysis is conducted to analyse how bond spread changes with the change of CDS premia interrelated with equity price movements.

4.1 Testing for Granger Causality

After the time series of CDS premia is found to be stationary for both levels and first difference and stationarity also confirmed to be stronger after the series is first differenced the existence of temporal relationship is examined.[19] First difference approach calculates the difference between CDS premia of day t and the previous day (t-1). It is concluded that CDS premia leads to price discovery. In the current paper the relationship between CDS premia and equity return is examined. The question what leads equity return or bond yield spread is addressed. Granger causality method is employed to infer the relationship between CDS and bond.

To analyse the price discovery process in the CDS, bond, and equity markets Granger Causality test is employed. The analysis is essential for the research because it helps to educe the causality link between different markets and can be applied to pairs of various financial securities. Indeed, Granger Causality plays an important role in determining the movements in the corporate bond and CDS prices (e.g. Forte and Pena, 2009). The Granger causality makes possible to test for different lags. In the study causality for 1, 3 and 5 lag days is performed. The results are tended to indicate the relationship between CDS and equity transactions and bond and equity transactions for defined lags. Financial academics employ Granger Causality test with different lags. For example, O'Kane (2012) performs tests for 1 lag and Palladini and Porters (2011) for 2 lags. However, the maximum of 5 lags is optimum choice, as more than 10 lags were never found to be a significant choice and no results are based

[19] Data is found to be stationary for both levels and first difference by Augmented Dickey–Fuller test. Data found to be stationary in the most cases for first difference and for neglect number of cases for levels for

on a lag number greater than 10 (Berggren and Mattsson, 2008). However, Garcia, Valle and Marin (2014) test causality for up to 20 lags. Moreover, the pioneers in researching of the interrelation between the three markets Chan-Lau and Kim (2004) employ 1, 5, 10, and 20 business day lags, so that price discovery up to a one-month horizon could be tested for each market combination. In the current research price discovery can be tested fortnightly.

The analysis is applied to four independent subsamples determined by currency criteria of CDS and bond spreads. The first subsample is defined for CDS premia determined in EUR, bond yield spread in EUR, and equity prices in all remained currencies of the sample defined in the Sample section. (hereafter pairs EUR/EUR). The second subsample is defined for CDS premia determined in EUR, bond yield spread in USD, and equity prices in all remained currencies of the sample defined in the Sample section. (Hereafter pairs EUR/USD). The third subsample is defined for CDS premia determined in GBP, bond yield spread in GBP, and equity prices in all remained currencies of the sample defined in the Sample section. (hereafter pairs GBP/GBP). The fourth subsample is defined for CDS premia determined in GBP, bond yield spread in EUR, and equity prices in all remained currencies of the sample defined in the Sample section. (hereafter pairs GBP/EUR).

Overall, 137 pairs of CDS premia denominated in GBP and 233 pairs of CDS premia denominated in EUR are tested for 10 percent level of significance. According to Garcia, Valle and Marin (2014), there can be 4 possible outcomes: market ‘a’ causes market ‘b’, market ‘b’ causes market ‘a’, feedback between the both markets and causality between them does not exist. The possible outcomes are acknowledged by various researches. (Chan-Lau and Kim, 2004, Delis and Mylonidis, 2011, Li and Huang, 2011, O'Kane, 2012, Aktuğ, 2015 and Fontana and Scheicher, 2016)

4.1.1. CDS equity relationship EUR/EUR and EUR/USD pairs

In this section the Granger Causality is run for the data of first difference time series of CDS premia and equity returns.

Table 17: Granger causality of the CDS-equity relationship (EUR/EUR and EUR/USD)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of CDS premia and equity return. The results show the summary of outcomes when the null hypothesis is rejected.

EUR/EUR			EUR/USD		
Lags (days)	Equity Return do not cause CDS Spreads	CDS Spread do not cause Equity Return	Lags (days)	Equity Return do not cause CDS Spreads	CDS Spread do not cause Equity Return
1	28/38.89%	13/18.06%	1	74/45.96%	47/29.19%
3	13/18.06%	15/20.83%	3	25/15.53%	22/13.66%
5	15/20.83%	15/20.83%	5	36/22.36%	24/14.91%

For pairs EUR/EUR one-lag analysis shows that only in 13 cases out of 72 we can reject the null hypothesis that CDS premia does not Granger causes equity return, when in 28 cases out of 72 it is possible to reject the null hypothesis that equity return does not cause CDS premia and accept the alternative hypothesis that equity return causes CDS premia.

If the null hypothesis is rejected, equity return is determined to lead CDS premia. In 4 cases both CDS premia and equity return leads to price discovery, and in 31 cases causality between equity return and CDS premia does not exist. Overall, for 38.89% the hypothesis that equity return does not cause CDS premia is rejected for a lag of 1 day. For 3 and 5 days the hypothesis that equity return does not cause CDS premia is rejected at 18.06% and 20.83% level. Moreover, for lag of 3 days only in 15 pairs CDS premia causes equity return. In 1 case both lead to price discovery. The number of cases increases to 41 for the relationship when none of the instruments causes each other. In 5-lag the both null hypothesis can be rejected in 15 cases, while there is feedback between CDS and equity return and the both assets lead in 6 cases and no causality is observed in 40 cases. Hence, it can be concluded that for a one-day lag relationship it is confirmed that equity return leads CDS premia, while for 3 and 5 day lags the relationship is controversial and shows not as strong lead-lag relationship as 1-day lag analysis.

For pairs EUR/USD one-lag analysis shows that in 74 cases out of 161 we can reject the null hypothesis that equity return does not Granger causes CDS premia, when only in 47 cases out of 161 it is possible to reject the null hypothesis that CDS premia does not cause equity return and accept the alternative hypothesis that CDS premia causes equity return. Both assets lead in 4 cases out of 161, and in 117 cases causality between equity return and CDS premia does not exist. Overall, for 45.96% the hypothesis that equity return does not cause CDS premia is rejected for a lag of 1 day.

For 3 and 5 days the hypothesis that equity return does not cause CDS premia is rejected at 15.53% and 22.36%. However, for a lag of 3 and 5 days the null hypothesis that CDS premia does not cause equity return is rejected in the less number of cases. For 3 day lag in 4 cases both lead to price discovery. The number cases growths to 117 when none of the instruments causes each other. In 5-lag analysis equity return leads to price discovery in 36 cases and CDS premia causes equity return in 24 cases, while there is feedback between CDS and equity return in leading in 4 cases and no causality is observed in 104 cases. Hence, the conclusion can be drawn that for one-day lag relationship it is clearly confirmed that equity return tends to lead CDS premia, while for 3 and 5 day lags the relationship is controversial and shows not as strong lead-lag relationship as 1-day lag analysis.

Comparing to previous empirical papers the results overlap with the current results. Chan-Lau and Kim (2004) assess CDS equity relationship for Mexico, Colombia, Brazil, The Philippines, Russia, Turkey and Venezuela for the period March 19, 2001 through May 29, 2003. For purposes of cross-country comparisons, country bond and equity indexes are used.

It's concluded that for Brazil, Colombia, Mexico and Venezuela the null-hypothesis that CDS premia does not cause equity price can be rejected for 1 and 5-day lags.

