Department of Economics

Master essay

Price discovery of sovereign credit risk in the Euro zone

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Abstract

This paper compares credit pricing on the bond market and the credit default swap market with focus on countries of the Euro zone and in particular on Greece. For the period 2006 to 2008 we find that the two markets are closely related and that the CDS market is the main forum of price discovery. After 2008 the relationship loosened, however we find evidence that the bond market still is affected by the CDS market. Overall, the results of this paper suggest that the relationship between the two markets on sovereign level is similar to the relationship on corporate level. However, in contrast with previous findings on corporate level, the German government bond is found to be the best proxy of the risk free rate when pricing the credit risk of the analyzed countries.

Key words: Bond spread, credit default swap, cointegration, price discovery, Vector error correction model

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Glossary

Basis spread: Difference between the CDS spread and the bond spread

Bond spread: see credit spread

Credit default swaps (CDS): Credit derivative that allows a bond holder to protect himself against the default of the corresponding bond issuer.

CDS premium: see CDS spread

CDS spread: Premium paid by the protection buyer to the seller. Expressed in basis points per annum of the contract's notional amount

Credit spread: Yield to maturity of a bond subtracted by the yield to maturity of another bond (often a risk free bond)

Naked CDS: Buying a CDS without owning the reference entity. Alternative definition: Buying a CDS without being exposed to a corresponding risk.

1. Introduction

1.1. Background

Credit derivatives are financial instruments with the purpose to transfer credit risk from one investor to another investor. Credit default swaps are the most liquid instruments of this sort and provide protection against the risk of a default by a particular reference entity. For this protection, the buyer pays periodically a fixed fee to the seller of the protection. If a credit event occurs, the seller of the protection compensates the buyer for the loss. Figure 1 shows the development of the worldwide outstanding CDS contracts in billion USD. Despite the decreasing volume since 2007, the outstanding contracts in the first half year of 2009 amounted on over 30 trillion USD. The notional value of the CDS market has nearly doubled from 2006 to 2007 (from 34.4 to 62.2 trillion). This tremendous increase has lead to improvements of the markets infrastructure, e.g. reduction of the total notional values through trade compression, timely matching of CDS trades and the central clearing of CDS have become industry priorities.[1] Those actions are partly responsible for the contraction of the amount of outstanding CDS contracts in 2008 and 2009. The main regulator body in Europe is the European Securities Committee (ESC) which is run by the European Commission and works together with major CDS dealer to improve the market framework.[2] In order to be more efficient, the International Swap Derivatives Association (ISDA) implemented new protocols for CDS contracts starting April 2009 (the "*Big bang protocol*" closely followed by a "*Small bang*")[3]. The Big Bang Protocol is intended to standardize the auction settlement process across different credit derivatives transactions and Credit Events in the North American market.[4] The Small Bang is the natural extension of the Big bang protocol to the European market.[5] The ISDA represents participants in the privately negotiated derivatives industry and is

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[1] The CDS Big Bang: Understanding the Changes to the Global CDS Contract and North American Conventions.

[2] http://ec.europa.eu/internal_market/securities/esc/index_en.htm

[3] The CDS Big Bang: Understanding the Changes to the Global CDS Contract and North American Conventions.

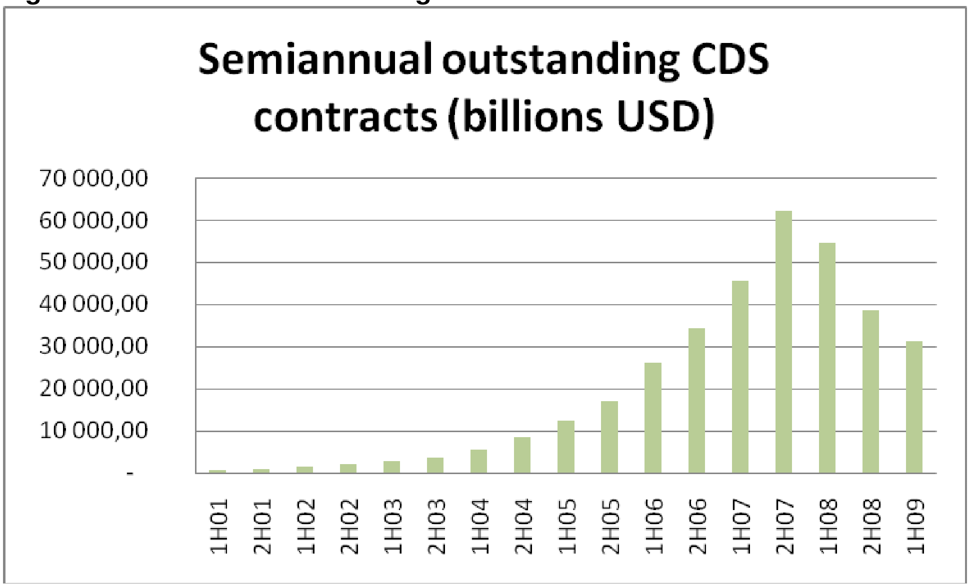
[4] The Big Bang Protocol and A New Structural Framework for Credit Default Swaps,2009 Paul, Weiss, Rifkind, Wharton&Garrison LLP

[5] CDS Small Bang: Understanding the Global Contract & European Convention Changes

one of the largest global financial trade associations. The members include most of the world's major institutions that deal in privately negotiated derivatives[6].

Credit default swaps are traded over the counter (OTC), increasingly on "bilateral OTC markets featuring electronic platforms that provide efficient access to real-time pretrade prices"[7]. The OTC market is not regulated like a traditional exchange but in 2009 an estimated 90% of CDS traded globally were matched and confirmed on one system provided by the Depository Trust & Clearing Corporation (DTCC).[8]

Figure 1: Semiannual outstanding CDS contracts



Source of data: ISDA[9]

1.2. Criticisms of CDS

The ISDA describes the formation of the CDS as follows: "CDS arose in response to demand by financial institutions, mainly banks, for a means of hedging and diversifying credit risks similar to those already used for interest rate and currency risks. But CDS also have grown in response to demands for low-cost means of taking on credit exposure."[10]

[6] http://www.isda.org/press/press040809.html

[7] Cechetti et al. (2009). Central counterparties for over-the-counter derivatives. BIS Quarterly Review, September 2009.

[8] http://www.dtcc.com/about/business/global/global_capabilities.php

[9] http://www.isda.org/statistics/historical.html

[10] http://www.isdacdsmarketplace.com/about_cds_market

Following, the main criticisms of the CDS market are briefly summarized. The main source of this summary is an article written by Zabel which has been published in the September 2008 issue of Pratt's Journal of Bankruptcy Law[11].

In the early 2000, the credit derivatives market went through some modifications: investors started to speculate on CDS. Several criticisms related to speculations and market opacity rose especially after the financial crisis of 2007-2008. One point of criticism is the use of "naked CDS" where the seller and the buyer are not owner of the underlying asset. In other words, the buyer might be betting on the default of an asset. Hedge funds are often accused to use naked CDS in their portfolio not only for hedging but also for speculation[12]. Then, the creation of CDS with structured investment vehicles (MBS, ABS, CDO) as the underlying asset became a common practice. The direct consequence is the difficulty to evaluate the health of the concerned bonds or loans. Finally, a secondary market has been established which is darkening the financial situation of the protection seller. All those changes led the CDS market to a significant growth. According to Zabel, in 2007 almost half of the notional value were naked CDS and therefore speculative. In addition, the market is lacking from efficient regulations and transparency[13]. Michael Greenberger, a law professor at the University of Maryland and a former senior official of the Commodity Futures Trading Commission, said the following about CDS: "It is an insurance contract, but they've been very careful not to call it that because if it were insurance, it would be regulated".[14].

1.3. Political discussions

The sovereign CDS market is a widely discussed topic in politics and newspapers. Ben Bernanke, chairman of the Federal Reserve, said that using CDSs to destabilize a government was "counter-productive" [15]. European Commission President Jose Barroso was cited: The commission will examine "the relevance of banning purely speculative naked sales on CDS of sovereign debt" [16]. Parties that want to ban naked CDS call naked CDS "a purely speculative

[11] http://www.rkmc.com/Credit-Default-Swaps-From-Protection-To-Speculation.htm

[12] http://www.ft.com/cms/s/0/e7ba5862-2c7c-11df-be45-00144feabdc0.html

[13] http://www.rkmc.com/Credit-Default-Swaps-101-A-Primer-On-Legal-Remedies-.htm

[14] http://www.dailymarkets.com/stocks/2008/10/21/credit-default-swaps-%E2%80%93-a-disastrous-unwind/

[15] http://www.businessweek.com/news/2010-03-09/-speculative-sovereign-cds-sales-could-face-ban-barroso-says.html

[16] http://www.businessweek.com/news/2010-03-09/-speculative-sovereign-cds-sales-could-face-ban-barroso-says.html

gamble" [17]. However, the ISDA warns, with regard to the situation in Greece, that "Greek CDS provide effective hedges not only for holders of Greek government bonds but also for international banks that extend credit to Greek corporations and banks, for investors in Greek stocks and for entities that have significant real estate or corporate holdings in Greece. (…) Much of this activity could be misinterpreted as "naked CDS"."[18] Apparently, there lies one of the problems when discussing naked CDS. While some refer to naked CDS, they mean that the protection buyer does not own the underlying entity. Others only refer to a naked CDS, when the CDS is not used to hedge a risk exposure which isn't necessarily the underlying bond.

