STOCKHOLM SCHOOL OF ECONOMICS
Master Thesis in Finance

Relationship Crisis?

- An Empirical Study of the Theoretical Equivalence Relationship between CDS and Bond Markets in a Time-Varying Context

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Abstract

This paper compares prices of traded European corporate credit risk in the CDS and bond market in a time-varying context. Theory predicts that the two markets would price credit risk equally in the long-run. However, our empirical findings between the two time periods chosen for this study contradict this theory. The interrelationship between the two markets is found to be more pronounced during the financial crisis of 2007-2009 compared to the period before. Despite of this, the CDS spreads are on average significantly lower than the corresponding bond spreads during the financial crisis, in contradiction to previous research findings on other time periods. Furthermore, the short-run dynamics of each market's relative contribution to price discovery is examined. In line with previous research on US data, our results imply that the CDS market's contribution to price discovery dominates the full sample, but the relative contribution of the bond market increases during the financial crisis.

Keywords: CDS spread, Bond spread, Cointegration, Price discovery, Negative basis

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Contents

1. Introduction

The innovation of credit derivatives has revolutionized the marketplace for tradable credit risk. Pay-offs from derivatives dependent on credit quality have broadened the range of investment opportunities available for investors and corporations. The most common credit derivative is the Credit Default Swap (henceforth CDS) in which the seller is compensated for accepting the credit risk of a corporation, known as a reference entity. Single-name CDS contracts have quickly formed the most important market for trading credit risk. Between 1997 and 2009, the notional amount of CDSs outstanding has grown from a reported $180 billion to approximately $36 trillion (Bank for International Settlements (2009)).

A corporate bond investor can insure a bond from default by buying protection, i.e. buying a CDS contract, on the reference entity. In case of default, the bond investor will be compensated for the value reduction of the bond arising from the default event. Prior to default, the investor will receive the coupon payments from the bond and will pay the issuer of the CDS for the insurance. Since the investor has eliminated the risk of the bond issuer defaulting, he/she is not exposed to default risk and should thus not be compensated for this. Hence, the investor should earn the risk-free rate of return. As will be shown formally later in this paper, in the absence of arbitrage opportunities the bond yield's spread over the risk-free rate (i.e. the difference between the bond yield and the risk-free rate, henceforth bond spread) should be equal to the annual cost of the CDS contract, expressed as a percentage of the notional amount (CDS spread). This relationship has been tested previously and found to be approximately true over time. However, previous research has not examined this in a time-varying context in which the market characteristics change substantially. The financial crisis of 2007-2009 provides an opportunity to examine if the relationship holds for European firms in extreme market conditions and whether previous empirical findings have been influenced by the time-period of choice. In order to be able to draw any conclusions from this, a period prior to the crisis will be compared to the crisis period. Furthermore, the equivalence relationship has not been tested previously during a period of negative basis.[1]

As bond and CDS spreads measure the same risk, namely the credit risk of a reference entity, their reaction to news related to the same reference entity could be expected to be similar. If the risk of

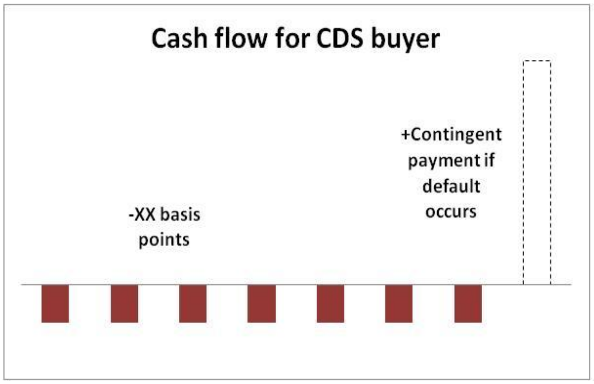
[1] When the CDS spread trades below the corresponding bond spread

default increases, both the bond and the CDS spread should increase. For instance, if Standard & Poor's announces that it will downgrade the debt of a corporation, the bond spread as well as the CDS spread should increase to reflect this new information regarding the credit quality of the issuer. However, this might not happen simultaneously in both markets. The more liquid a market is, the faster are news incorporated in the price of its securities. Thus, price discovery is believed to occur in the most liquid market. Most previous research has been conducted on US data showing that the CDS market leads in terms of price discovery, i.e. a change in the CDS spread is more likely to be followed by a similar change in the bond spread than vice versa. The few studies performed on European corporations have challenged this view and suggest that the bond market is leading this process. The market for CDS contracts in Europe has grown rapidly in the last five years and there could be reason to believe that the CDS market is now dominating in terms of price discovery in Europe as well.