While for 1 and 5 day lags the null hypothesis that equity price does not cause CDS spread in Brazil and the Philippines for 1-day lag and Russia and Turkey for 5-day lags is rejected. Hence it is possible to accept the alternative hypothesis that CDS spreads cause equity prices and equity prices cause CDS spreads respectively. Overall, the results are mixed and it is difficult to conclude that one particular market dominates the price discovery process. However, for the current study if the rejection of one null hypothesis is considered for 1-day lag it is possible to conclude that the number of cases where equity returns do not cause CDS premia can be rejected with higher frequency. Fonseca and Gottschalk (2015) confirm that for the sample comprising data from 14/09/2007 to 31/12/2010 of Asia-Pacific region at the firm level stock returns leads CDS premia and index level of volatility. However, at the index level volatility and CDS spreads are equally important. For lags 1 to 2 of stock returns Granger cause changes in CDS spreads (realized volatility) in 19% (15%) of the cases. These findings become much stronger if a 5% significance level is adopted. The results are in line with Norden and Weber (2009), who find that stock returns lead CDS as well as bond spread changes. It is concluded that for lags 1–5 of stock returns Granger cause CDS spread changes at 39 of 58 firms for s the time period 2 July 1998 to 2 December 2002. For the US market Longstaff et al. (2005) indicate that stock markets and CDS markets led corporate bond markets. Bystrom (2005) analyses the association between the performance of a CDS iTraxx index and stock market returns during the period 2004-2005 and concludes that stock market returns Granger cause CDS spread changes, but the reverse does not occur. (Svec and Peat, 2010) continue that at the index level ASX 200 Index Returns, S&P 500 Index Returns, Changes in CBOE VIX Index and 6 Month Bank Bill Rate cause iTraxx index for the period from January 2006 to December 2009. At the firm level for 2 cases out of 25 changes in company CDS premia cause changes in Australian market index, while in 8 cases out of 25 changes in company CDS premia cause changes to CDS index. Moreover, in 20 cases out of 25 changes in the US index cause changes in the firm specific CDS spread for 5% significance level. Shahzad et al., (2017) conclude that all stock markets Granger cause their CDS counterparts and there is also bidirectional causality for the banking, healthcare and material industries for the period December 14, 2007 to December 31, 2014. Patev et al. (2013) report country-dependent causality stating that for Russia and Poland Index return granger causes the change in CDS spread and variance in CDS is explained by index 40% and 31% respectively. For Hungary, Bulgaria and Romania change in CDS premia granger causes a change in stock market index and the variance in index explained by the CDS spread is 36%, 11% and 27% respectively. Finally, Corzo et al., (2012), who investigate the relationship between the markets in Europe report that for countries with high-risk premiums, the stock market leads the other two markets during 2008 and 2009. In 2010 the countries with low-risk exhibit the CDSs leading the stock market and displaying bidirectional Granger causality in relation with the bond market. The results for 2011 are revealing: for the six countries with more sovereign credit risk, that the leading role of sovereign CDS remains (despite the Greek situation) in relation to both the stock and the bond markets. Report equity for 36 out of 45.

Hence, in summary, equity return leads CDS premia, as in a higher number of cases the null hypothesis that equity return does not cause CDS premia is rejected. Moreover, the relationship is stronger for 1ag of 1 day comparing to 3 and 5 lags analysis.

4.1.2 Bond equity relationship EUR/EUR and EUR/USD pairs

According to the Table 18 for pairs EUR/EUR the number of cases where we can reject the hypothesis that equity Return does not cause bond spreads is equal to 33, which is 45.83% of cases. Bond spread grange causes equity return only in 15 cases out of 72 bond spread causes equity return for a lag of 1 day, while in 28 pairs both CDS and bond lead to price discovery, and no relationship found in 8 cases.

Table 18: Granger causality of the bond-equity relationship (EUR/EUR and EUR/USD)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of bond spread and equity return. The results show the summary of outcomes when the null hypothesis is rejected.

EUR/EUR			EUR/USD		
Lags (days)	Equity Return do not cause Bond Spreads	Bond Spread do not cause Equity Return	Lags (days)	Equity Return do not cause Bond Spreads	Bond Spread do not cause Equity Return
1	33/45.83%	15/20.83%	1	38/23.60%	40/24.84%
3	15/20.83%	10/13.89%	3	29/18.01%	23/14.29%
5	14/19.44%	10/13.89%	5	27/16.77%	23/14.29%

As the number of lags increases the number of cases where equity return causes bond spread slightly changes to 15 for 3 days and 14 for 5 days. However, the number of cases when we can reject the null hypothesis that equity return does not cause bond spread still exceeds the number of cases when we can reject the null hypothesis that bond spread does not cause equity return. For 3 and 5 day lag the second one equals to 10 cases. Hence the hypothesis that equity return does not cause bond spreads is rejected for 20.83% and 19.44% for 3 and 5 days respectively. Both equity return and bond spreads are found to Granger in 4 cases out of 72 for 3 days and 3 cases out of 72 for 5 days. Both hypotheses are not rejected, and hence, in 3 and 5 lags analysis equity return does not Granger bond spread, and bond spread does not Granger equity return as well in 47 cases. Thus equity return leads in more cases for a lag of 1 day comparing to 3 and 5 example. Hence for bonds denominated in EUR currency equity return lags bond spread earlier in more cases. This means that in a higher number of cases equity return reacts to the flow information faster than the bond spread.

For pairs EUR/USD for 1-day lag the null hypothesis that equity return does not cause bond spread is rejected for 23.60% comparing to the 24.84% when we can reject the hypothesis that bond spread does not cause equity return. Hence, it can be concluded that the relationship role of each market is almost equal. Moreover, both markets lead in 6 cases and there is no causality in 89 cases out of 161. For 3 and 5-day lad analysis it is possible to conclude that equity return leads in a higher number of cases and exceeds the number of cases when the null hypothesis that bond spread does not cause equity return by 4 cases for 3 and 5-day lags. Both markets lead to price discovery in 5 cases for 3-day lag and 4 for 5 days lag. There is no causality in 113 for 3 days lag and 114 for 5 days lag. Thus for the results are mixed and it is difficult to conclude that one particular market dominates the price discovery process.

Overall, new information seems to be incorporated faster to equity return than to bond spread. Moreover, for bonds denominated in EUR currency equity return causes the first ones for higher percentage comparing to USD sample.

The causality relationship shows that equity returns precede the risk spreads of bonds and the findings are opposite to the conclusion made by Chan-Lau and Kim (2004). Despite the fact that the results are mixed and it is difficult for us to conclude that one particular market dominates the price discovery process equity markets mostly play a secondary role in price discovery for CDS, bond and equity market analysis. However, several studies of monthly and weekly data found causality link between the markets and suggested that stock return lags bond yield changes. (Kwan, 1996). The findings of Hotchkiss and Ronen (2002) establish that lagged stock return is not significant in explaining bond yield spread, which overlaps with the current results. Chordia et al., (2004) state that at the 10% level, there is two-way causation between stock and bond quoted spreads. Also, stock returns and volatility directly impact the bond spread, while bond returns and volatility affect the stock spread indirectly. For example, bond returns impact stock volatility which, in turn, Granger-causes the stock spread. Particularly for the US and European stock and bond markets (Baur, 2010) provides the evidence that the US stock market causes Australian Bond market, while the UK stock market causes all bond markets, The UK bond market causes only the UK and Canadian stock market. German stock market also causes all markets, while bond market causes only Canadian market. Italian stock market causes all markets and bond market causes French, Italian and the US ones. French bond market causes Italian, the UK and Canadian stock market, while all bond markets are led by French equity market. Italian stock market causes all bond markets and bond market causes only the UK, French and Italian stock markets. Australian stock market causes all bond markets, while only the US, the UK and Canadian stock markets are led by Australian bond market. Canadian stock market causes all markets, while stock market leads only the US market. Japanese stock market also affects all bond markets while bond market affects only the US market. Overall, there is no causality from bond to stock markets or from stock to bond markets on average but in several sub-periods, the US stock and bond markets are affecting both foreign stock and bond markets and, the influence of the US stock and bond markets has increased for all countries (the influence of the stock market is considerably stronger) and dominates other influences, e.g. the effects of a country's own stock or bond markets. The data consists of daily continuously compounded MSCI stock and bond index returns of the US, the UK, Germany, France, Italy, Australia, Canada and Japan for 12 years from January 1994 until September 2006. Hong et al., (2012) argue that for Index level from October 1, 2002 to December 31, 2010 corporate bond market returns are predictable. There is evidence of return predictability for both investment-grade and high-yield bonds for the US market.

4.1.3. CDS equity relationship GBP/GBP and GBP/EUR pairs

In this section the Granger Causality is run for the data of first difference time series of CDS premia and equity return. Table 19 presents the evidence that it can be deduced that equity return causes CDS spreads for the majority of the cases for one-day lag.

For pairs GBP/GBP one-lag analysis shows that in more than 50% cases we can reject the null hypothesis that equity return does not cause CDS premia and accept the alternative hypothesis that equity return Granger causes CDS premia. Both CDS premia and equity return lead in 8 cases out of 73, while there is no causality in 21 cases. For 3 days lag the relationship is inverse and the null hypothesis can be rejected for more cases when CDS premia does not cause equity return, however the number of cases is much lower comparing to 1 day lag relationship and equals to 22 out of 73, while the number of cases when equity return causes CDS spread for 1 day lag equals to 38. For 5 days lag analysis CDS premia leads equity return in 10 cases out of 73 and equity return leads CDS premia in 13 cases out of 73. Both markets lead in 9 and 3 cases out of 73 and there is no causality for 34 and 45 for 3 and 5 days lag respectively.