The discussions above are related to the situation in Greece, which has an estimated debt to GDP of 113 %[19] and a budget deficit of 13 % in 2009[20]. Combined with the fact that Greece has large rollover needs in the coming years[21], the Financial Times amongst others writes of a Greek "debt crisis"[22]. Naked CDS have been blamed to be partly responsible for bringing down Greek bond prices[23], which increases the costs for Greece to issue debt. The ISDA points out that "the activity and outstanding volumes in the Greek CDS market need to be contrasted with the outstanding volumes in the Greek government bond market, which exceeds $400 billion. None of the data can possibly lead to a conclusion that a market of $9 billion can dictate prices in the $400 billion government market."[24] However, the ISDA admits that "if prices in the CDS market widened significantly relative to the Greek government market, arbitrageurs and holders of Greek government bonds would simply sell the bonds and write protection in the form of the sovereign CDS." [25]

[17] http://www.ft.com/cms/s/0/7b56f5b2-24a3-11df-8be0-00144feab49a.html

[18] http://www.isda.org/media/press/2010/press031510.html

[19] http://www.reuters.com/article/idUSATH00496420091105

[20] http://www.economist.com/world/europe/displaystory.cfm?story_id=15452594

[21] http://www.reuters.com/article/idUSN1012068320100511

[22] http://www.economist.com/world/europe/displaystory.cfm?story_id=15452594

[23] http://www.ft.com/cms/s/0/e7ba5862-2c7c-11df-be45-00144feabdc0.html

[24] http://www.isda.org/media/press/2010/press031510.html

[25] http://www.isda.org/media/press/2010/press031510.html

1.4. Problem discussion

The aim of this paper is to analyze the relationship between sovereign CDS and government bonds. No information about the amount of naked CDS is available, since naked CDS are neither clearly defined nor are they reported. Therefore, this paper focuses on the price discovery of credit risk, i.e. which market leads the price discovery of credit risk. The findings of this paper are not able to show what impact the CDS market has on a debt crisis. However, it provides indications on the relationship of the bond and CDS market in Europe and how this relationship changes during a crisis. There are four main problems that are investigated step by step. First of all, is there a long-term equilibrium relationship between the Greek credit spreads and the Greek CDS spreads? Secondly, which of the two markets is leading the price discovery of credit risk? In a third step, are there significant differences in the bond spread / CDS spread relationship between the period 2006-2008 and 2009-2010? Finally, how do the findings for Greece differ from findings for other countries?

Considering the significant growth of the credit derivatives instruments (especially CDS) several empirical studies in this area have been investigated. They inspired some main ideas of our paper. Zhu (2004), Blanco et al. (2005) and Alexopoulou et al. (2009) analyze the long-term and short-term relationship of CDS spread and credit spread on a corporate level (mostly US companies). All of them find significant evidence of cointegration and in most cases price discovery dominated by the CDS market. Furthermore, two papers in particular (Chan-Lau & Kim (2004) and In et al. (2007)) apply on sovereign level with focus on emerging markets. Their findings regarding price discovery are overall inconclusive.

This paper extends previous research by contributing in three main ways: Firstly, we analyze the bond/CDS relationship in European countries. To our knowledge, there have been no studies which are focusing on the European sovereign area. Secondly, we cover a relatively long time period, which allows comparing two periods with different characteristics. Thirdly, we make use of several variants of risk free rates to test which is the benchmark used by investors when pricing sovereign credit risk.

1.5. Outline of the Thesis

Chapter 2: Price discovery: Theory and literature review

Chapter 2 provides a theoretical framework and a literature review which is the foundation of this thesis. The mechanism of Credit Default Swaps is explained and a theoretical approach of the relationship between the two credit markets is outlined. In addition, the main results of prior research are presented. Only papers that are closely related to our research field are considered. At a later stage, we will refer to prior research to compare our results.

Chapter 3: Methodology

The methodology chapter is divided into the three main steps of our proceeding. Firstly, it describes how we select and obtain the data. Secondly, the tools of cointegration analysis are explained. Finally, we explain how we proceed to investigate price discovery.

Chapter 4: Empirical Analysis A: Greece

The results of the empirical analysis in the case of Greece are presented in this chapter. In an attempt to interpret our findings, we discuss, analyze and compare them with results of previous research.

Chapter 5: Empirical Analysis B: Italy, Portugal and Spain

Chapter 5 provides the results of the empirical analysis for the Euro zone countries Italy, Portugal and Spain. These results are compared to the findings in chapter 4. In addition, the results of all four countries are summarized and linked to previous research.

Chapter 6: Conclusion

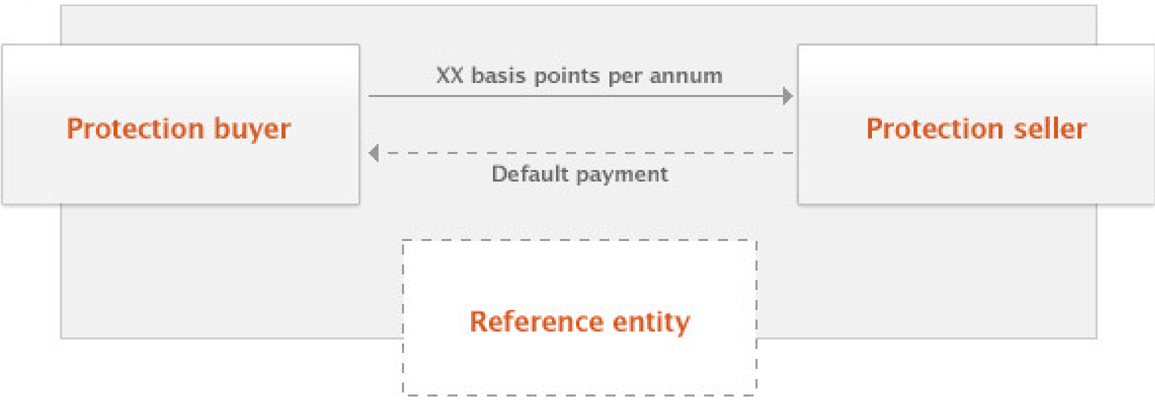
In this section we provide a quick summary of our main findings and discuss their validity. We also mention ideas on further studies related to this paper.

2. CDS and bond markets: theory and literature review

2.1. Mechanism of a CDS

Credit default risk is the risk that an issuer of debt is unable to meet its financial obligations.[26] A Credit Default Swap can be seen as an insurance against a credit default. Figure 2 shows how a CDS basically works. The buyer pays periodically a fixed fee to the seller of the protection. If a credit event occurs, the seller of the protection compensates the buyer for the loss.

Figure 2: Mechanism of a CDS



Source: ISDA online[27]

The price of a CDS, the CDS spread, reflects the market expectations regarding the risk of default and the recovery rate, i.e. the value of the reference security after the default. [28] The CDS spreads are expressed in basis points of the underlying security. In order to illustrate the mechanism of a CDS, a numerical example follows:

Investor A owns a Greek government bond with a notional of €10 million and wants to protect himself against the default risk. Therefore Investor A enters a CDS contract and pays a premium of 200 basis points. This means that it costs Investor A €200,000 per year, for the duration of the contract, to insure against default.

[26] Choudhry, M. (2004). An Introduction to Credit Derivatives. Elsevier Ltd. Page 2.

[27] http://www.isdacdsmarketplace.com/about_cds_market/how_cds_work

[28] Chan–Lau, Jorge A. Anticipating Credit Events Using Credit Default Swaps, with an Application to Sovereign Debt Crises. IMF Working Paper. May 2003. Page 3.