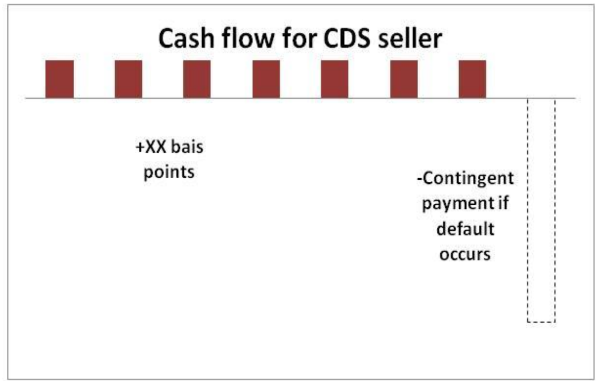
A single-name CDS is a bilateral contractual agreement that transfers the risk of a credit event (comprises events such as bankruptcy and default, henceforth default) on a bond issued by a corporation or sovereign entity to the protection seller from the protection buyer. The bond is called the reference obligation and the issuer of the bond is called the reference entity. In return for this risk transfer, the protection buyer pays a periodic fee (quarterly or semiannually) on the notional amount to the protection seller until default or until maturity of the CDS contract, whichever comes first. This total fee per year, expressed as a percentage of the notional amount in basis points[2], is referred to as the CDS spread (or CDS premium) and remains constant during the life of the contract (Mengle (2007)). Similar to the bond yield in the bond market, the CDS puts a market price on the credit risk of a reference entity (Zhu (2004)). In the event of a default during the life of the CDS contract, the protection buyer is compensated by the protection seller for incurred losses on the bond (represented by the dashed boxes in *Graph 1* and *2* below and is equal to the value loss of the bond).

[2] One basis point is 1/100 of a percentage

Graph 1 – Cash Flow for CDS Buyer



Graph 2 – Cash Flow for CDS Seller



When a credit event occurs between two premium payment dates, the accrued premium from between the last payment date and the credit event date is paid to the protection seller (Hull (2007)). It should be noted that the protection buyer is not compensated for any value reductions in the reference obligation not attributable to a credit event. The economic consequences of a CDS contract are similar to those of an insurance contract with the protection seller being paid ex ante for compensating ex post, but legally there are some distinctions; the protection buyer does not need to own the underlying security and the protection buyer needs not to incur any loss to recover on the contract. This enables speculators to take long or short positions in credit risk without trading the underlying cash instrument. These features make it possible for investors to use CDS positions for hedging, speculation or for other arbitrage reasons (Rule (2001)). Theoretically, combining a long position in a defaultable bond with a CDS written on the same reference obligation makes the position riskless and the position should thus be priced equal to a default-free bond (Daniels et al (2005)).

1.1. Credit event and settlement

Standard definitions of credit events that trigger settlement for a credit default swap are (ISDA (2003)):

- *Bankruptcy*: only a credit event for corporate reference entities
- *Failure to pay:* failure to make principal or interest payments
- *Repudiation/Moratorium:* certain actions undertaken by sovereign reference entities that triggers compensation since they do not intend to live up to their obligations
- *Obligation acceleration and obligation default:* the reference obligation becomes due and payable as a result of a default by the reference entity, usually referring to events like violations of bond covenants leading to technical default

- *Restructuring:* generally included and concerns actions like coupon reductions and maturity extensions

If a credit event occurs, either cash settlement or physical settlement is undertaken between the counterparties depending on the contract specification. The cash settlement is designed to reflect the loss a creditor would incur from a credit event, i.e. the notional amount of the underlying reference obligation less the market value after the credit event. In a physical settlement, the face value of the reference obligation is repaid in exchange of the delivery of a deliverable obligation. It is not necessary that the reference obligation is the actual obligation delivered; other obligations meeting certain specifications can potentially be delivered, such as any senior unsecured claim against the reference entity. Hence, the protection buyer will choose the bond that can be purchased least expensively for delivery, giving the holder of a CDS a cheapest-to deliver bond option (Hull (2007)).

1.2. CDS risks

Effectively, a CDS contract gives the CDS seller a long position in the credit risk of the reference entity, similar to the default risk associated when purchasing a bond by the same entity. The main difference is that the protection seller does not have to provide any funding as opposed to the bond creditor.[3] The protection seller faces some counterparty risk in the sense of lost premium payments given a possible default by the protection buyer. The protection buyer is introduced to risks in the form of i) counterparty replacement risk if the protection seller defaults and ii) "double default", i.e. simultaneous default by the protection seller and the reference entity (Mengle (2007)). Both parties are exposed to counterparty risk, but in line with the discussion above, this risk is not symmetrical and the protection buyer bears greater counterparty risk than the protection seller.

The rest of the paper is structured as follows. In the next section, the theoretical background of CDS and credit risk pricing will be covered. The relevant literature will be summarized in section three and hypotheses will be stated in the fourth section. Following this, the dataset will be discussed in section five and the econometric models applied will be outlined in section six. The empirical findings will be presented and analyzed in section seven followed by concluding remarks in section eight.