Table 19: Granger causality of the CDS-equity relationship (GBP/GBP and GBP/EUR)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of CDS premia and equity return. The results show the summary of outcomes when the null hypothesis is rejected.

GBP/GBP			GBP/EURO		
Lags (days)	Equity Return do not cause CDS Spreads	CDS Spread do not cause Equity Return	Lags (days)	Equity Return do not cause CDS Spreads	CDS Spread do not cause Equity Return
1	38/52.06%	14/19.18%	1	27/42.19%	16/25.00%
3	18/24.66%	22/30.14%	3	6/9.38%	20/31.25%
5	13/17.81%	10/13.70%	5	11/17.19%	12/18.75%

For pairs GBP/EUR equity return leads to price discovery in 42.19% of cases, while CDS premia lags equity return only in 25% of cases. Both assets lead to price discovery in 27 cases out of 64 and there is no causality in 7 cases. Hence, it can be concluded that for the Sample 4 the causality link is stronger than the causality link for the Sample 3 for 1 day lag and that equity return leads to price discovery in the both samples. For 3 and 5 days lag analysis the relationship is inverse and CDS premia leads in more cases than equity return. Both assets lead to price discovery in 2 and 5 cases for 3 and 5 days lag respectively and there is no causality in 39 and 44 cases out of 64.

Overall, equity return tends to lead to price discovery and although the tendency is the strongest for 1-day lag it weakens with an increase of lags.

Comparing to previous empirical papers the results overlap with the current results. Particularly for the UK market Corzo et al., (2012) report that log stock index return Granger causes the CDS sovereign spread change in 2009 for 2 days lag. The findings are supported by the following empirical outcomes: Bystrom (2005) analyses the relationship between the performance of a CDS iTraxx index and stock market returns from 2004 to 2005 and concludes that stock market returns cause CDS spread changes, but the reverse does not occur. Fung et al. (2008) find a negative correlation between CDS indexes and stock indexes performance. That correlation is higher amid financially distressed entities, and in the overall the correlation surged after July 2007. The results are consistent with Merton (1974) model: the decline of stock prices results in an increase of leverage, contributing to a rise of default risk and CDS spreads. The outcomes also suggest that the stock market leads the CDS market and the relationship does not depend on the firm's financial situation. Norden and Weber (2009) research the relationships between stock markets, bond markets and CDS markets from 2000 to 2002 for a set of 58 companies. They find that, first, the CDS market reacts to the stock market movements, and that the magnitude of that reaction is affected by the credit quality of the firm and by the liquidity of the bond market; second, stock returns lead credit spreads and CDS spreads. Data comes from 58 firms over the period 2000–2002. The sample represents the UK, US and European markets.

4.1.4 Bond equity relationship GBP/GBP and GBP/EUR pairs

For pairs GBP/GBP Table 20 reports that in 32 cases out of 73 we can reject the null hypothesis that equity return does not cause bond spread, while in 11 pairs both equity and bond lead to price discovery, and no relationship found in 26 cases.

Table 20: Granger causality of the bond-equity relationship (GBP/GBP and GBP/EUR)

Summary of results for causality test for 10% level of significance for 1, 3 and 5 lags. Granger causality test is run for each pair of bond spread and equity return. The results show the summary of outcomes when the null hypothesis is rejected.

GBP/GBP			GBP/EURO		
Lags (days)	Equity Return do not cause Bond Spreads	Bond Spread do not cause Equity Return	Lags (days)	Equity Return do not cause Bond Spreads	Bond Spread do not cause Equity Return
1	32/43.84%	19/26.03%	1	26/40.63%	12/18.75%
3	12/18.75%	10/13.70%	3	16/25.00%	13/20.31%
5	14/19.18%	13/17.81%	5	11/15.63%	13/20.31%

With the increase of lags the number of cases where equity return causes bond spread changes to 12 for 3 days and 14 for 5 days. Hence the hypothesis that equity return does not cause bond spreads is rejected for 18.72% and 19.18% for 3 and 5 days respectively. Both equity return and bond spreads are found to lead in 2 cases out of 73 for 3 days and 3 cases out of 73 for 5 days. Both hypotheses are not rejected, and hence, in 3 lags analysis equities do not Granger bonds and bonds do not Granger equities at the same time in 45 cases and in 43 cases for 3 and 5 lags respectively. Therefore equity return leads in more cases for lag of 1 day comparing to 3 and 5 days. Moreover, for bonds denominated in GBP currency equity return lags bond spread earlier in more cases. This means that in a higher number of cases equity return reacts to the information flow faster.

For the final pairs GBP/EUR the number of cases where we can reject the null hypothesis that equity return does not cause bond yield spread exceeds in more than twice a number of cases where the hypothesis that bond yield spread does not cause equity return is rejected. For 5 lags the relationship inverses and in 2 more cases bond yield leads compared to the number of cases when equity return leads to price discovery. Moreover, for 1,3 and 5 lags both assets lead in 4, 4 and 3 cases respectively and there is no causality in 29, 37 and 42 cases out of 64.

Overall, new information seems to be incorporated faster to equity return than to bond spread when causality exists. Moreover, equity leading role is more significant for a time lag of 1 day for the both samples.

The results intersect with other conclusions. For example, according to Baur (2010), the UK equity market leads all bond markets, while the UK bond market leads only the UK and Canadian stock markets. There are cases when German bond market leads the UK and Canadian stock markets, French bond market leads the UK, and Italian stock markets and Italian bond market leads the UK, French and Italian markets. The data consists of daily continuously compounded MSCI stock and bond index returns of the US, the UK, Germany, France, Italy, Australia, Canada and Japan for 12 years from January 1994 until September 2006.

4.2 CDS bond equity markets – Regression Analysis

In this section linear regression model (LRM) with random and fixed effect is used to evaluate the relationship between CDS premia, bond yield spread and equity return. The LRM estimates assist in finding the probability rate of significance for the regression coefficients. The first equation of LRM regression estimates bond spread and equity return with a lag of 1 day that explains CDS premia change by changing of bond yield spread and equity return including all explanatory variables during eight years period of time from 2007 to 2014. The second equation is conducted to explain bond yield spread change by changing of CDS premia and equity return with a lag of 1 day and all explanatory variables from 2007 to 2014. The third and forth equation estimates bond spread and CDS premia with a lag of 1 day that explains change in equity return respectively with all other explanatory variables for 2007-2014. Each equation includes explanatory variables apart from dependent ones. Explanatory variable included in the equation are investment grade, market value, market return, market volatility and iTraxx. Additionally, the sample is tested for two subperiods and applied to pairs EUR/EUR/USD and GBP/GBP/EUR.

According to Zivot-Andrews unit root test, the period is divided into two sub periods with a break point on 09/07/2010 for pairs GBP/GBP/EUR and 03/12/2008 for pairs EUR/EUR/USD, and which indicates the end of the financial crisis. The test is aimed to find a break point in the time series. Thus, structural break points at observation 09/07/2010 and 03/12/2008 have been found.

Thus, the model is performed in 3 different specifications. First, the whole sample indicates how first difference CDS premia and equity return and spread investment variable change influences change of bond spread. Second, sample is split by a breaking point, and the relationship is tested for time periods of 1 January 2007 to 2 December 2008 included and from 3 December 2008 until 1 September 2014 for pairs EUR/EUR/USD and 1 January 2007 to 8 July 2010 included and from 9 July 2010 until 1 September 2014 for pairs GBP/GBP/EUR.

4.2.1 CDS Bond Equity regression analysis of EUR/EUR pairs

To investigate the relationship between CDS premia, equity return and bond spread of pairs EUR/EUR the model is performed in 3 different specifications. Table 21 provides the outcomes of the analysis.