Settlement in case of a credit event can be in cash or physically. In most cases the protection buyer delivers a specific predefined asset (in case of the example above, the Greek government bond) to the seller and receives in return 100% of the notional.[29]

2.2. Relationship between bond market and CDS market

The analysis in this paper is based on the relationship between CDS prices and the bond spreads established by Duffie (1999) and Hull & White (2000). In simple terms, the relationship can be described as follows:

An investor who owns a bond can protect himself against the credit risk by buying a CDS with the same underlying as the bond. This strategy is riskless and should therefore yield the same cashflows as a risk free instrument.

This relationship can be used to estimate the price of credit default swaps. Start with a yield on a T-year bond (y) and subtract the T-year Treasury par yield (r). The result is a bond spread. The corresponding T-year credit default swap spread (p_{cds}) should equal the bond spread. Thus, the following equation should hold:

$$p_{CDS} = y - r \qquad \textbf{(1)}$$

This approximate relationship implies that an arbitrage opportunity arises if equation one does not hold. For pcds>y-r, an investor could short the risky bond, buy a cds protection as well as a risk free instrument to make an arbitrage profit. For pcds<y-r, she could again buy a cds protection but sell the risk free instrument and buy the risky bond.

Nevertheless, the equivalence relationship of equation one is based on a number of assumptions. In practice there are several reasons why the relationship might not exactly hold. Among other imperfections, transaction costs and bond short-sales restrictions are the most obvious and reduce the arbitrage opportunities. This asymmetry may have important

[29] http://www.dbresearch.de/PROD/DBR_MOBILE_EN-PROD/PROD0000000000183612.pdf Page 3

implications for the dynamic adjustment of credit spreads.[30] Unrealistic is the assumption that the risk free rate is constant over time. De Wit (2006, p. 7-8) summarizes and discusses the various basis drivers that have been described by both academic and market sources. Table 1 presents factors that can make the basis deviating from zero. They can have both positive and negative influence. The "factors can be grouped according to whether they are more fundamental or technical in nature." Fundamental factors would concern the characteristic of the CDS itself while technical ones are related to the market where the trading happens. It is not the aim of this paper to analyze these factors. Nevertheless, it is important to bear in mind that there a certain reasons why the relationship in practice does not hold perfectly. Despite the described weaknesses, the relationship in equation one is regularly applied by researchers when examining credit risk.[31] As the literature review in section 2.3 will show, previous research found the relationship to hold on the long run in most cases.

Table 1: Basis drivers summarized by De Wit (2006, p. 7)

		Basis		
		Positive	*Negative*	*Undecided*
Factors	*Fundamental*	**CDS cheapest to deliver option** CDS premia are floored at zero CDS restructuring clause - technical default Bond trading below par Profit realization	Funding issues Counterparty default risk Accrued interest differences on default Bond trading above par	Coupon specificities
	Technical	**Demand for protection - difficulties in shorting cash** Issuance patterns	**Synthetic CDO issuance**	**Relative liquidity in segmented markets**

Researchers in the field are in disagreement about the instrument one shall use to approximate the risk free rate. Instead of the government treasury bonds many researchers used the swap rate as approximation of the risk free rate. Hull et al. (2004) and Zhu (2006) find that the average price difference (with regard to equation (1)) is smaller and evidence of cointegration is stronger with the swap rate as risk free approximation than with US Treasury rates. They conclude that at least for the US market the swap rate has replaced the Treasury rate as proxy for the risk-free rate. Analyzing the period 1993 to 2001, Reinhart & Sack (2002) conclude that Treasury yields increasingly separated from the risk free rate. Several factors such as

[30] Zhu H (2004). An Empirical Comparison of Credit Spreads Between the Bond Market and the Credit Default Swap Market. BIS Working Paper No. 160, page 6

[31] Examples of papers with equation one as foundation are Zhu (2004), Blanco et al. (2005) and Chan-Lau & Kim (2004).

taxation, regulation and liquidity are responsible that government bond yields drop below the true risk-free rate.[32]

2.3. Literature review

Credit default swaps are a rather new instrument[33]. However, since the year 2000 there have been done numerous empirical researches in this field. Most of them focused on the corporate market, while only a few analyzed the sovereign market. Table 2 provides an overview of the main papers covering the CDS and bond relationship on corporate and sovereign level. On corporate level, previous findings indicate that the CDS market is leading the price discovery. Blanco et al. (2005) are mainly investigating the validity of the theoretical relationship between credit default swap prices and credit spreads. Their data consists of 33 companies (US and European) for the period 2001-2002. A similar study was conducted by Zhu (2004) with 24 mainly US firms for the period 1999-2002. In addition, Alexopoulou et al. (2009) discover that the lead-lag relationship strengthened following the sub-prime crisis in 2008. While most recent research deals with daily data, Alexopolou et al. examine weekly data. Dötz (2007) extends the work of Blanco et al. (2005) for 36 European firms for the period from 21 January 2004 to 31 October 2006. He finds evidence of cointegration for most of the companies. Concerning price discovery both markets make net contributions to price discovery, with the CDS market dominating slightly. Overall, Dötz (2007, p. 2) argues that the CDS market dominance seems to be stronger in the US market than in Europe.

The results for the sovereign market are mostly inconclusive. Chan-Lau & Kim (2004) discover indeed evidence of cointegration but concerning price discovery the findings are mixed. They examine eight emerging countries for the period March 2001–May 2003. They suggest that because bonds are more liquid in emerging markets, they are more likely to lead price discovery. Chan-Lau & Kim (2004) as well as In et al. (2007) find that the CDS market leads the pricing of risk in only little more than 50 % of the analyzed countries.

32 Hull et al. (2004). The relationship between credit default swap spreads, bond yields and credit rating announcements, Journal of Banking and Finance, 2004:28, pp. 2789-2811.

33 For the exact year of its invention no reliable source was found. Ranciere R.G. (2001) mentions the years 1996 and 1997 as real starting point of credit derivatives.

Finally, Houweling & Vorst (2001) and Hull et al. (2004) compare the credit risk pricing between the bond market and the CDS market with alternative risk free instruments. They suggest that using the swap rate as a proxy for the risk free rate gives better results to estimate the credit spread.

Our thesis is inspired by the mentioned papers and we follow mainly the proceedings of Zhu (2004) and Blanco et al. (2005). However, we expand the research in several ways. All studies known to us that focus on the sovereign market restrict their analysis on emerging markets, based on the findings of Packer & Suthiphongchai (2003, p. 87) that sovereign CDS trading activities are highest in emerging markets. However, the liquidity of sovereign CDS of developed countries increased in 2009, occasionally became even superior to sovereign CDS of emerging markets. The liquidity of Greek sovereign CDS is consistent with this trend.[34] Furthermore, we focus on a little number of countries but due to a relatively long sample period, we are able to compare two periods with different characteristics.

[34] Aubrey T & Brigo D (2010). Greece Sovereign CDS — A History of Myth and Reality. Fitch Solutions. Special report. Page 2

Table 2: Summary of main papers

Thesis	**Zhu (2004)**	**Chan-Lau, Kim (2004)**	**Blanco et al. (2005)**	**In, Kang, Kim (2007)**	**Alexopoulou et al. (2009)**
Reference entities	24 Corporates	8 Sovereigns (EM)	33 Corporates	7 Sovereigns (EM)	29 corporates
Period	1999-2002	2001-2003	2001-2002	2003-2006	2004-2008
Methods					
Bond spreads	Interpolation	EMBI+	Interpolation	Interpolation	Interpolation
Price discovery	VECM, Gonzalo-Granger	Granger Causality, VECM, Gonzalo-Granger, Hasbrouck	VECM, Gonzalo-Granger, Hasbrouck	CCR-VECM, Gonza-lo-Granger	VECM, Gonzalo-Granger
Findings					
Cointegration	15 of 24	5 of 8	26 of 33	7 of 7	mostly cointegrated
Price discovery	CDS leads in US	Inconclusive	CDS leads	in 3 of 7 countries CDS leads	CDS leads

3. Methodology

In order to test the long term equilibrium relationship between CDS and bond markets we use the cointegration analysis. The price discovery is determined using Granger causality tests and the price discovery measure proposed by Gonzalo & Granger (1995).

3.1. Cointegration analysis

Brooks (2008, p. 336) defines a cointegration relationship as follows: "A cointegrating relationship may (…) be seen as a long-term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association would return in the long run."