[3] There are also funded CDS contracts where the seller lends the notional amount to the buyer, thereby reducing the counterparty risk

2. Theoretical background

The academic frameworks used for pricing credit risk are divided into two main groups, structural models and reduced form models. The basic intuition in the structural model is that the face value of the firm's liabilities represents a barrier point for the value of the firm in the sense that once the value of the firm's asset lie below this point, the firm will default (Merton (1974)). In the reduced form model approach, the credit risk is determined by the default event which is unpredictable and driven by stochastic default intensity as a function of hidden state variables (Arora et al (2005)). The reduced form models are often used by practitioners in credit risk trading because they are easy to support by mathematical arguments and relies less heavily on the user having complete information. Risk neutral default probabilities under the absence of arbitrage opportunities determine the bond spread and the reduced form model's framework is suitable when linking the CDS spread with the bond spread. Since it is the equivalence relationship between these markets that will be examined in the empirical part of this thesis, we will rely on the reduced form model.

2.1. Credit default swap pricing model

To illustrate the theoretical equivalence between the CDS and bond spread, consider the following example where some simplifying assumptions have been made (Duffie (1999)):

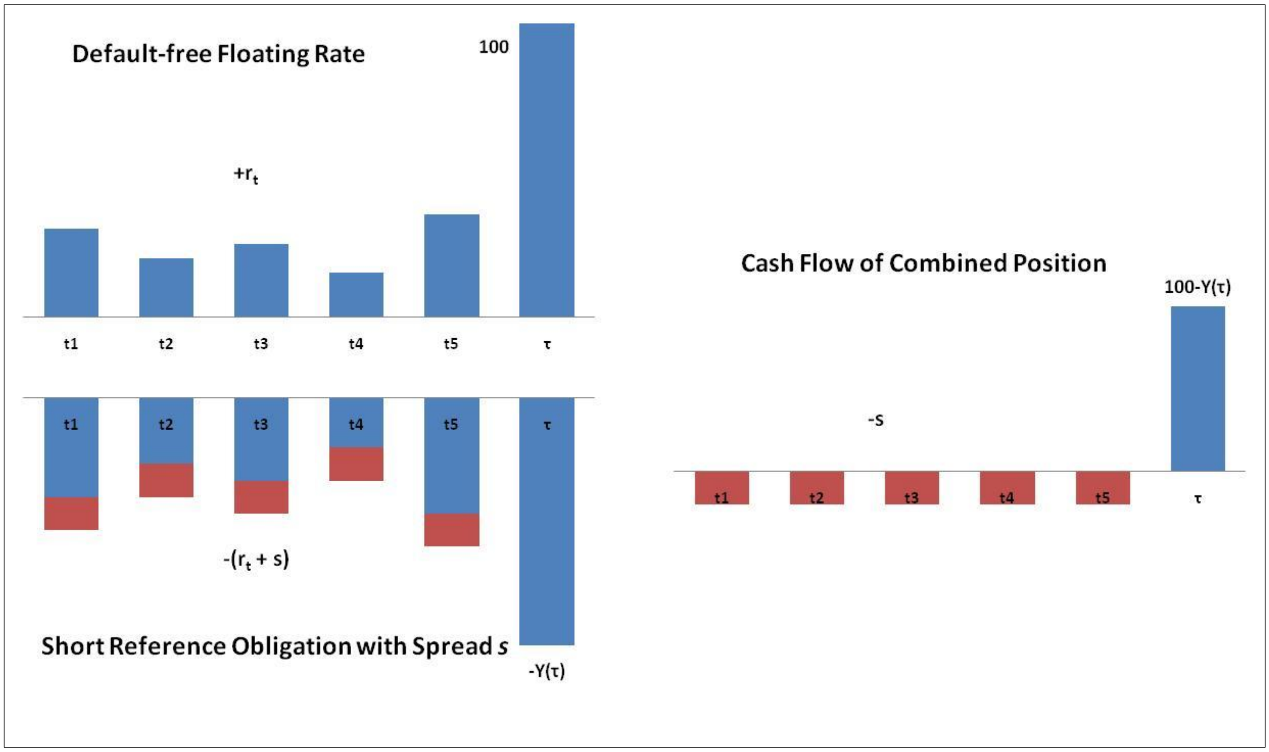
- The protection buyer pays a constant CDS premium (*p*) at a predetermined frequency to the protection seller until maturity of the contract or until the occurrence of a credit event, whichever comes first. The protection buyer receives nothing if no credit event occurs during the contract period.
- The CDS contract specifies that the contingent payment amount (*CP)* is the difference between the face value and the market value ($Y(\tau)$) at the time of a credit event (τ) on a note issued by Entity A. For illustration purposes, assume that the face value of the note is 100. $CP = 100 - Y(\tau)$.
- The protection buyer does not pay the accrued premium in case of a default on the reference obligation between payment dates.
- A default-free floating rate note with a floating rate of r_t exists at date t.
- The reference obligation issued by Entity A is a par floating rate note, i.e. a note trading at par at all coupon dates. The coupon payments are due at the same dates as the CDS premium payments and the reference obligation has the same maturity as the CDS contract. The coupon

payments (c) on this note is specified to have a fixed spread over the default free floating rate r_t, *i.e.* $c_t = s + r_t$, where s is the fixed spread.