Table 21: Regression Analysis EUR/EUR Pair

Panel A: Results for the Equation 5 for the whole time period from the 1st of January 2007 to the 1st of September 2014

	EUR/EUR			
	Dependent Variable			
Independent Variables	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$
CDS_{t-1}		0.0152164*** (5.10)	0.0078166 (0.21)	
$Bond_{t-1}$	0.0079593 (1.18)			-0.0503029 (-0.83)
$Equity_{t-1}$	-0.0016803*** (-4.12)	-0.0014149*** (-4.76)		
Investment grade	-0.0038908*** (-16.51)	0.0000187 (0.44)	0.0005359 (0.25)	0.0005 (0.24)
Market value	-0.0001128*** (-3.79)	-4.00e-06 (-0.69)	0.0027813*** (10.38)	0.0027789*** (10.38)
Market return	-0.0065734*** (-4.73)	-0.0075113*** (-7.45)	0.7891787*** (63.09)	0.7893078*** (63.10)
Market volatility	-0.0004262* (-1.91)	-0.0001758 (-1.09)	-0.0099084*** (-4.94)	-0.009906*** (4.93)
iTraxx	0.6333095*** (18.62)	0.1865745*** (7.56)	-4.094296*** (-13.39)	-4.091723*** (-13.38)
R-squared	0.0041	0.0080	0.1957	
# observations	58,596	58,596	58,596	58,596
Unique firms	72	72	72	72
Hausman test	265.59***	10.66	55.19***	73.72***

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Panel B: Results for the Equation 5 for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test.

	EUR/EUR<03/12/2008				EUR/EUR≥03/12/2008			
	Dependent Variable				Dependent Variable			
Independent Variables	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$
CDS_{t-1}		0.0715187*** (4.85)	-0.4913709 (-1.54)			0.0146105 *** (4.68)	0.015174 (0.41)	
$Bond_{t-1}$	-0.0312964 *** (-2.76)			-0.6137227 ** (-2.11)	0.0093388 (1.30)			-0.0251378 (-0.40)
$Equity_{t-1}$	-0.0019802*** (-4.94)	-0.0013017 *** (-2.76)			-0.0015823*** (-3.49)	-0.0013215*** (-4.04)		
Investment grade					-0.0038807 *** (-15.71)	0.0000109 (0.24)	0.0003392 (0.16)	0.0002748 (0.13)
Market value	-0.0001597 *** (-3.48)	-0.0000144 (-1.46)	0.0027044 ** (2.30)	0.0025799 ** (2.19)	-0.000148 *** (-4.06)	-3.41e-06 (-0.54)	0.0036014 *** (11.43)	0.0035983 *** (11.42)
Market return	-0.001223 (-1.33)	3.34e-06 (0.00)	0.8424035 *** (35.79)	0.8433317 *** (35.86)	-0.0087939*** (-5.08)	-0.0090097 *** (-7.24)	0.7831048 *** (52.27)	0.7831854 *** (52.28)
Market volatility	0.0005473 *** (2.72)	0.0022832 *** (9.66)	-0.0012258 (-0.24)	-0.001401 (-0.21)	-0.0006824 *** (-2.71)	-0.0005868*** (-3.24)	-0.0097169 *** (-4.46)	-0.0097134*** (-4.46)
iTraxx	0.4417567***	0.024817	0.540471	0.529983	0.6569361 ***	0.2200653 *** (7.56)	-4.990344 *** (-14.46)	-4.988526 *** (-14.26)

	(17.91)	(0.86)	(0.86)	(0.84)	(16.24)			
R-squared	0.0848	0.0519	0.3916	0.3931	0.0037	0.0075	0.1613	0.1614
# observations	5,796	5,796	5,796	5,796	52,800	52,800	52,800	52,800
Unique firms	15	15	15	15	72	72	72	72
Hausman test	265.59***	10.66	55.19***	73.72***	265.59***	10.66	55.19***	73.72***

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

For the entire time period Table 21 Panel A reports that one day lagged CDS premia ifluences bond yield spread and the coefficient equals to 0.0152164, which means if lagged CDS premia increases/decreases bond yield spread increases/decreases. Equity return with one-day lag leads CDS premia and bond yield spread with negative sign and coefficients are equal to -0.0016803 and -0.0014149 respectively. However, equity return is not influenced by CDS and bond spreads. With an increase of investment grade CDS premia decreases. With increase/decrease of market value and market return CDS premia and bond spread decrease/increase, while equity return goes up/down. With an increase of market volatility CDS premia and equity return decreases. iTraxx variable is statistically significant for all dependable variable and coefficients are positive for CDS premia and bond spread and negative for equity return. The results are consistent for the time periods before and after the breakpoint. However, the results are slightly different to the coefficients for the whole period. Before the 03.12.2008 CDS premia is negatively affected by lagged bond yield spread. If one day lagged bond yield spread increases/decreases by 1% CDS premia decreases/increases by 3.1%. CDS premia leads bond yield spread and the relationship is stronger before the break point than after it. Opposite to the coefficients for the whole period market volatility is positively correlated with CDS and bond spread before the financial crisis. (Table 21 Panel B)

4.2.2 CDS Bond Equity regression analysis of EUR/USD pairs

To analyse the relationship between CDS premia, equity return and bond spread of pairs EUR/USD the same regression models are employed and the results are reported in Table 22.

Table 22: Regression Analysis EUR/USD Pair

Panel A: Results for the Equation 5 for the whole time period from the 1st of January 2007 to the 1st of September 2014

	EUR/USD			
	Dependent Variable			
Independent Variables	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$
CDS_{t-1}		0.0336427 *** (18.21)	-0.108055 *** (-3.19)	
$Bond_{t-1}$	0.011448 ** (1.73)			-0.0670798 (-1.07)
$Equity_{t-1}$	-0.001595*** (-4.56)	0.0013341*** (7.42)		
Investment grade	-0.0004195*** (-2.80)	-0.0001577 (-0.23)	0.0012864 (0.10)	0.0012366 (0.10)
Market value	-0.0000184 (-1.62)	-0.0001014 *** (-3.59)	0.0031677*** (6.10)	0.0031853*** (6.13)
Market return	-0.02521*** (-15.86)	-0.0247225 *** (-30.15)	1.045221 *** (69.40)	1.044847*** (69.36)
Market volatility	-0.0024957*** (-7.44)	-0.0025242*** (-14.59)	0.0134956 *** (4.24)	0.0134708*** (4.23)
iTraxx	0.8297686 *** (18.91)	0.5817087 *** (25.79)	2.701277 *** (6.53)	2.692688 *** (6.51)
R-squared	0.0132	0.0330	0.0919	0.0917
# observations	83,944	83,944	83,944	83,944
Unique firms	161	161	161	161
Hausman test	6.03	18.55***	78.39***	55.73***

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Panel B: Results for the Equation 5 for time periods before and after the financial crisis (03.12.2008)-the breaking point calculated by Zivot-Andrews test.

	EUR/USD<03/12/2008				EUR/USD≥03/12/2008			
	Dependent Variable				Dependent Variable			
Independent Variables	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$
CDS_{t-1}		0.1212501*** (17.38)	-0.5939085*** (-4.04)			0.0330508*** (13.27)	-0.0962886*** (-2.13)	
$Bond_{t-1}$	0.0426266*** (12.97)			0.178576* (1.73)	0.0094799 (0.97)			-0.0711176 (-0.82)
$Equity_{t-1}$	-0.0044992*** (-33.49)	-0.0011343*** (-5.69)			-0.001144** (-2.14)	0.0018472*** (7.05)		
Investment grade	-7.88e-06 (-0.22)				-0.0007789*** (-2.68)	-0.0001734 (-0.19)	0.0011297 (0.07)	0.0010825 (0.06)
Market value	-0.0000307*** (-9.93)	-0.0003885*** (-16.69)	0.0043148*** (8.85)	0.0046544 *** (9.57)	-9.02e-06 (-0.43)	-0.0001382** (-2.23)	0.0075678 *** (6.70)	0.0076004*** (6.73)
Market return	-0.0036452*** (-10.52)	-0.0025749*** (-5.06)	0.9162757*** (84.91)	0.9127961*** (84.55)	-0.0461086*** (-14.69)	-0.0459176*** (-29.78)	1.17217*** (41.78)	1.171585*** (41.76)
Market volatility	0.0002526*** (3.59)	0.0005165*** (5.00)	-0.0039363* (-1.79)	-0.0040267* (-1.83)	-0.0045533*** (-6.51)	-0.0049125*** (-14.13)	0.0247975*** (3.97)	0.0247419*** (3.96)
iTraxx	0.3825797*** (39.87)	0.2137499*** (15.17)	0.9473854 *** (3.23)	0.8029329 *** (2.75)	1.072151*** (11.90)	0.7510012*** (16.99)	5.120924*** (6.37)	5.114732*** (6.36)
R-squared	0.1091	0.0087	0.2757	0.2707	0.0166	0.0479	0.0349	0.0347
# observations	42,224	42,224	42,224	42,224	41,717	41,717	41,717	41,717
Unique firms	139	139	139	139	99	99	99	99