In order to test for cointegrating equations we apply a two step approach, as proposed by Engle-Granger (1987). In a first step, we test if the credit risk series have unit roots using Augmented Dickey-Fuller (ADF), Philips Peron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. While the null hypothesis of the ADF and PP tests is that the series is characterized by a unit root, the KPSS tests for stationarity. The equation of the ADF test is as follows:

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + u_t \tag{2}$$

The lagged first-differenced variables in the regression control for higher order correlation in the series. The null hypothesis is that $\psi = 0$ which implies that y is characterized by a unit root. The Phillips-Perron test is based on the following regression:

$$\Delta y_t = \alpha + \beta y_{y-1} + e_t \tag{3}$$

The null hypothesis is that $\beta=0$. The PP test allows for autocorrelated residuals, but still suffers of the weaknesses of the ADF test that its power is low if the process has a root that is close to non-stationary.[35] Therefore, also KPSS tests have been conducted in order to base our conclusions on stronger evidence. The test statistic is:

$$LM = \sum_t S(t)^2 /(T^2 f_0) \qquad (4)$$

Where f0 is an estimator of the residual spectrum at frequency zero and where S(t) is accumulative residual function[36]:

$$S(t) = \sum_{r=1}^{t} \hat{u}_r \qquad (5)$$

For the next step, checking if the series are cointegrated, we follow the proceeds of Zhu (2004) and De Witt (2005). Predicted by theory, arbitrage opportunities exist if the CDS spread does not equal the credit spread. Thus, one expects an equilibrium relationship in the long run between these two series. Since theory exactly suggests which linear combination we expect to be stationary (the series resulting of CDS spread minus credit spread, i.e. the basis spread), we can test for a unit root in the basis spread. Is this series found to be stationary, then the CDS spreads and the credit spreads are cointegrated, i.e. both markets price credit risk equally on the long run. Thus, theory predicts that the CDS spread and bond spread series are I(1) while the basis spread should be I(0). A less restricted and more common way of testing for cointegration is the residual based approach, where one checks if the residual series of the linear combination of two series have the property I(0). We proceed as follows: We first check if the restricted relationship holds, i.e. if the basis is I(0). Does this relationship not hold, we test if the residuals in equation (6) are I(0).

$$p_{cds} = \alpha + \beta p_{cs} + \varepsilon \qquad (6)$$

For both methods, we use again the Augmented Dickey Fuller and the Phillips Peron tests. However, for the residual based approach, the critical values change since we are “now oper-

[35] Brooks C (2008). Introductory Econometrics for Finance. Cambridge University Press. Page 330

[36] Eviews 5 User’s Guide. Quantitative Micro Software, LLC

ating on the residuals of an estimated model rather than on raw data"[37]. These critical values are taken from Brooks (2008, p. 624), while the critical values for the non-residual tests are given in EViews. Note that the two methods are very similar. In the restricted method, the parameters α and β in equation (6) are set to zero and one, respectively.

During the process of cointegrating analysis, the choice of the lag-length is an issue. The Schwarz information criterion (SIC) has been found to be a good indicator for large sample sizes[38] and is used in our tests. However, we restrict the lag length to a maximum of five lags since we expect the liquid markets to absorb new information within a week. EViews applies a modified version of the SIC when computation unit root tests.

$$-2(l/T)+2((k+\tau)/T) \tag{7}$$

Where l is the value of the log of the likelihood function with k parameters estimated using T observations. The information criterion is based on –2 times the average log likelihood function, adjusted by a penalty function 2((k+τ)/T). The modification factor τ is computed as[39]

$$\tau = \alpha^2 \sum_t y_{t-1}^2 / \sigma^2 \tag{8}$$

3.2. Price discovery

Lehman (2002, p. 259) interprets price discovery as follows: "the efficient and timely incorporation of the information implicit in investor trading into market prices". Yan & Zivot (2007, p. 10) provide a simpler definition: "price discovery is the dynamic process by which a market incorporates new fundamental information". The term is commonly used with regard to the stock market, e.g. if a corporate stock is traded on two stock markets, in which market is information quicker incorporated in the price. In relation with the CDS market, price discovery tools are used when analyzing where the price of credit risk adapts quicker to new

[37] Brooks C (2008). Introductory Econometrics for Finance. Cambridge University Press.

[38] Asghar & Abid (2007). Performance of lag length selection criteria in three different situations. Quaid-i-Azam University Islamabad,Pakistan. Page 8

[39] Eviews 5 User's Guide. Quantitative Micro Software, LLC

information. Credit risk is priced on two markets, the CDS market and the bond market. Analyzing price discovery means examining whether the CDS or the bond market moves ahead. If the bond market moves ahead of the CDS market, one can say that the bond market dominates price discovery. There are several ways to determine price discovery. In this paper we use the most common tools.

As a first indication of the dynamic relationship between the two markets, Granger causality tests are conducted. These tests answer the question if changes in series X cause changes in series Y. Theory suggests for the credit markets a bidirectional relationship, i.e. changes in the bond spreads cause changes in the CDS spreads and vice versa. The Granger causality test between variable X and Y is based on the following equation:

$$X_t = c + \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{i=1}^{p} \beta_i Y_{t-i} + \varepsilon_t \qquad (9)$$

The parameter β is zero if there is no Granger causality from Y to X. Thus, the null hypothesis, H_0: β_i=0 for all i. The test is performed using standard F-tests. If H_0 can be rejected, then Y Grangers-causes X. However, the word 'causality' is somewhat misleading because "Granger-causality really means only a correlation between the current value of one variable and the past values of others".[40] In order to capture the relationship in more detail, we model a Vector error correction model (VECM) which is a VAR (Vector autoregressive model) augmented by an error correction term. A prerequisite for this step is that the bond spreads and the CDS spreads are cointegrated. In our case, the VECM looks as follows:

$$\begin{aligned} \Delta p_{CDS,t} &= \lambda_1 \left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{CS,t-1} \right) + \sum_{j=1}^{p} \beta_{1j} \Delta p_{CDS,t-j} + \sum_{j=1}^{p} \delta_{1j} \Delta p_{CS,t-j} + \varepsilon_{1t} \\ \Delta p_{CS,t} &= \lambda_2 \left(p_{CDS,t-1} - \alpha_0 - \alpha_1 p_{CS,t-1} \right) + \sum_{j=1}^{p} \beta_{2j} \Delta p_{CDS,t-j} + \sum_{j=1}^{p} \delta_{2j} \Delta p_{CS,t-j} + \varepsilon_{2t} \end{aligned} \qquad (10)$$

[40] Brooks, Chris, Introductory Econometrics for Finance, Cambridge University Press 2008, p. 298.

The term ($p_{cds,t-1}$-α_0-$\alpha_1 p_{cs,t-s}$) is called the error correction term. If α_0 set to zero and α_1 set to 1, the term equals a lagged basis spread. The adjustment coefficients λ1 and λ2 measure to which degree prices in each market adjust to pricing differences from their long term trend.[41] If λ2 is significantly positive, the bond market adapts to erase pricing errors. This would imply that the CDS market moves ahead of the bond market and that the bond market has to adjust for new information. The reverse situation is that λ1 is significantly negative, i.e. the bond market moves ahead of the derivative market. Previous studies by among others Zhu (2004), Blanco et al. (2005) and Chan-Lau & Kim found mostly significant lambdas with the expected sign, positive for λ2 and negative for λ1.

In order to measure the relative contribution of each market to price discovery, the Gonzalo-Granger method[42] is introduced. This model is expressed as follow:

$$GG = \frac{\lambda_2}{\lambda_2 - \lambda_1} \tag{11}$$

Where λ_1 and λ_2 stand for the speed adjustment factors estimated in the VECM. The Gonzalo-Granger ratio reveals the relative magnitude of λ1 and λ2, i.e. which of the markets dominates in terms of price discovery.

3.3. Obtaining data

In order to analyze the relationship between the bond spread and the CDS spread, data for the mentioned two variables is needed. While the latter is given on Thomson Reuters Datastream, bond spreads must be created stepwise.

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[41] Zhu H (2004). An Empirical Comparison of Credit Spreads Between the Bond Market and the Credit Default Swap Market. BIS Working Paper No. 160. Page 7

[42] Gonzalo J & Granger C.W.J. (1995). Estimation of Common Long-Memory Components in Cointegrated Systems. *Journal of Business and Economic Statistics*, Vol. 13, pp. 27–35.