- The reference obligation can be short-sold costless through, for example, a reverse repurchase agreement at any desired date.
- There are no transaction costs and the market is frictionless.
- The contingent payment in the occurrence of a credit event is settled at the following coupon date of the reference obligation and by physical delivery in exchange for the face value. Recall that the contingent payment is determined by the value at default, $Y(\tau)$.
- Different marginal tax rates for investors are ignored.

Following these assumptions, an investor can short-sell the reference obligation and receive 100 to invest in the par default-free floating note. By doing this, the coupon payments from the default-free note is received (r_t) and the coupon payments (c_t) on Entity A's note is paid out. This position is held throughout the maturity of the notes or until a credit event occurs, whichever comes first. The net effect of this transaction is that the investor pays the fixed spread s over the default-free rate ($r_t - c_t = -s$) (Duffie (1999)). In the absence of a credit event, both notes mature at par value, yielding a net cash flow of zero at termination. However, if a credit event would occur before maturity, the portfolio is liquidated at the coupon date following the credit event (given the assumptions stated above). The default-free floater will yield 100 (since this trades at par on the coupon dates) and the short position in the defaultable note will cause a cash outlay of $Y(\tau)$ when terminating the short position. Hence, the investor will collect the difference $D = 100 - Y(\tau)$.

Graph 3 – Cash flow from a long position in a default-free note and a short position in the reference obligation from origination until the occurrence of a credit event



Note that this is the same payoff that was specified in the credit default swap contract in *Graph 1*. Therefore, in the absence of arbitrage opportunities, since the CDS can be replicated synthetically, equality between the CDS spread and the fixed bond spread (*s)* is needed (Duffie (1999).

2.2. Pricing credit risk

This relationship can be validated mathematically using a risk neutral valuation principle with the following assumptions (Zhu (2004)):

- The risk-free note is a par fixed rate bond with a coupon rate r, where r is the constant risk-free rate.
- The reference obligation is a fixed par coupon bond paying the coupon c at a predetermined frequency.
- There is no payment of the accrued CDS premium if a credit event occurs.
- The protection buyer pays the CDS premium p at the same frequency as the bond pays coupons until a credit event occurs or until the CDS contract matures, whichever comes first.
- The time of default is represented by the stochastic variable T.

- The risk neutral default probability for the bond at time t is denoted by $q^D(t)$.
- The risk neutral survival probability for the bond at time t is denoted by $Q^S(t) = Q(T > t)$.
- The market value of the bond in the occurrence of a credit event at time t is Y_t.
- There are no transaction costs and markets are frictionless.
- Different marginal tax rates for investors are ignored.

The value of a defaultable fixed par coupon bond is constituted by three parts; the present value of the coupon payments, the principal value at maturity given no default and the market value of the bond in the event of default.

$$P = 100 = \sum_{i=1}^{N} e^{-rt_i}\, Q^S(t_i)c + e^{-rt_N} \cdot 100Q^S(t_N) + \int_0^{t_N} e^{-rt}\, (Y_t)q^D(t)dt \qquad (1)$$

In a CDS contract, the protection seller receives a regular premium (p) until t_N, or until the occurrence of a credit event, here assuming that this is done at the same frequency as the bondholder collects coupon payments. Since no cash flows are involved when entering into a CDS contract, the expected value at origination must be zero:

$$\sum_{i=1}^{N} e^{-rt_i}\, Q^S(t_i)p - \int_0^{t_N} e^{-rt}\, (100 - Y_t)q^D(t)dt = 0$$

$$\sum_{i=1}^{N} e^{-rt_i}\, Q^S(t_i)p = \int_0^{t_N} e^{-rt}\, (100 - Y_t)q^D(t)dt \qquad (2)$$

$$PV(Expected\ premium\ payments) = PV(Expected\ default\ compensation)$$

Since the protection seller is obliged to compensate the protection buyer in the event of a default, the present value of this cash flow must be equal to the present value of the CDS premium in equilibrium. Hence, one must determine the CDS premium p that makes the value of the CDS contract zero at origination.