Hausman test	6.03	18.55***	78.39***	55.73***	6.03	18.55***	78.39***	55.73***

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

The results for the whole period for EUR/USD pairs are consistent with the results for EUR/EUR pairs. However, for the EUR/USD pair one day lagged bond yield spread leads CDS premia, and the coefficient is positive equal to 0.011448. At the same time the leading role of CDS is stronger for CDS bond relationship. Equity market leads CDS and bond markets, while only CDS leads equity market and the coefficients are negative. Opposite to EUR/EUR pairs market volatility for EUR/USD pairs has positive correlation for dependent equity return. For timespans before and after the break point the results are consistent, however, before 03/12/2008 CDS leading role is stronger for CDS bond relationship comparing to the timespan after the break point. CDS premia with one-day lag influences equity market and the effect is stronger before the break point. Thus, for the European markets the coefficients are consistent across years and currencies. One day lagged bond yield spread does lead CDS premia. However, the coefficients vary. The leading role of CDS premia is more discernable. CDS premia leads to price discovery and the coefficient of the relationship is positive for the whole time period as well as for the time periods before and after the financial crisis. The relationship is stronger before the financial crisis than after it. Equity market leads to price discovery in both equity bond and equity CDS relationship and the coefficients are negative. However, the inverse relationship is not so obvious. The influence of investment grade variable is not so consistent and influences all dependent variable negatively. With the increase/decrease of market value and market return CDS premia decreases/increases, bond yield spread decreases/increases and equity return increases/decreases. Market volatility and iTraxx don’t affect all dependent variables unfailingly. The coefficients vary and can be negative and positive.

The results intersect with outcomes of existing studies. Chan-Lau and Kim (2004) found that CDS spreads and equity prices are negatively correlated for such European countries as Bulgaria and Russia for 2001-2003. However, for the plot of the CDS and bond spreads the most countries have a positive correlation between these two markets. Kwan (1996) states that changes of bond yields are positively influenced by changes of Treasury bond yields and negatively affected by contemporaneous and lagged equity returns. Alexander, Edwards and Ferri (2000) conclude that stocks and bonds are positively correlated for financially distressed firms in the period 1994-1997. Norden and Weber (2009) have not found a strong relationship between the markets but found that stock returns are significantly negatively correlated with CDS and bond yield changes for a set of 58 companies from European, the UK and the US markets for the time period from 1998 to 2002. Finally, Bystrom (2005) and Lake and Apergis (2009) found that equity across European and US markets was negatively correlated to European CDS spread changes in the period from June 16, 2004 to November 13, 2008. Kikuchi (2009) found a negative correlation of 0.95 between the iTraxx Japan and the equity market (TOPIX). Chan, Fung & Zhang (2008) also found a very strong negative relationship between CDS spreads and equity prices. This outcome is consistent with Merton (1974) model: the decline of stock prices increases leverage, contributing to a rise of default risk and CDS spreads. Results also suggest that the stock market leads the CDS market, regardless of the firm's financial situation. However, the volatility spillovers from the CDS markets to the stock markets are higher than the reverse.

4.2.3 CDS Bond Equity regression analysis of GBP/GBP pairs

To investigate the relationship between CDS premia, equity return and bond spread for pairs GBP/GBP the model is performed in 3 different specifications. Table 23 reports the results for the whole sample.

Table 23: Regression Analysis GBP/GBP Pair

Panel A: Results for the Equation 5 for the whole time period from the 1st of January 2007 to the 1st of September 2014

	GBP/GBP			
	Dependent Variable			
Independent Variables	CDS_t	$Bond_t$	$Equity_t$	$Equity_t$
CDS_{t-1}		0.0256876 *** (4.21)	-0.5065263*** (-9.27)	
$Bond_{t-1}$	-0.0097182 *** (-4.33)			0.1706949 *** (4.52)
$Equity_{t-1}$	-.0040107*** (-22.17)	-0.0027546*** (-8.11)		
Investment grade	-0.0000201 (-0.46)	-0.0000595 (-0.72)	0.0002966 (0.32)	0.0003229 (0.34)
Market value	-5.04e-11 (-0.17)	-2.00e-11 (-0.04)	-6.33e-09 (-1.07)	-6.20e-09 (-1.04)
Market return	-0.0077055*** (-11.90)	-0.0109351*** (-9.05)	0.8043862*** (73.79)	0.8012817*** (73.51)
Market volatility	-0.0005528*** (-4.76)	-0.0011046*** (-5.10)	-0.0114401*** (-5.85)	-0.0115093 *** (-5.88)
iTraxx	0.6615165*** (39.33)	0.4078809 *** (13.00)	-4.07296 *** (6.53)	-4.166001*** (-14.74)
R-squared	0.0441	0.0072	0.1619	0.1612
# observations	90,889	90,889	90,889	90,889
Unique firms	73	73	73	73
Hausman test	0.88	0.67	1.92	2.05

*, ** and *** indicates significance of results for 10%, 5% and 1% confidence levels

Panel B: Results for the Equation 5 for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test.

	GBP/GBP<09/07/2010				GBP/GBP≥09/07/2010			
	Dependent Variable				Dependent Variable			
Independent Variables	CDS	Bond	Equity	Equity	CDS	Bond	Equity	Equity
CDS		-0.0025309 (-0.67)	-0.546249*** (-7.51)			0.1370219*** (8.15)	-0.3575633*** (-3.48)	
Bond	-0.0604815*** (-9.01)			0.6469651*** (6.65)	0.0033698** (2.31)			0.0419789 (1.18)
Equity	-0.0054466*** (-17.12)	-0.0031489*** (-13.10)			-0.0018796*** (-11.20)	-0.0020144*** (-3.01)		
Investment grade	-0.0000808 (-0.94)	-0.000015 (-0.23)	0.0013039 (1.04)	0.0013644 (1.09)	0.0000455 (1.27)	-0.0001076 (-0.43)	-0.0011855 (-1.36)	-0.0011964 (-1.37)
Market value	-5.17e-10 (-0.37)	1.38e-10 (0.13)	-1.65e-08 (-0.80)	-1.56e-08 (-0.76)	-1.53e-10 (-0.50)	-1.42e-09 (-0.81)	-1.67e-08** (-2.25)	-1.67e-08** (-2.25)
Market return	-0.0029734*** (-2.74)	-0.0032265*** (-3.96)	0.8111939*** (51.47)	0.8068406*** (51.22)	-0.0191671*** (-26.46)	-0.0349845*** (-12.14)	0.7479756*** (42.37)	0.7471437*** (42.33)
Market volatility	0.0001286 (0.54)	-0.0003528*** (-1.98)	-0.018863*** (-5.46)	-0.0189032*** (-5.47)	-0.0013143*** (-13.79)	-0.0028815*** (-7.60)	-0.0066272*** (-2.85)	-0.0066243*** (-2.85)
iTraxx	0.7510648*** (25.80)	0.3865275*** (17.67)	-3.268443*** (-7.74)	-3.379815*** (-8.01)	0.4655621*** (28.59)	0.3308828*** (5.11)	-5.85653*** (-14.77)	-5.884821*** (-14.84)

R-squared	0.0412	0.0204	0.1812	0.1809	0.0755	0.0084	0.1317	
# observations	38,870	38,870	38,870	38,870	52,019	52,019	52,019	52,019
Unique firms	59	59	59	59	67	67	67	67
Hausman test	0.88	0.67	1.92	2.05	0.88	0.67	1.92	2.05

*, **, *** indicates significance of results for 10%, 5% and 1% confidence levels

First, for the whole sample 1 day lagged CDS premia is positively correlated with bond yield spread and the coefficient is equal to 0.0256876. However, one day lagged bond yield spread is negatively correlated with CDS premia, and the coefficient is equal to -0.0097182. One day lagged equity return has a negative influence on CDS premia and bond yield return. However, one day lagged CDS is positively correlated with equity return. At the same time the relationship between one day lagged bond and equity return is the strongest, and the coefficient is negative (-.0040107).

Investment grade and market value don't influence the dependent variables. The market return has the strongest positive influence on equity return, while it is negatively correlated with CDS and bond spreads. The tendency of the results is consistent before and after the break point. However, before the break point of 09.07.2010 one day lagged CDS premia does not influence bond yield spread. However, the relationship is strong and positive after the breakpoint. Lagged bond yield spread leads CDS premia. However, the relationship varies across years, where it is negative before the breakpoint and negative after it.