3.3.1. CDS spreads

Concerning the CDS data series we have to decide upon the currency and maturity we want to analyze. Since 5-year contracts are the most liquid and frequently quoted ones[43] they are in favor of previous researchers. Since the purpose of this paper is to investigate a relationship between two markets, we follow this path and use CDS series with 5 years to maturity. Using a series of less liquid contracts might distort the relationship of the two markets and give a wrong picture in terms of price discovery. Regarding the currency, the Euro seems to be the currency of choice because we analyze countries in the Euro zone and the bonds are issued in Euro. However, there are also factors speaking for the series of contracts denominated in US Dollar. In times when investors rather expect a depreciation of the Euro against the US Dollar, the market of (Greek) CDS contracts in USD becomes more liquid. This is obvious, because a CDS contract that is traded in USD will be more valuable than the same contract in Euro after the depreciation. Considering the currency expectations during the Greek debt crisis (Euro depreciating against USD), the choice of the series in USD makes sense. In addition, in our case the series in USD is longer and allows for a comparison of the relationship before and during the debt crisis. The daily sovereign CDS spreads can be obtained from Thomson Reuters Datastream. The sample period is 01-2006 – 04-2010. Besides Greece, we also download data for Italy, Portugal and Spain. The findings for these countries are expected to provide a useful comparison to the findings in the case of Greece since they also are in the EMF. This might be important in order to get comparable results since CDS spreads can be depressed due to the fact that a country is member in the EMF.[44] The CDS spreads of Euro zone countries might incorporate the possibility that the EMF supports a country in the case of a crisis. In addition, these three countries are among the big names on the sovereign CDS market.[45]

3.3.2. Bond spreads

Optimally, we would have for each day of the CDS series a yield of a bond with 5 years to maturity. Since this is not the case in practice, we need to create a generic bond. For this pur-

[43]http://www.markit.com/assets/en/docs/products/data/indices/credit-index-annexes/CDS_glossary.pdf

[44] Gros Daniel (2010). How to deal with sovereign default in Europe: Towards a Euro(pean) Monetary Fund. European Parliament. Brussels.

[45] http://www.isda.org/media/press/2010/press031510.html

pose, the interpolation and matching methods are used, as proposed by Houweling & Vorst (2005). They use bonds that differ at most by 10 % from the maturity of the CDS (matching method) or linearly interpolate two bonds. One of these two bonds must have a larger maturity than the CDS premium (maximum twice as large), the other must have a smaller maturity than the CDS premium (maximum twice as small). Since the sovereigns we are investigating have issued many bonds for the sample period, we can apply stricter rules to receive more precise approximations. We construct the generic bond series as follows:

1. If there are two bonds of which the maturity differs from the CDS maturity by maximum 5 % (one bond with larger maturity, the other bond with smaller maturity), we linearly interpolate these bond yields.
2. If there is only one bond of which the maturity differs from the CDS maturity by maximum 5 %, we use the yield of this bond.[46]
3. If there is no bond of which the maturity differs from the CDS maturity by maximum 5 %, we linearly interpolate the yield of a bond with larger maturity and a bond with smaller maturity.

In order to avoid measurement errors, we choose no bonds that have embedded options, are subordinated or have special features.

3.3.3. Risk free rate approximation

In order to receive the bond spread, we deduct in a final step the risk free rate from the created bond yield series. There are various alternatives that can be used as approximation of the risk free rate. As discussed in section 2.3, previous research considered the swap rate as well as the Treasury yields. Since we solely deal with data from the euro zone, we consider the Euro swap rate and the German government bond relevant alternatives. The German government bond is often referred to as the euro zone benchmark.[47] Blanco et al. (2005) use in their study the Euro swap rate and the German government bond for European corporate. He finds a closer relationship between the two markets when using the swap rate. However, the difference between the two rates is small compared to the US market. Blanco et al. (2005) also point to the fact that the swap rates contain credit premia because they are based on the LI-

[46] One situation for the Portuguese generic bond occurred, when the matching method had to be extended to five months.

[47] http://www.reuters.com/article/idUSLDE64B1XO20100512

BOR or EURIBOR, which are default-risky interest rates. In addition, the rates contain counterparty risk. As a new alternative, we use a hypothetical AAA government bond yield benchmark for the euro zone, which is provided by Datastream.

Thus, three bond spread series per country are computed:

- Generic bond series over the German government bond yield
- Generic bond series over the Euro swap rate
- Generic bond series over a benchmark AAA government bond yield

All of the three risk free proxies are available with 5 year to maturity and are obtained from Datastream.

3.4. Reliability and Validity

To enhance the quality of our work and ensure that a replication of our proceedings would result in the same outcome, the following measures are taken:

- All quantitative data is gathered from the same source (Thomson Reuters Datastream).
- All tests are run systematically for all countries and randomly double checked.
- Alternative approximations of the risk free rate are used to minimize the probability of wrong conclusions.
- Well known and commonly applied methods are used (simplifies comparability with related papers).
- All tests are conducted with the same software (EViews 5).
- Stricter rules regarding the interpolation of the bond yields are imposed than in previous studies.

4. Empirical Analysis A: Greece

4.1. Basis and implied risk free rate

Figure 3 presents the CDS spreads in relationship with the bond spreads over the sample period. At a first glance, all three series of bond spreads move close with the CDS series. However, during 2008 the bond spreads computed using the swap rate and the benchmark are obviously far below the CDS spreads. Computing the bases with the three alternative risk free rates and comparing their characteristics gives an indication of how close the relationships are. Table 3 summarizes the main characteristics. The results are presented for three periods:

01-2006 to 04-2010

01-2006 to 12-2008

01-2009 to 04-2010

We split up the sample period for the following reasons. Firstly, the liquidity in the sovereign CDS markets of developed countries increased strongly in 2009[48]. Therefore, these two periods might give different results. Secondly, we want to compare the period of the debt crisis to a pre-crisis period. The periods are divided in the same manner for all steps of the empirical analysis. The results of Table 3 imply that investors rather use the German government bond as risk free proxy than the Euro Swaprate. The mean, the median as well as the standard deviation are smaller for the German government bond, no matter which period we observe. While Basis 1 has a negative mean, the mean of the basis computed with the swaprate is positive. This is based on the fact that the Euro Swaprate is in most cases above the German bund yields. Our findings are partly in line with the findings of Blanco et al. (2005) and Zhu (2004) for US corporations. On average, they find a positive basis when using the Swaprate and a negative basis with the Treasury bond yields. However, in their case the Swaprate is the better proxy than the Treasury yields, they find a basis of +6bps (Zhu +13 bps) and -41 bps (-55 bps), respectively. Observing European corporations, Dötz (2005) uses the Euro Swaprate as risk free rate and finds a mean of +4 basis points. In the case of Greek sovereign credit risk, we find for both periods an average basis spread of at least +30 basis points when we use the Swaprate as risk free proxy.

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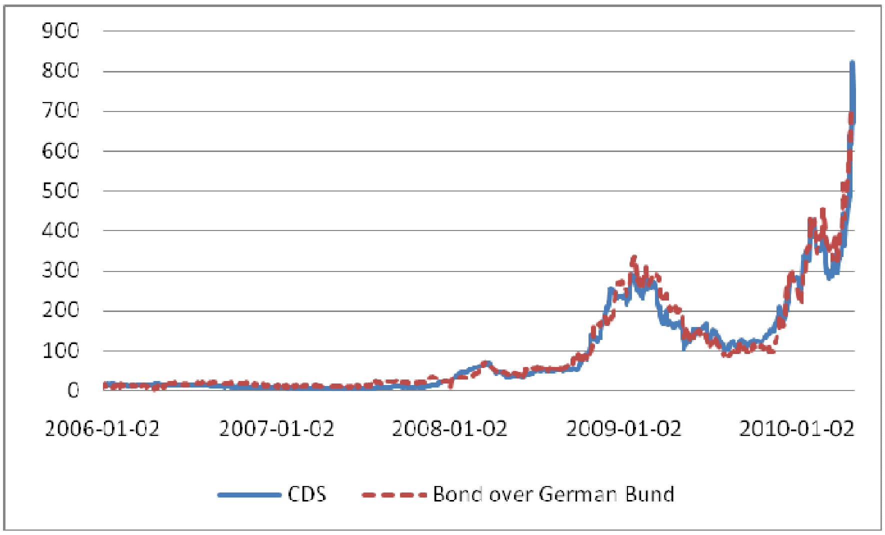
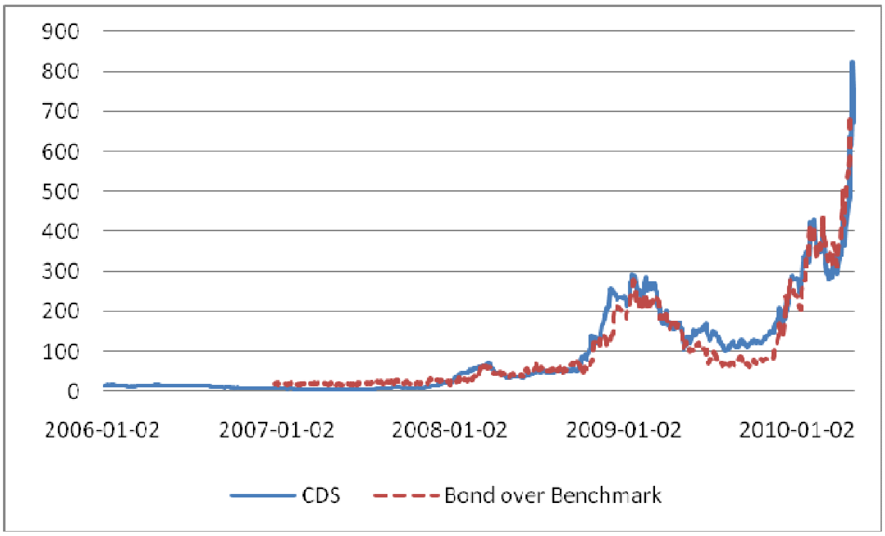
[48] Aubrey T & Brigo D (2010). Greece Sovereign CDS — A History of Myth and Reality. Fitch Solutions. Special report. Page 2

The basis computed with the AAA Benchmark yields provided by Datastream give mixed results and is somewhere between the Swaprate and the German bond, which was expectable. An AAA Benchmark is expected to have lower yields than the German bond, since it is less risky. The Basis is the generic bond minus the risk free rate. Thus, the Basis should be larger using the AAA Benchmark.