As discussed earlier, a synthetic CDS can be created by shorting the defaultable bond and investing the proceeds in a par fixed rate risk-free bond with coupon rate *r*. It is always possible to sell the risk-free note at par due to the (assumed) constant risk-free rate. Since the initial net investment of the transaction is zero, the present value of the combined positions must be zero in the absence of arbitrage opportunities:

$$0 = \sum_{i=1}^{N} e_i^{-rt_i} Q^S(t_i) r + \int_0^{t_N} e^{-rt}\ 100 q^D(t) dt +\ e^{-rt_N} 100 Q^S(t_N) - \sum_{i=1}^{N} e_i^{-rt_i} Q^S(t_i) c$$

$$-\ e^{-rt_N} 100 Q^S(t_N) - \int_0^{t_N} e^{-rt}\ Y_t q^D(t) dt$$

$$\int_0^{t_N} e^{-rt}\ (100 - Y_t) q^D(t) dt = \sum_{i=1}^{N} e_i^{-rt_i} Q^S(t_i)(c - r) \tag{3}$$

By combining this with the pricing equation (2) of the CDS contract above, we get:

$$\sum_{i=1}^{N} e^{-rt_i}\ Q^S(t_i) p = \sum_{i=1}^{N} e_i^{-rt_i} Q^S(t_i)(c - r) \tag{4}$$

$$\boldsymbol{p = c - r}$$

Since the risk-free rate is assumed to be constant, the bond's yield will be determined by the coupon payments (*c*) that are paid out at the same frequency as the CDS premium. Hence, using a risk neutral valuation principle with no-arbitrage conditions leads to the conclusion that the CDS spread should be equal to the underlying bond's yield in excess of the risk-free rate, i.e. the CDS spread should be equal to the bond spread.

The difference between the CDS spread and the bond spread is known as basis [*p-(c-r)*] and should theoretically be zero, otherwise profitable trading opportunities exist. In the event of a negative basis ($p < s$), an opportunity arises where an investor would purchase the CDS contract and the reference obligation while shorting the risk-free note. A risk-free note will thus be created synthetically yielding an interest rate greater than the risk-free rate. When the basis is positive, an investor can buy the risk-free note while selling the CDS and shorting the corporate bond and earn a return on an initial net investment of zero (Zhu (2004)). It should be noted that the trades are based on the basis narrowing in the future, so that the investor can reverse the trade and collect a profit. During certain market conditions, this might not be the case and traders would not engage in this activity as it could lead to losses.

3. Literature review

The arbitrage relationship between CDS and bond spreads has been the topic in a number of previous studies. The majority of these papers conclude that there is a long-run (equal to sample period) equilibrium relationship between the two spreads, but deviations may be present in the short-run.

Zhu (2004) finds that the theoretical relationship holds in the long-run in his study of 24 reference entities during the period 1999–2002. In the short-run, price discrepancies between the different spreads exist. This is explained by different responses to changes in credit quality in the reference entities. Zhu finds that the CDS market leads the bond market in price discovery for US firms, however, not for European firms.

Hull, Predescu and White (2004) test the theoretical arbitrage relationship for 31 companies during 1998–2002 and find that it holds approximately when using the swap rate as the risk-free rate. The results are in line with a previous paper by Houweling and Vorst (2005), which compares the market prices of CDSs to model prices. The authors find that the models provide unbiased price estimates only when the swap rate is used as the proxy for the risk-free rate.

Blanco, Brennan and Marsh (2005) test the arbitrage relationship for 16 investment grade firms in the US and 17 investment grade firms in Europe during 2000–2002. They find that the relationship holds on average for most firms over time and especially well for US firms when the swap rate is used as a proxy for the risk-free rate. However, there are deviations in the short-run and it is shown that the CDS market is more efficient in incorporating new information about the credit risk of a reference entity (price discovery) than the bond market for the majority of the companies examined.

Dötz (2007) conducts a similar study on 36 companies listed on the iTraxx Europe index between 2004 and 2006 and finds support for the pricing equilibrium between the CDS and bond spreads. In contradiction to previous papers on European data, the derivatives market is slightly leading the bond market in terms of price discovery.

Chan-Lau and Kim (2004) test the relationship between CDS spreads, bonds spreads and equity prices in emerging markets. They confirm an equilibrium pricing relationship between the CDS and bond spread for five out of eight countries. For a one-day horizon, the derivatives market dominates in terms of price discovery. Furthermore, Ammer and Cai (2007) examine the relationship between CDS and bond yield spreads for nine emerging markets between 2001 and 2005. The authors find that the two credit risk measures deviate significantly in the short-run, but confirm stable long-run equilibriums in most countries. A similar study including a larger sample of countries and a longer time period is done by Aktug, Vasconcellos and Bae (2008) where 30 emerging economies are examined between 2001 and 2007. They conclude that the sovereign CDS and bond markets have become more integrated over time. The bond market is leading the price discovery process, argued to be largely ascribed a relative liquidity advantage for the bond markets studied. The liquidity advantage of the bond is natural, since the CDS sovereign market is very young in comparison.