4.2.4 CDS Bond Equity regression analysis of GBP/EUR pairs

To analyse the relationship between CDS premia, equity return and bond spread of pairs GBP EUR the same regression models are employed. Table 24 reports the results of the sample

Table 24: Regression Analysis GBP/EUR Pair

Panel A: Results for the Equation 5 for the whole time period from the 1st of January 2007 to the 1st of September 2014

	GBP/EUR			
	Dependent Variable			
Independent Variables	CDS	Bond	Equity	Equity
CDS		0.1074981 *** (13.85)	-0.8482039*** (-10.45)	
Bond	0.0124158 *** (5.29)			-0.0579684 (-1.24)
Equity	-0.002819 *** (-15.07)	-0.0008414*** (-2.37)		
Investment grade	-0.0000209 (-0.23)	-0.0000411 (-0.74)	-0.0004123 (-0.22)	-0.0003959 (0.21)
Market value	-0.0000898*** (-4.78)	6.12e-06 (0.73)	0.0028441*** (7.57)	0.0029654*** (7.89)
Market return	-0.002719 *** (-3.91)	-0.0178267 *** (-13.93)	0.9538687*** (68.63)	0.9516536*** (68.41)
Market volatility	0.0001404*** (-5.10)	-0.0008705*** (-3.93)	-0.0109553*** (-4.61)	-0.0108529*** (-4.56)
iTraxx	0.9502628 *** (52.70)	0.1287619 *** (3.88)	-6.099447 *** (16.95)	-6.213139*** (-17.26)
R-squared	0.1088	0.0144	0.2464	0.1612
# observations	53,831	53,831	53,831	53,831
Unique firms	64	64	64	64
Hausman test	306.94***	6.54	60.41***	57.78***

*, **, *** indicates significance of results for 10%, 5% and 1% confidence levels

Panel B: Results for the Equation 5 for time periods before and after the financial crisis (09.07.2010)-the breaking point calculated by Zivot-Andrews test.

	GBP/EUR<09/07/2010				GBP/GBP≥09/07/2010			
	Dependent Variable				Dependent Variable			
Independent Variables	CDS	Bond	Equity	Equity	CDS	Bond	Equity	Equity
CDS		0.0970114 (3.99)***	-0.0822021 (-0.42)			0.1086437*** (14.19)	-0.9553826*** (-10.70)	
Bond	0.0030744 (1.20)			-0.0660723 (-0.96)	0.0183241*** (5.50)			-0.0497577 (-0.81)
Equity	-0.0019696*** (-7.66)	-0.0007097 (-0.83)			-0.0030181*** (-12.70)	-0.0008335** (-2.23)		
Investment grade	-0.0000851 (-1.23)	-0.0000604 (-0.69)	-0.0001964 (-0.11)	-0.0001923 (-0.10)	0.0002694 (1.03)	-0.0000144 (-0.18)	-0.0000295 (-0.01)	-0.0003085 (-0.06)
Market value	-0.0001275*** (-4.48)	6.62e-07 (0.04)	0.0033569*** (4.39)	0.0033611*** (4.40)	-0.0001204*** (-4.24)	6.51e-06 (0.69)	0.0039276*** (7.46)	0.0041205*** (7.82)
Market return	0.0009938 (1.41)	-0.0071496*** (-3.18)	0.7108377*** (37.55)	0.7104726*** (37.59)	-0.0075464*** (-6.92)	-0.0285112*** (-17.08)	1.246532*** (61.56)	1.2453*** (61.41)
Market volatility	0.0005442*** (3.56)	0.0006015 (1.23)	-0.0342522*** (-8.34)	-0.034312*** (-8.36)	-0.0003225** (-2.06)	-0.0017505*** (-7.29)	0.0113271*** (3.89)	0.0117728*** (4.04)
iTraxx	0.8278854*** (44.00)	0.170641*** (2.84)	-3.556141*** (-7.05)	-3.566641*** (-7.08)	1.010831*** (37.29)	0.0484238 (1.19)	-6.288615*** (-12.70)	-6.421032*** (-12.96)
R-squared	0.1891	0.0080	0.2818	0.2818	0.0944	0.0209	0.2345	0.2301
# observations	14,874	14,874	14,874	14,874	38,957	38,957	38,957	38,957
Unique firms	34	34	34	34	62	62	62	62

Hausman test	306.94***	6.54	60.41***	57.78***	306.94***	6.54	60.41***	57.78***

*, **, *** indicates significance of results for 10%, 5% and 1% confidence levels

For CDS bond relationship the leading role of CDS is positive and more statistically significant. One day lagged CDS premia also leads equity return. However, the relationship can be inverse. Investment grade does not influence dependent variables, while market value and market return have a negative effect on CDS premia and bond yield spread and positive on equity return. Market volatility varies; while iTraxx is positively correlated with CDS premia and bond yield spread and negatively with equity return. The results are consistent across time periods before and after the breakpoint. However, after the breakpoint, one day lagged CDS premia influences bond yield spread with a higher degree than before the breakpoint. Moreover, before and after the breakpoint lagged equity return leads CDS premia, while the relationship inverses only after the breakpoint.

Overall, for CDS, bond, equity relationship, lagged CDS premia is positively correlated with bond yield spread, the inverse relationship is not obvious and varies across currencies and years. Lagged equity return influences CDS and bond spread, while the relationship is inverse for CDS and equity market. In general, market value and market return have a negative effect on CDS and bond markets and positive on equity one. Investment grade does not play an important role in explaining the markets, while market volatility can influence them in different directions. CDS index has a positive effect on CDS premia and bond yield spread and negative on equity one.

Corzo et al., (2012) extend the research for European markets and state that for Germany and Greece. The negative correlation between CDS and stock indexes is apparent: spreads on the CDS widen when the market perceives deterioration in credit risk. As the CDS premiums goes up, the stock indexes fall (market risk also increases). Moreover, during 2009 the leading role of the stock market, with respect to the CDS market, is confirmed. The role is confirmed for most countries (Spain, Greece, Germany, Portugal, France, Netherlands, Italy, Belgium, UK, Austria and Finland). The bond leads CDS market only for Denmark. Note the negative sign relating the CDSs and the stock market and the fact that the magnitude of the coefficients associated with CDSs also grows noticeably during 2010.

The correlation matrices for every pair of CDS, bond, and equity sample are provided in the appendix of the paper.

5. Conclusions

The purpose of this paper is to analyse the relationship between CDS premia, equity return and bond spread during the period starting from 1st January 2007 to 1st September 2014. The indispensable data for CDS premia is collected from Markit and bond yield spread and equity return from DataStream source. We have matched the CDS premia with bond yield spread of the same reference entity-based "*remaining maturity*" approach, described earlier, adopting and developing the appropriate methodology and applying the tests defined previously. Equity has then matched to a set of pairs of CDS premia and bond yield spread. The sample consists of daily observations for 5-year CDS premia for a set of corporations and sovereigns that covers different countries, regions and industries.

The objectives of the study are to indicate which market leads in the relationship between the three markets, as it is important for the price discovery process and understanding of market efficiency. Moreover, it is tested by what extent the change in one market change the other two.

To address the objectives Granger Causality (GC) analysis is employed. GC indicates that in most cases the results are mixed and clear evidence is missing of one single market's leading role. However, there is evidence that the equity market tends to lead CDS market for all currencies and that CDS and that equity return causes bond spread for bonds denoted in GBP and EUR.

The results of regression reveal that the tendency is true and that the change in lagged equity return influences CDS premia; moreover, this influence is significantly strong and negative. The outcomes confirm conclusions of previous research regarding CDS equity relationship. The influence is stronger for pairs GBP/GBP/EUR than for EUR/EUR/USD ones. Equity market leads CDS across different time periods and bond ones in price discovery. However, equity CDS relationship is stronger with negative sign.

There is evidence of the influence of lagged CDS in CDS equity relationship, yet there is no relationship indicated for pairs EUR/EUR. Moreover, there is strong evidence of CDS playing a leading role in the CDS bond relationship. The strongest influence is reported for pairs GBP/EUR and the weakest for EUR/EUR. Across different time periods, the influence of lagged CDS on bond yield spread is stronger before the break point for EUR/EUR/USD pairs. For pairs GBP/GBP/USD the influence is stronger after the break point.