Figure 3: Greece, CDS spreads and bond yield spreads





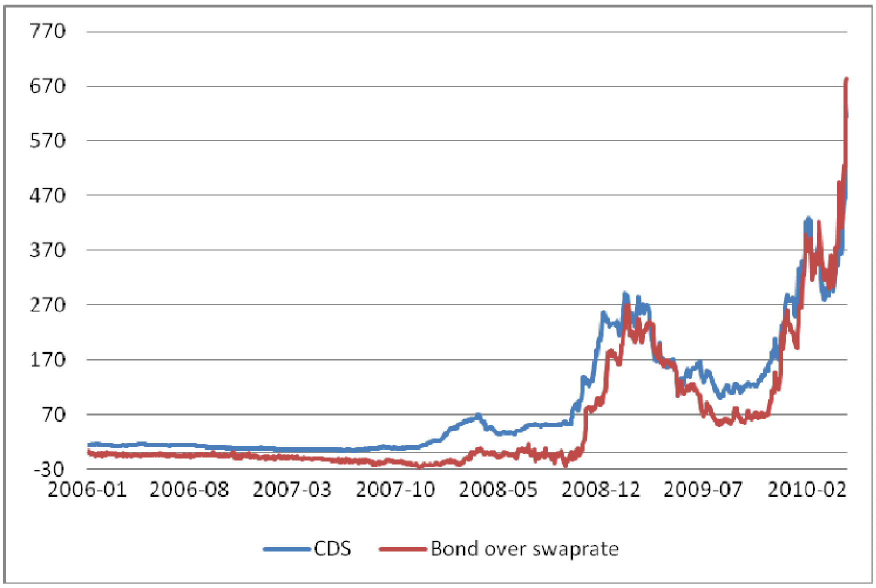


Table 3

Characteristics of basis spreads, Greece

	Mean	Median	Std. Dev.
Period: 01.01.2006-23.04.2010			
Basis 1	-5.6	-5.3	20.7
Basis 2	32.4	24.8	27.7
Basis 3	8.6	-2.0	29.9
Period: 01.01.2006-31.12.2008			
Basis 1	-4.1	-5.4	11.7
Basis 2	33.4	20.4	24.2
Basis 3	-1.1	-10.1	22.9
Period: 01.01.2009-23.04.2010			
Basis 1	-8.8	-4.1	33.0
Basis 2	30.0	39.5	34.5
Basis 3	23.4	34.7	33.0

Basis 1 = Generic bond yields over German Goverment bond yields
Basis 2 = Generic bond yields over swaprate
Basis 3 = Generic bond yields over AAA Benchmark

4.2. Dynamic relationship between the two credit spreads

4.2.1. Long term equilibrium

In order to examine the long term co-movements of the CDS premia and the bond spreads, the methods described in section three are applied. The ADF, PP and KPSS tests are run on the CDS spreads as well as the bond spreads series. The three tests deliver consistent results in levels. While the ADF and PP do not reject the null Hypotheses that the series have a unit root, the KPSS rejects that the series are stationary. Running the tests on the same series in first differences gives mixed results. The ADF and the PP are still consistent and reject a unit root for all of the series. However, the KPSS rejects stationarity in a few cases. With regard to the strong and consistent results of the unit root tests and the inconsistent but weak rejections of the stationarity test, we conclude that all of the series are integrated of order one.

In a next step, we check for a long term equilibrium relationship by simply testing for a unit root in the basis spread. In case we can reject the null hypothesis of a unit root, one can expect that both markets price credit risk equally. Except from the period 2006-2008 using the swap rate, the null hypothesis that the series have a unit root are rejected. Loosening the restrictions that α_0=0 and α_1=1, i.e. applying the residual based approach, we find a cointegrated relationship even for this series. Cointegration without these restrictions means that the two series move together on the long run. However, the model allows for a constant and a trend, meaning that the markets don't price credit risk equally. In general we find strong evidence that the two markets are closely related. The relationship predicted by theory holds on the long run. Regarding the alternative risk free rates, the series with the German government bond shows the strongest evidence of cointegration. With respect to the findings in 4.1, we conclude that the German government bond is the benchmark used by market participants. The results of the cointegration testing are provided in Table 4.

Table 4

Tests for cointegrating relationship

	Restricted				Residuals based			
	ADF		PP		ADF		PP	
Period: 01.01.2006-30.04.2010								
Basis 1	-4.226	***	-4.954	***	-		-	
Basis 2	-1.878	*	-2.008	**	-		-	
Basis 3	-3.114	***	-3.308	***	-		-	
Period: 01.01.2006-31.12.2008								
Basis 1	-7.491	***	-5.562	***	-		-	
Basis 2	-1.500		-1.308		-4.176	***	-3.740	**
Basis 3	-2.274	**	-2.878	**	-		-	
Period: 01.01.2009-30.04.2010								
Basis 1	-2.141	**	-2.485	**	-		-	
Basis 2	-1.706	*	-1.594		-3.588	**	-3.415	**
Basis 3	-2.062	**	-1.871	*	-		-	

Basis 1 = Difference between CDS spread and bond spread using German Bund
Basis 2 = Difference between CDS spread and bond spread using swap rate
Basis 3 = Difference between CDS spread and bond spread using AAA Benchmark
***H0 rejected at 99% level
**H0 rejected at 95% level
*H0 rejected at 90 % level
H0 not rejected
H0 rejected at 95 % level
H0 rejected at 99 % level

4.2.2. Short-term linkages

The Granger causality tests are conducted as described in the method section. The differenced series of bond spreads and CDS spreads are substituted into X and Y. The lag lengths are chosen upon the Schwarz information criteria. Regarding the complete sample period, the test results indicate a two-way relationship, i.e. CDS spreads Granger-cause bond spreads and vice versa. For the period starting 2009, the null hypothesis that bond spreads do not Granger-cause CDS spreads cannot be rejected. Thus, we find a bidirectional relationship for 2006-2008 and a unidirectional relationship for 2009-2010. Previous studies (among others Zhu (2004) and Blanco et al. (2005)) on corporate level found bidirectional relationships for most entities. However, the Granger-causality test results give no clear indication on the dominance of price discovery in the credit markets. Therefore, a Vector Error Correction Model is constructed.

The expectations for the VECM are that $\lambda1$ is significantly negative and $\lambda2$ significantly positive. Since the results of 4.2 imply that the German government bond is the most accurate approximation of the risk free rate in the examined relationship, the VECM is solely modeled using the German bond basis. As Table 5 shows, the signs of all coefficients are as expected. However, they are not significant during the final period, when the relationship between the two markets was the least strong.[49] The clearer the cointegrating relationship, the faster will the speed adjustment parameters correct short term errors. In our case, both coefficients are insignificant, statistically speaking zero. This suggests that the two variables are exogenous and have no impact on each other. The finding that the relationship is looser for the second period is puzzling because the liquidity in the CDS market rose at the same time. A liquid market is expected to correct quickly for pricing errors and remove arbitrage opportunities.

The last column of Table 5 presents the results of the Gonzalo-Granger measure. A value close to 0.5 indicates that no market is dominating the price discovery of credit risk. Values close to zero (one) imply that the bond market (CDS market) is stronger in the process of price discovery. For the period 2006-2008 the CDS market contributes 69 % of price discov-

[49] In 4.1.2 the unit root for the final period was rejected only on a 95 % level.

ery, which is in line with the findings on corporate level.[50] We find inverse results for the period starting 2009, when the GG measure indicates a rather strong dominance of the cash bond market. However, the validity of the GG ratio for the final period is at least questionable, since λ1 and λ2 in the VECM indicate no significant correction against errors. These results also stand in conflict with the findings of the Granger-causality tests where we found a unidirectional relationship from the CDS market to the bond market.