4. Hypotheses

Bond spreads and CDS spreads are essentially two measures of the same risk; the credit risk of a reference entity. The perceived risk of default increased substantially and both credit and CDS spreads sky-rocketed when investors grew anxious and risk-averse during the financial crisis, especially after the Lehman Brothers collapse in September, 2008. To what extent the changes in spreads were related during the crisis has, to the best of our knowledge, not been examined. The financial crisis of 2007–2009 is described as the worst since the Great Depression. Testing how the interrelationship between the CDS and bond markets are affected during such turbulent market conditions is interesting as it could provide insight to the efficiency of credit risk markets. Moreover, previous research has almost exclusively been based on the relationship between the CDS and bond markets in a single time period. Conducting the study in a time-varying context will thus provide greater insight to whether previous findings are influenced by the time period of choice. To find a specific date when the crisis started is obviously difficult and becomes a matter of subjectivity. August 9, 2007 could be argued as the day when the financial world entered a mode of crisis as the European Central Bank injected €95bn and the Federal

Reserve injected $24bn into their respective markets. A more scientific approach to determining when the crisis started by looking at, for instance, implied option volatility in relation to historical averages for the reference entities could be one alternative. The level of the iTraxx Europe 125 index, which consists of the CDSs of the reference entities used in this paper, could also have been observed in relation to its historical average, but the start date would still to some extent be set arbitrarily; how long should the measurement period for the historical average be and at what levels should a crisis be determined to be present? We are aware that the choice of time period in this thesis could be set differently, but we believe that the chosen time periods still provide a good comparison. Thus, in this thesis the financial crisis is determined to have started on August 9, 2007.

A common strategy for fixed income traders is to search for negative basis, i.e. when the CDS spread is lower than the bond spread for a reference entity. Entering a negative basis trade, the trader wishes for the spreads to narrow as this will increase the value of his portfolio. If the CDS becomes more expensive, he/she reverses the trade and earns a profit from the sale of the CDS contract. In the case of a decreasing bond spread, the bond price increases and the trader earns a profit from selling the bond. If the two spreads for some reason do not converge during crisis periods, setting up basis trades would not become profitable and the lack of basis trades would further decrease the arbitrage forces between the markets. If the equality relationship between the spreads holds better or worse on average during a crisis, this information could potentially be used for determining the timing of when to set up such trades. A striking characteristic of our data sample is the presence of an on average negative basis (CDS spread < bond spread) during the sample period. This pattern is more pronounced during the second time period compared to the first as can be seen in *Table I* on page 18. This suggest that the two spreads do not converge to the same level and we intend to provide possible explanations for this previously rare observation, as the average basis in previous studies has often been close to zero. Intuitively, the large negative basis would suggest that the interrelationships between the markets are less pronounced compared to when the basis is close to zero. However, this has not been examined before and we intend to fill that gap in this paper.

In this thesis we will study the relationship between the spreads for a number of investment-grade European firms with high liquidity bonds and CDSs. In addition to testing whether each market prices credit risk equally, we will test which market leads in terms of price discovery. The few papers examining the relationship on European data has found different results compared to US data with regard to price discovery. However, these studies are outdated and there could be reason to believe that the European CDS market's rapid expansion and increased liquidity make it resemble their American counterpart to a greater extent now. Both research questions will be put into a time-varying context where the properties of these relationships will be investigated before as well as during the crisis.

4.1. Credit risk pricing

Previous studies have confirmed a relationship between CDS and bond spreads for a majority of the investigated companies, implying that the two markets price credit risk equally in the long-run (see for example Zhu (2004), Dötz (2007), Hodgson et al (2003) and De Wit (2006)). This relationship has held especially well for US firms historically. However, temporary deviations are common and sometimes of significant magnitude.

The stock-market crash in 1987, the Mexican Peso crisis in 1994 and the Asian crisis in 1997-1998 increased the co-movements among stock markets, implying that linkages between financial markets increase during periods of financial crises (Choudry et al (2007)). In light of this, the current financial crisis' effect on the linkages of credit risk pricing between the bond and CDS market could potentially be similar. The theoretical framework and the possibility of engaging in arbitrage activities when the pricing of credit risk differ between the markets make us believe that there is a long-term equilibrium between the markets, just as previous studies have concluded. Furthermore, we believe that this linkage could be different during periods of financial turmoil. The negative basis during the financial crisis could be an indicator of a weaker interrelationship between the two markets. However, financial markets have been found to share common stochastic trends (Kasa (1992)). In periods of financial crisis, common stochastic trends have been observed to a greater extent, which potentially also could be true in the credit markets. In such a case, the two markets would move more closely together.

Hypothesis 1: **As bond and CDS spreads are prices of the same risk, there should be a long-run equilibrium relationship between them.**

4.2. Price discovery

The literature has shown contradicting results to whether the CDS or bond market leads in terms of price discovery, especially between US and European firms. Several studies suggest that new information is reflected more rapidly in the derivatives[4] market than in the spot market,[5] even though

[4] CDSs and futures on bonds

the spot market contributes to price discovery (Longstaff et al (2004)) and (Dötz (2007)). Furthermore, Zhu (2004) concludes that the CDS market leads the bond market in terms of price discovery for US firms whereas the opposite is true for European firms. The view of the CDS market making a greater contribution in the US market than in the European market has been confirmed by Dötz (2007), but he showed that the CDS market had been gaining in significance since 2004 and that it slightly leads the bond market in price discovery for European firms during the studied time period (Jan 2004-Oct 2006).