The influence of lagged bond on CDS premia is as yet incomprehensible. The influence of market and firm specific variable show that with the increase of market value CDS premia and bond yield spread falls but equity return increases. The influence of market volatility varies across currencies and time periods. Market return influence CDS and bond spreads positively. With the increase of equity market, CDS premia and bond yield spreads decrease while equity return goes stay abreast with market return. iTraxx is positively correlated with CDS premia.

The strongest influence has then been reported for GBP/EUR pairs. Hence, if the CDS market goes up GBP/EUR pairs are affected mostly, while EUR/EUR and GBP/GBP pairs are affected with the lowest extent.

This paper contributes to the otherwise scarce literature on the interrelation between CDS, bond and equity market. Compared to previous existing empirical research that employs country or index analysis, this research has analysed data for a set of different companies for different countries and industries. The paper thus extends the analysis of the three markets for the period before and after the financial crisis, employing firm specific and market variables to explain the change in a market.

The results of the paper can be useful for all market participants as traders, risk managers and regulators. Price discovery helps to understand how CDS premia and bond spread react to information flow at the markets. The concept of positive and negative basis may brings arbitrage opportunity and understanding of it drivers helps to gain from arbitrage opportunities. To manage default risk the influence of credit rating announcements should lead to a conception of its relationship with CDS premia and predictable opportunity.

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Appendix

Table 25: Correlation between variables for EUR/EUR pairs

EUR/EUR	*CDS*	*Bond*	*Investment grade*	*Equity return*	*Market value*	*Market return*	*Volatility*	*lagged CDS*	*lagged Bond*	*lagged Equity return*	*iTraxx*
CDS	*1*										
Bond	*0.0564*	*1*									
Investment grade	*-0.0188*	*0.0005*	*1*								
Equity return	*-0.109*	*-0.0481*	*-0.0002*	*1*							
Market value	*-0.0102*	*-0.0032*	*0.3863*	*0.0145*	*1*						
Market return	*-0.0985*	*-0.0775*	*-0.0027*	*0.4591*	*0.0039*	*1*					
Volatility	*0.0753*	*0.0575*	*0.0011*	*-0.3576*	*-0.0014*	*-0.7415*	*1*				
lagged CDS	*-0.0609*	*0.0239*	*-0.02*	*-0.0034*	*-0.0099*	*-0.0054*	*0.0072*	*1*			
lagged Bond	*0.006*	*-0.1654*	*0.0005*	*0.0008*	*-0.0017*	*0.0106*	*-0.0067*	*0.0669*	*1*		
lagged Equity return	*-0.0239*	*-0.0245*	*0.0002*	*0.0243*	*0.0151*	*0.0067*	*0.0059*	*-0.1089*	*-0.0575*	*1*	
iTraxx	*0.1238*	*0.0769*	*0.0014*	*-0.356*	*-0.0043*	*-0.693*	*0.5881*	*0.009*	*-0.0009*	*-0.0466*	*1*

Table 26: Correlation between variables for EUR/USD pairs

EUR/USD	*CDS*	*Bond*	*Investment grade*	*Equity return*	*Market value*	*Market return*	*Volatility*	*lagged CDS*	*lagged Bond*	*lagged Equity return*	*iTraxx*
CDS	*1*										
Bond	*0.4074*	*1*									
Investment grade	*-0.0104*	*-0.003*	*1*								
Equity return	*-0.0816*	*-0.1183*	*0.0062*	*1*							
Market value	*-0.0078*	*-0.0089*	*0.1466*	*-0.0051*	*1*						
Market return	*-0.0883*	*-0.1484*	*-0.0017*	*0.318*	*0.0068*	*1*					
Volatility	*0.049*	*0.0768*	*0.0004*	*-0.2182*	*-0.0023*	*-0.7207*	*1*				
lagged CDS	*-0.0006*	*0.0592*	*-0.0191*	*-0.0071*	*-0.0115*	*0.0117*	*-0.0044*	*1*			
lagged Bond	*0.0067*	*-0.0115*	*-0.003*	*0.0018*	*-0.0088*	*0.0179*	*-0.0063*	*0.4239*	*1*		
lagged Equity return	*-0.0208*	*0.0146*	*0.0063*	*-0.0111*	*-0.0053*	*-0.0273*	*0.0226*	*-0.0848*	*-0.1183*	*1*	
iTraxx	*0.0982*	*0.1412*	*0.0025*	*-0.1248*	*-0.0044*	*-0.4538*	*0.3692*	*0.0034*	*0.0002*	*-0.0761*	*1*

Table 27: Correlation between variables for GBP/GBP pairs

GBP/GBP	*CDS*	*Bond*	*Investment grade*	*Equity return*	*Market value*	*Market return*	*Volatility*	*lagged CDS*	*lagged Bond*	*lagged Equity return*	*iTraxx*
CDS	*1*										
Bond	*0.0934*	*1*									
Investment grade	*-0.0018*	*-0.0026*	*1*								
Equity return	*-0.1223*	*-0.0253*	*0.0008*	*1*							
Market value	*-0.145*	*-0.0632*	*0.0012*	*0.398*	*1*						
Market return	*0.1052*	*0.0372*	*-0.0003*	*-0.2965*	*-0.7004*	*1*					
Volatility	*0.0696*	*0.0181*	*-0.0018*	*-0.0254*	*0.0116*	*-0.0013*	*1*				
lagged CDS	*-0.0133*	*-0.4032*	*-0.0036*	*0.0169*	*0.0076*	*-0.0057*	*0.1181*	*1*			
lagged Bond	*-0.0787*	*-0.0307*	*0.0006*	*0.0045*	*-0.0169*	*0.0013*	*-0.1223*	*-0.0319*	*1*		
lagged Equity return	*0.1938*	*0.0733*	*-0.0016*	*-0.284*	*-0.6186*	*0.5182*	*0.0229*	*-0.0076*	*-0.0483*	*1*	
iTraxx	*-0.0006*	*-0.0002*	*0.0321*	*-0.0039*	*-0.0007*	*-0.0019*	*-0.003*	*0.0015*	*-0.0051*	*-0.0029*	*1*

Table 28: Correlation between variables for GBP/EUR pairs

GBP/EUR	*CDS*	*Bond*	*Investment grade*	*Equity return*	*Market value*	*Market return*	*Volatility*	*lagged CDS*	*lagged Bond*	*lagged Equity return*	*iTraxx*
CDS	*1*										
Bond	*0.134*	*1*									
Investment grade	*-0.0066*	*-0.0028*	*1*								
Equity return	*-0.2734*	*-0.1119*	*0.0038*	*1*							
Market value	*-0.0037*	*0.0015*	*0.3665*	*0.0042*	*1*						
Market return	*-0.2477*	*-0.0977*	*0.0018*	*0.5037*	*0.0026*	*1*					
Volatility	*0.2092*	*0.0607*	*-0.0006*	*-0.3834*	*-0.0013*	*-0.7216*	*1*				
lagged CDS	*0.18*	*0.0651*	*-0.0072*	*-0.0424*	*-0.0051*	*-0.001*	*0.0013*	*1*			
lagged Bond	*0.0269*	*-0.0831*	*-0.0012*	*-0.0024*	*0.0015*	*0.0053*	*-0.0047*	*0.1348*	*1*		
lagged Equity return	*-0.0797*	*-0.0292*	*0.0037*	*0.004*	*0.0045*	*0.0072*	*-0.0042*	*-0.274*	*-0.112*	*1*	
iTraxx	*0.3323*	*0.0803*	*-0.0005*	*-0.4031*	*-0.0027*	*-0.7036*	*0.5969*	*0.0221*	*-0.0056*	*-0.0468*	*1*

CONCLUSION

Credit default swaps are a recent innovation in capital markets and there exists a theoretical relationship between credit default swap spreads, bond yield spreads and equity return. This dissertation analyses the equilibrium price relationship between CDS, bond, and equity prices, while examining the price discovery process in these markets for a period from 1st January 2007 to 1st September 2014.

The study has found that theoretical relationship held fairly and CDS yield spread leads in CDS bond relationship. The relationship between the three markets is not as clear as the CDS bond relationship. However, it can be concluded that the equity market tends to lead the CDS market.