Table 5

VECM test results

	λ1	T-statistics		λ1	T-statistics		GG
Period: 01.01.2006-23.04.2010	-0.0294	[-2,366]	**	0.0216	[1,896]	*	0.4236
Period: 01.01.2006-31.12.2008	-0.0289	[-3,837]	***	0.0653	[6,026]	***	0.6929
Period: 01.01.2009-23.04.2010	-0.0312	[-1,258]		0.0049	[0,228]		0.1354[51]
*** significant on a 99% level ** significant on a 95% level * significant on a 90% level							

[50] Blanco (2005) found on average a GG measure of 79% and Zhu (2004) found 66 %.

[51] The coefficients λ1 and λ2 are insignificant for this period, statistically speaking zero. Anyway, following Blanco et al. (2005), the GG measure is computed to give an indication of price discovery.

5. Empirical Analysis B: Italy, Portugal and Spain

We now want to compare our findings for Greece with other European countries by applying the same methodology. Our analysis focuses on Italy, Portugal and Spain. Due to our results for Greece, only the German Government bond is used as a proxy for the risk free rate through all the following computations. In addition, the same method as for Greece to construct a generic bond has been applied. All data is provided by Thomson Reuters DataStream.

We first test for a unit root (ADF, PP and KPSS) in the main series for the three countries. In accordance with Greece, CDS spread and bond spread have one unit root. We then investigate for cointegration with the restricted (with the basis spread) and where necessary with the unrestricted (using the residuals) model. The results are summarized in Table 6 showed below. For the period 2006-2008, the null-hypothesis of one unit root in the basis spread is rejected at 99% for Spain and Portugal and 95% for Italy. In other words, we have evidence of cointegration. However, when investigating the period 2009-2010, we fail to find stationarity in the basis spreads for all three countries. We end up with the same results when we run the test on the residuals of equation (6). These findings imply that for the period 2009-2010 the series were not cointegrated and credit risk was not equally priced on the two markets. Compared to the results for Greece, these outcomes are not totally surprising. The VECM as well as the unit root tests on the basis suggest a weaker relationship after 2008. Extreme movements in both markets might be the explanation for these results.

Table 6

Tests for cointegrating relationship

	Restricted				Residual based approach		
	ADF		PP		ADF		PP
Period: 01.01.2006-31.12.2008							
Italy	-2.4971	**	-2.5108	**	-		-
Spain	-3.9906	***	-3.5289	***	-		-
Portugal	-2.4971	**	-2.5108	**	-		-
Period: 01.01.2009-30.04.2010							
Italy	-0.3858		-0.1510		-1.9623		-1.8270
Spain	-0.0742		0.1457		-2.2014		-2.1162
Portugal	-0.3858		-0.1510		-1.9623		-1.8270

*H0 rejected at 90% level
**H0 rejected at 95% level
***H0 rejected at 99 % level

In a next step we conduct a Granger causality test on the two series for each country. The lag length is defined by the Schwarz information criterion (SIC). We plotted the results in Table 7.

Table 7

Results of Granger causality

	CDS spreads do not Granger cause bond spreads		Bond spreads do not Granger cause CDS spreads	
Period: 01.01.2006-31.12.2008				
Bond spread - Greece	14.8613	***	6.83562	***
Bond spread - Spain	20.6916	***	7.14842	***
Bond spread - Italy	9.0309	***	1.22937	
Bond spread - Portugal	12.3562	***	3.07845	**
Period: 01.01.2009-23.04.2010				
Bond spread - Greece	3.20835	***	0.74302	
Bond spread -Spain	13.469	***	2.14844	
Bond spread - Italy	5.2475	***	2.48029	*
Bond spread - Portugal	24.5391	***	5.77743	***

***rejected on 99% level
**rejected on 95% level
*rejected on 90% level

As we can see, the results are overall heterogeneous regarding countries. However, in one point the results are consistent. For all countries, we can reject that CDS spreads do not Granger-cause bond spreads. In the case of Italy and Spain, we have a unidirectional relationship from CDS spreads to bond spreads in the second period. Portugal is the only country in our data set where for both periods the series Granger cause each other.

In order to investigate price discovery we compute a VECM with the two spreads. A lag length of 5 was used for all countries according to SIC and since we deal with daily data. We only analyze the short run interaction of the two series for the period 2006-2008 because we didn't find co-integration in the second period. For all countries the restrictions $\alpha_0=0$ and $\alpha_1=1$ are imposed on the model, since we found that the restricted relationship holds (see Table 6). The results of the VECM are provided in Table 8.

Table 8

Results VECM and GG

	λ1	T-statistics		λ2	T-statistics		GG
Period: 01.01.2006-31.12.2008							
Spain	-0.0015	[-0,18700]		0.0339	[4,30194]	***	0.957
Italy	-0.0044	[-1,11983]		0.0125	[2,18214]	**	0.741
Portugal	-0.0138	[-1.61361]		0.0191	[2.36878]	**	0.580
Greece	-0.0289	[-3,83799]	***	0.0653	[6,02632]	***	0.693
Average							0.743

*** significant on a 99% level
** significant on a 95% level
* significant on a 90% level

Consistent with the findings in the case of Greece, all λ_2 are positive and statistically significant. As expected, all λ_1 are negative, implying that also the CDS markets removes short term pricing errors. However, for all three countries the coefficient λ_1 is found to be insignificant. This is in line with the findings of Blanco et al. (2005). In his paper examining the US credit market on corporate level, he finds λ_2 to be significantly positive in 25 of 27 cases, while in only 8 cases λ_1 is significantly negative.

In all three countries, the CDS spread contributes to price discovery. While the signs of λ_1 are correct, the speed adjustment parameters do not confirm contribution to price discovery for the bond spread.

We also perform a Gonzalo-Granger ratio for Spain, Portugal and Italy to see the relative contribution to price discovery of the two markets. In the case of Portugal, the ratio is very close to 0.5, implying that both markets contribute almost equally to price discovery. When we include the results of Greece, we find strong evidence that for the period 2006-2008 the process of price discovery was dominated by the CDS market. The average GG ratio of 74 % is comparable to previous results on corporate level[52]. The GG ratios are also more consistent than the findings of Chan-Lau & Kim (2004) and In et al. (2007) for emerging markets. Chan-Lau & Kim find GG ratios between 8% and 84% and also In et al. find ratios both below and above 50 %.

[52] Blanco et al. (2005) found on average a GG measure of 79% and Zhu (2006) found 66 %.

6. Conclusion

This paper has examined the relationship of the bond market and the Credit default swap market on a sovereign level in the Euro zone. The results support theory in the way that the two markets are bound by a long term relationship. However, we find short periods when large price discrepancies occur. In the case of Greece, prices on the CDS market differ by up to 100 basis points from the bond spreads. Remarkably, these extreme values are found on days when the bond spreads are above the CDS spreads. Looking at the limited period 2009 to 2010, no cointegration is found for three of the four investigated countries. This indicates a loosening relationship after 2008.

Three instruments were used as approximation of the risk free rate when examining the relationship of the two credit markets. For the market of sovereign credit risk in the Euro zone, the German bund might be the best benchmark. The Euro Swaprate is in most cases above the German bund yields, which results in bond spreads often way below the CDS spreads. On corporate level, previous research found the Swaprate to be the best approximation of the risk free rate.

Regarding price discovery, the CDS market moves ahead of the bond market for the period of 2006 to 2008. On average, about 75 % of price discovery takes place on the derivative market. Previous research on corporate level indicated that the dominance of the CDS market in terms of price discovery is stronger in the US than in Europe. Our results however show that at least on a sovereign level, the credit risk is mainly priced on the CDS market. The results are consistent for all of the four examined countries. This stands in contrast with the findings for emerging markets where big differences between the countries were found.

The lack of cointegrating relationships for the period starting 2009 made it impossible to investigate the short term interactions with a VECM. Nevertheless, the results of the Granger-causality test indicate that the bond market is Granger-caused by the CDS market while the latter is exogenous in some countries, including Greece. In general, the relationship between the markets is loser for the period 2009 to 2010. Extreme reactions on both markets might be responsible for this result. They lead to high price discrepancies and the markets were not efficient enough to remove the pricing errors, despite increasing liquidity on the CDS market.

It was not the aim of this paper to investigate the influence of so-called naked CDS on the pricing of credit risk. Nevertheless, we showed that the CDS market plays an important role for the pricing of sovereign credit risk in the Euro zone. This combined with the fact that naked CDS are allowed, implies that at least theoretically big market players might be able to distort the picture of a country's credibility by misusing the instrument CDS.