Price discovery during a period of financial distress was investigated by Upper and Werner (2002) in the German market during the Long-Term Capital Management recapitalization crisis in 1998. During this crisis, the futures market's role to price discovery was further strengthened with the bond market making almost no contribution at all. In contrast, the CDS market's contribution to price discovery decreased in the spring of 2005 after Standard & Poor's downgrade of Ford and General Motors (Dötz (2007)). This is in line with the reasoning that the liquidity in the CDS market can dry out due to the small number of market participants, and that even though demand for credit protection increases, the protection sellers will no longer be willing to sell from a certain barrier, thereby limiting the liquidity and the resulting price discovery in the CDS market (Dötz (2007)). It can be argued that the increased liquidity, the absence of short-sale restrictions and the unfunded nature of the CDS market should make it better suited to adjust to new information than the bond market. Despite some previous contradicting results, the CDS market is expected to dominate as the European CDS market continues to develop and to more resemble the US market. However, the bond market could potentially have a more dominant effect during the crisis period. Even though the CDS market in Europe has evolved tremendously, there could be reason to suspect that the number of market participants is limiting the liquidity in the market. Hence, the relative importance of the bond market in the price discovery process could increase in line with observed patterns in previous financial crises.

Hypothesis 2: **The CDS market incorporates new information faster than the bond market and is thus leading in terms of price discovery.**

The bond market's contribution to price discovery is increasing during the crisis.

[5] In which the financial instruments are traded and delivered immediately

5. Data

The iTraxx CDS index was created in 2004 through a merger between Trac-x and Dow Jones iBoxx, the two most important providers of corporate CDS information up until that point. The iTraxx Europe 125 consists of single-name CDSs of the 125 most liquid European investment grade corporations and covers a broad range of companies by both geography and industry. Large trading volumes for these entities ensure low bid-ask spreads, thus making the mid-market quote a reasonable proxy for the actual price traded. This is one reason for choosing to focus our attention on this index. Another important reason involves the data availability. Obviously, the reference entities included in the iTraxx index all have CDSs and the issue comes down to locating appropriate bonds. In order to be able to test for any relationship between CDS and bond spreads, one must create a dataset of CDS and bond spreads with matching maturities. When no bond with matching maturity to a CDS exists, sufficient data to construct a generic bond must be available. We find adequate data for 30 companies,[6] displayed in *Table VI* in the Appendix.

We have decided to split our sample into two equally long time periods. Our start date is thus determined by when we define the crisis to have started (August 9, 2007). To have equally long periods, our full sample starts at June 9, 2005 and ends at October 7, 2009. Both sub-samples include 565 trading days.

Period 1: 2005-06-09 to 2007-08-08

Period 2: 2007-08-09 to 2009-10-07

Thomson Datastream provides time-series data on annual CDS spreads for the reference entities on the iTraxx Europe 125 index for the chosen time-periods. We use 5-year maturity CDSs as these are most liquid and we use the daily close of business mid-market quote, i.e. the average of the bid and the ask quotes. Only contracts denominated in Euro are used.

To test the equivalence relationship, a 5-year CDS spread should be compared to a 5-year bond spread. An ideal situation would be if, at all dates in the sample period, a bond with exactly five years to maturity was available for all companies. Since corporations do not issue bonds daily, generic bonds are

[6] Index composition as of September 25, 2009

created by interpolating between bonds with longer maturities and bonds with shorter maturities than five years in order to get the residual maturity equal to five years.

Following Zhu (2004), we collect information on bonds that fulfill the following criteria:

- Bonds must be straight, i.e. not callable, putable, convertible etc
- Bonds must be denominated in Euro (same as the CDS contract)
- Bonds must be senior
- Bonds must have fixed coupon-payments

For those dates where a bond with precisely 5 years to maturity exists, its yield to maturity is used. For all other dates, we download the life to maturity (in years) and solve for the weights according to the following formula where w is the weight of the shorter maturity bond:

$$w = 1 - \frac{5 - Life\ to\ maturity\ (short\ bond)}{Life\ to\ maturity\ (long\ bond) - Life\ to\ maturity\ (short\ bond)}$$

The weight applied to the longer dated bond is consequently $1 - w$. In accordance with Dötz (2007), we do not imply any rigorous restrictions on the different bond maturities apart from:

- One bond must have less than five years to maturity
- One bond must have more than five years to maturity, but less than ten years

If a combination of a longer and a shorter bond is unavailable at some dates, we check if there is a bond with maturity between 4 and 6 years and use this bond's yield instead as a proxy for the 5-year yield. It should be noted that this option has been used for a total of 8 reference entities[7] during time intervals ranging from a few days to a few months. Similar methods are used by for instance Hull et al (2004) and Norden & Weber (2004). With the weighting done, the yield to maturity is downloaded for the bonds used in the interpolation process and the weights are multiplied with the respective yields. Thus, we have calculated the 5-year generic bond yield.