The dissertation consists of three independent empirical papers. The first paper analyses the relationship between CDS premia denominated in GBP and bond yield spread in GBP and EUR. The main conclusion is that CDS premia leads to price discovery over the entire period. Assuming the leading role of CDS premia, lagged CDS premia and bond yield spread have been used as independent and dependent variables respectively in linear regression model. The outcomes show that CDS premia and bond yield spread are positively correlated for the entire period, as well as before and after the breakpoint (9 July 2010), meaning that with yield spread increases/decreases with the increase/decrease of CDS premia bond.

The results differ for the various time periods and the different currencies. For the pairs GBP/GBP (CDS premia and bond yield spread denominated in GBP currency), the impact of lagged CDS premia on bond yield spread is stronger after the breakpoint than before it. The opposite is the case the GBP/EUR pairs (CDS premia denominated in GBP currency and bond yield spread denominated in EUR), the impact of lagged CDS premia is stronger before the breakpoint than after it. Moreover, GBP bonds are more influenced by CDS premia comparing to EUR bonds.

The model also includes an investment grade variable, demonstrating that for bonds with a rating higher or equal to the BBB bond, the yield spread is less influenced by a change in CDS premia, meaning that investment grade bonds are less influenced by credit risk compared to junk bonds.

The second paper extends the research of the first paper by employing CDS premia denominated in EUR and bond yield spread in EUR and USD. Here we have applied the same methodology and found that CDS premia leads to price discovery, although the leading role decreases with an increase of lags. Moreover, the results for the EUR/USD pairs are mixed.

The outcomes of regression show that CDS premia and bond yield spread are positively correlated for the entire period, as well as before and after the breakpoint (3 December 2008). The conclusion to draw here is that with increase/decrease of CDS premia bond yield spread increases/decreases.

The results differ for various time periods and for different currencies. For EUR/EUR pairs (CDS premia and bond yield spread denominated in EUR currency), the impact of lagged CDS premia on bond yield spread is stronger and statistically significant after the breakpoint than before it. For EUR/USD pairs (CDS premia denominated in EUR currency and bond yield spread denominated in USD) the opposite is the case and the impact of lagged CDS premia is stronger and more statistically significant before the breakpoint than after it. Moreover, USD bonds are more influenced by CDS premia compared to EUR bonds.

The model also includes an investment grade variable, which shows that for bonds with a rating higher than a BBB bond the yield spread is less influenced by a change in CDS premia, meaning that investment grade bonds are less influenced by credit risk compared to junk bonds. The results are significant for EUR/USD pairs before the financial crisis.

The third paper analyses the three markets and the relationship between CDS premia denominated in GBP and EUR, bond yield spread in GBP, EUR and USD and equity return denominated in GBP, USD, EUR and Canadian dollars. After applying Granger causality analysis and linear regression model, we found that there is no clear evidence of a leading role of a particular market. However, a stronger leading role of equity return over CDS premia can be observed.

The outcomes of the linear regression model show that CDS premia and bond yield spread are positively correlated and the influence of lagged CDS premia on bond yield spread is stronger than the influence of lagged bond yield spread on CDS premia. CDS premia is negatively correlated with equity return, meaning that if credit risk increases/decreases equity returns decreases/increases. Moreover, the research employs explanatory variables, including investment grade variable, market value, market return, market volatility and CDS index. Market value and return are positively correlated with equity return, meaning that if a market goes up then the equity prices will rise; meanwhile, the variables are negatively correlated with CDS premia and bond yield spread.

The influence of market volatility is different for different currencies. It is negatively correlated with nearly all the variables apart from equity return for EUR/USD pairs and from CDS premia for GBP/EUR pairs.

Overall, CDS premia leads to price discovery in CDS bond relationship. The influence of CDS premia on the investment grade bond is less than on junk bonds. Regarding the relationship between the three markets, the outcomes confirm the negative correlation between CDS premia and equity return concluded by previous empirical studies.

The findings of the dissertation can benefit market participants. Some have proposed using CDS spreads for regulatory purposes and for estimation of systematic risk. Investors can also benefit from a new understanding of market efficiency. If a market leads to price discovery it means that when, for example, some good news about the economy arrives speculators act quickly and feed the information into a market causing changes in the price of securities. Therefore, these markets indicate what is likely to happen and thus assist in better price discovery. Granger causality tests can give us indications of the direction of any information flow and help to understand which market is more efficient. Application of market and firm specific factors can benefit investors, risk managers and regulators. By understanding how explanatory variables influence the markets, it is possible to make predictions and mitigate risks or to increase a potential reward.

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Appendix A:

Summary of papers on the CDS bond relationship from 2005 to 2016

Authors and title	Year of publication	Estimated period	Type of CDS	Before FC	During FC	After FC
Alagöz 'The relationship of CDS spreads and Credit spreads: A comparison before and after the financial crisis'	2012	2006-2012	49 institutions listed in Markit iTaxx	CDS premia leads in PDP	CDS premia leads in PDP	CDS premia leads in PDP
Alexopoulou, Andersson and Georgescu 'An empirical study on the decoupling movements between corporate bond and CDS spread'	2009	2004-2008	29 large European financial and non-financial firms	CDS premia leads in PDP	CDS premia leads in PDP	-
Ammer and Cali 'Sovereign CDS and Bond Pricing Dynamics in Emerging Markets: Does the Cheapest-to-Deliver Option Matter?'	2011	2001-2006	Sovereigns	CDS markets seem to lead bond markets in price discovery in some instances, but lag bond prices in other cases.	-	-
Arce and Pena 'Do Sovereign CDS and Bond Markets Share the	2013	2004-2010	Sovereigns	The relationship is country-dependable	The relationship	The relationship

Same Information to Price Credit Risk? An Empirical Application to the European Monetary Union Case’					is country-dependable	is country-dependable
Baba and Inda ‘Price discovery of subordinated credit spreads for Japanese mega-banks: Evidence from bond and credit default swap markets’	2009	2004-2005	Japanese banks	CDS leads in PDP	-	-
Berggren and Mattsson ‘The relationship between CDS spreads and bond spreads – an empirical comparison’	2008	2004-2008	Financial institutions	CDS premia leads in PDP	-	-
Blanco, Brennan and March ‘An empirical analysis of the dynamic relationship between investment grade bonds and credit default swaps’	2005	2001-2002	119 corporate companies	CDS premia leads in PDP[20]	-	-
Buhler and Trapp ‘Explaining the Bond-CDS Basis – The Role of Credit Risk and Liquidity’	2012	2007-2011	Financial institutions	CDS premia leads in PDP	CDS premia leads in PDP	CDS premia leads in PDP
Calice, Chen and Williams ‘Liquidity spillovers in sovereign bond and CDS markets: An analysis of the Eurozone sovereign debt crisis’	2013	2009-2010	Eurozone sovereigns	-	-	CDS leads to price discovery

[20] PDP-price discovery process

Coudert and Gex 'Credit default swap and bond markets: which leads the other?'	2010	2007-2010	Sovereigns and corporations	CDS leads in PDP	CDS leads in PDP	-
Delis and Mylonidis 'The chicken or the egg? A note on the dynamic interrelation between government bond spreads and credit default swaps'	2011	2004-2010	Eurozone sovereigns	-	CDS leads in PDP	CDS leads in PDP
Fontana and Scheicher 'An analysis of euro area sovereign CDS and their relation with government bonds'	2016	2006-2010	Sovereign	No relationship	CDS premia leads in PDP	CDS premia leads in PDP
Gomes and Brandi 'The relationship between credit default swaps and bonds: an empirical analysis applied to Brazil's risk'	2005	2003-2004	Brazil's CDS spread series	CDS premia leads in PDP	-	-
Gyntelberg et al. 'Intraday dynamics of euro area sovereign CDS and bond'	2013	2008-2011	Sovereign	-	The relationship is country-dependable	The relationship is country-dependable
Lehtonen 'An empirical analysis of sovereign CDS - Bond relation before and during financial crisis'	2012	2005-2010	Sovereigns	Bond spread leads in PDP	-	The relationship is country-dependable
O'Kane 'The Link between Eurozone Sovereign Debt and CDS Prices'	2012	2009-2011	Sovereigns	-	-	The relationship is country-dependable

Shim and Zhu ‘The impact of CDS trading on the bond market: Evidence from Asia’	2014	2003-2009	226 CDSs on major US and European firms	CDS premia leads in PDP	-	-
Zhu (2006) ‘An Empirical Comparison of Credit Spreads between the Bond Market and the Credit Default Swap Market’	2006	1999-2002	Contracts denominated in EUR and USD	Bond leads in PDP	-	-