Future research might depend on the question if new regulations are imposed on the CDS market. This would open the door for researchers to measure the influence of new regulations. In the case of Greece, it would be interesting to see if the future relationship between the two markets goes back to the level before the debt crisis.

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Appendix 1

Table

Unit root test - Greece

Period: 01.01.2006-30.04.2010	ADF	PP	KPSS
CDS spread	I(1)	I(1)	not I(0)
Bond spread 1	I(1)	I(1)	not I(0)
Bond spread 2	I(1)	I(1)	not I(0)
Bond spread 3	I(1)	I(1)	not I(0)
Period: 01.01.2006-31.12.2008			
CDS spread	I(1)	I(1)	not I(0)
Bond spread 1	I(1)	I(1)	not I(0)
Bond spread 2	I(1)	I(1)	not I(0)
Bond spread 3	I(1)	I(1)	not I(0)
Period: 01.01.2009-30.04.2010			
CDS spread	I(1)	I(1)	not I(0)
Bond spread 1	I(1)	I(1)	not I(0)
Bond spread 2	I(1)	I(1)	not I(0)
Bond spread 3	I(1)	I(1)	not I(0)

Unit root test - Levels I(0) **Period: 01.01.2006-30.04.2010**	ADF (SIC-max 5 lags)	PP	KPSS
CDS spread	3.443	3.331	3.14466###
Bond spread 1	4.232	3.846	2.891228###
Bond spread 2	4.241	4.411	2.542785###
Bond spread 3	3.939	3.562	2.218235###
Period: 01.01.2006-31.12.2008			
CDS spread	2.764	4.206	1.668242###
Bond spread 1	3.864	4.876	1.836466###
Bond spread 2	1.989	2.935	0.714276##
Bond spread 3	2.970	2.734	1.885376###
Period: 01.01.2009-30.04.2010			
CDS spread	1.540	2.031	0.945338###
Bond spread 1	1.268	2.456	0.791589###
Bond spread 2	2.140	2.769	0.886605###
Bond spread 3	1.709	2.877	0.938036###

Appendix 1 continued

Unit root test - First difference I(1) **Period: 01.01.2006-30.04.2010**	ADF (SIC-max 5 lags)	PP	KPSS
CDS spread	-8.5466***	-29.342***	0.585514##
Bond spread 1	-22.593***	-23.116***	0.653311##
Bond spread 2	-8.4148***	-27.490***	0.755915###
Bond spread 3	-20.498***	-21.091***	0.674841##
Period: 01.01.2006-31.12.2008			
CDS spread	-8.4424***	-25.915***	0.811929###
Bond spread 1	-12.672***	-29.702***	0.90846###
Bond spread 2	-12.6422***	-32.667***	0.777653###
Bond spread 3	-14.5258***	-24.207***	0.512418##
Period: 01.01.2009-30.04.2010			
CDS spread	-5.7466***	-16.461***	0.665008###
Bond spread 1	-11.886***	-11.437***	0.871716###
Bond spread 2	-21.306***	-21.950***	0.86369###
Bond spread 3	-12.3471***	-12.079***	0.901634###

Bond spread 1 = Generic bond over German Bund — *H0 rejected at 90% level
Bond spread 2 = Generic bond over Swap rate — **H0 rejected at 95% level
Bond spread 3 = Generic bond over AAA Benchmark — ***H0 rejected at 99 % level
Stationarity rejectecd at 99% level. — H0: Has one unit root
Stationarity rejectecd at 95% level.
Stationarity rejectecd at 90% level.

Appendix 2

Table

Unit root test - ITALY

	ADF	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	I(1)	I(1)	I(1)
Bond spread	I(1)	I(1)	I(1)
Period: 01.01.2006-31.12.2008			
CDS spread	I(1)	I(1)	not I(0)
Bond spread	I(1)	I(1)	not I(0)
Period: 01.01.2009-30.04.2010			
CDS spread	I(1)	I(1)	I(1)
Bond spread	I(1)	I(1)	I(1)
Unit root test - Levels			
I(0)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	-0.097785	0.057471	3.003691###
Bond spread	-0.815511	-0.653898	2.067557###
Period: 01.01.2006-31.12.2008			
CDS spread	2.531709	2.618707	1.736919###
Bond spread	1.569252	1.715959	1.330843###
Period: 01.01.2009-30.04.2010			
CDS spread	-0.945842	-0.674096	0.8271###
Bond spread	-1.529116	-1.602082	1.633231###
Unit root test - First difference			
I(1)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	-25.5694***	-25.42005***	0.092204
Bond spread	-30.30685***	-30.16122***	0.062423
Period: 01.01.2006-31.12.2008			
CDS spread	-13.39278***	-18.60728***	0.620641##
Bond spread	-27.62055***	-27.61867***	0.349552#
Period: 01.01.2009-30.04.2010			
CDS spread	-15.08567***	-15.00517***	0.242931
Bond spread	-15.11009***	-14.81819***	0.178787

*H0 rejected at 90% level
**H0 rejected at 95% level
***H0 rejected at 99 % level
H0: Has one unit root

Stationarity rejectecd at 99% level.
Stationarity rejectecd at 95% level.
Stationarity rejectecd at 90% level.

Appendix 3

Table

Unit root test - SPAIN

	ADF	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	I(1)	I(1)	I(1)
Bond spread	I(1)	I(1)	I(1)
Period: 01.01.2006-31.12.2008			
CDS spread	I(1)	I(1)	I(1)
Bond spread	I(1)	I(1)	not I(0)
Period: 01.01.2009-30.04.2010			
CDS spread	I(1)	I(1)	I(1)
Bond spread	I(1)	I(1)	I(1)
Unit root test - Levels			
I(0)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	0.624436	0.773927	3.597816###
Bond spread	-0.427286	-0.196588	2.820757###
Period: 01.01.2006-31.12.2008			
CDS spread	0.624436	0.773927	3.597816###
Bond spread	1.94991	2.939425	1.820663###
Period: 01.01.2009-30.04.2010			
CDS spread	0.181336	0.387117	0.438535#
Bond spread	-0.796654	-0.711226	0.921724###
Unit root test - First difference			
I(1)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	-28.5298***	-28.52815***	0.153838
Bond spread	-30.18307***	-30.0196***	0.085779
Period: 01.01.2006-31.12.2008			
CDS spread	-28.5298***	-28.52815***	0.153838
Bond spread	-31.45431***	-31.65544***	0.597004##
Period: 01.01.2009-30.04.2010			
CDS spread	-14.94346***	-14.907***	0.227631
Bond spread	-12.59594***	-13.11164***	0.257631

*H0 rejected at 90% level
**H0 rejected at 95% level
***H0 rejected at 99 % level
H0: Has one unit root

Stationarity rejectecd at 99% level.
Stationarity rejectecd at 95% level.
Stationarity rejectecd at 90% level.

Appendix 4

Table

Unit root test - Portugal

	ADF	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	I(1)	I(1)	not I(0)
Bond spread	I(1)	I(1)	I(1)
Period: 01.01.2006-31.12.2008			
CDS spread	I(1)	I(1)	not I(0)
Bond spread	I(1)	I(1)	I(1)
Period: 01.01.2009-30.04.2010			
CDS spread	I(1)	I(1)	not I(0)
Bond spread	I(1)	I(1)	I(1)
Unit root test - Levels			
I(0)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	1.746865	1.957563	3.209111###
Bond spread	0.520404	1.168283	2.936496###
Period: 01.01.2006-31.12.2008			
CDS spread	1.466516	1.867446	2.223853###
Bond spread	0.520404	1.168283	2.936496###
Period: 01.01.2009-30.04.2010			
CDS spread	1.167512	1.174918	0.614553##
Bond spread	0.027562	0.456211	0.543655##
Unit root test - First difference			
I(1)	ADF (SIC-max 5 lags)	PP	KPSS
Period: 01.01.2006-30.04.2010			
CDS spread	-11.03083***	-25.97178***	0.358981#
Bond spread	-15.90636***	-20.07716***	0.266003
Period: 01.01.2006-31.12.2008			
CDS spread	-13.80682***	-20.59427***	0.400689#
Bond spread	-15.90636***	-20.07716***	0.266003
Period: 01.01.2009-30.04.2010			
CDS spread	-14.02293***	-14.15072***	0.412162#
Bond spread	-8.465618***	-10.14158***	0.38053#

*H0 rejected at 90% level
**H0 rejected at 95% level
***H0 rejected at 99 % level
H0: Has one unit root

Stationarity rejectecd at 99% level.
Stationarity rejectecd at 95% level.
Stationarity rejectecd at 90% level.