[7] Casino Guichard, EnBW, Fortum, Holcim, Repsol, Unicredit, Vivendi and Wolters Kluwer

To find the bond spread, the bond yield needs to be adjusted with the risk-free rate. As a proxy for the risk-free rate, we use daily data from Bloomberg on the 5-year Euro Swap Rate, i.e. the average borrowing Euro rate between financial institutions calculated from the fixed leg of interest rate swaps. The bond spread for company *i* at time *t* is obtained through:

$$Bond\ spread_{i,t} = Bond\ yield_{i.t} - Swap\ rate_t$$

A number of previous papers have examined which rate to be used as a benchmark for the risk-free rate. Common for the findings is that the use of the swap rate as a proxy for the risk-free rate instead of the Treasury rate narrows the basis (Blanco et al (2005)) and (Zhu (2004)). It has been argued that swap and repo rates to a large extent have taken over as the preferred reference default-free rate from government bonds (Houweling and Vorst (2005)). Moreover, it has been argued that the swap rate is less affected by regulation and taxation issues and more closely represents market participants' financing cost (Dötz (2007)) and (De Wit (2006)). It is not the purpose of this thesis to further examine which proxy for the risk-free rate that results in the narrowest basis, and the Euro swap rate will be used in all tests.

After having checked for data availability according to the procedure presented above, 30 reference entities are found to have both CDS and bond data for the full sample period. Our complete dataset thus consists of time-series data between 2005-06-09 and 2009-10-07 for CDS and bond spreads for the entities displayed in *Table I*. With 1,130 trading days included we have a total of 67,800 observations.

5.1. Characteristics of the data

To give an overview of the data used, descriptive statistics including the average spreads for all the entities in the different time periods as well as the average basis over time is presented in *Table I*. Following this, some apparent abnormalities in the dataset will be discussed.

Table I – Average spreads

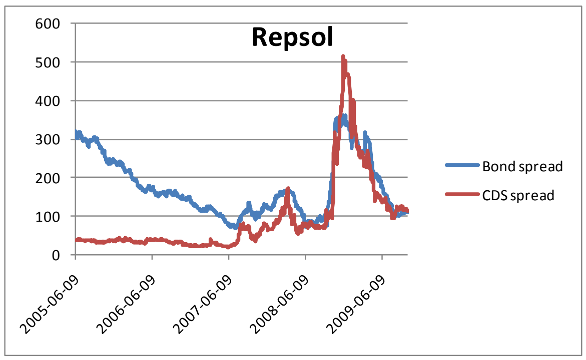
This table displays average CDS and bond spreads expressed in basis points for all entities for the individual time periods as well as for the full sample size. The average basis, calculated as the CDS spread less the corresponding bond spread is also displayed for all entities. Average spreads are considerably higher in the second time period compared to the first. Moreover, the average basis is considerably lower in the second time period compared to the first, -28.11 and -4.95 respectively.

Company	Average spreads								
	2005/06/09 - 2009/10/07			2005/06/09 - 2007/08/08			2007/08/09 - 2009/10/07		
	CDS	*Bond*	*Basis*	*CDS*	*Bond*	*Basis*	*CDS*	*Bond*	*Basis*
Aegon	106.70	47.37	59.33	16.99	-31.12	48.10	196.68	126.21	70.55
Allianz	46.05	36.07	9.99	13.56	3.26	10.30	78.63	68.98	9.68
Banco Bilbao	46.44	24.65	21.80	10.02	-1.56	11.58	82.95	50.93	32.02
Banco Santander	47.33	24.42	22.90	10.48	-0.68	11.16	84.26	49.60	34.65
Barlcays	61.00	126.33	-65.33	8.73	72.69	-63.96	113.43	180.24	-66.69
Basf	40.15	20.64	19.50	14.75	2.70	12.04	65.63	38.63	26.96
BNP Paribas	34.02	89.75	-55.73	7.66	20.67	-13.01	60.45	159.00	-98.44
Bouygues	67.15	76.88	-9.73	25.28	26.67	-1.39	109.15	127.25	-18.06
Carrefour	38.27	44.20	-5.93	18.99	17.21	1.79	57.59	71.27	-13.64
Casiono Guichard	111.31	157.28	-45.97	77.11	80.13	-3.01	145.62	234.71	-88.94
Commerzbank	48.73	85.77	-37.04	13.78	1.18	12.60	83.74	170.55	-86.68
Credit Agricole	43.97	95.10	-51.13	7.99	20.62	-12.63	80.03	169.80	-89.63
Deutsche Bank	52.65	31.78	20.86	13.74	2.46	11.28	91.65	61.30	30.44
Deutsche Telekom	65.99	75.09	-9.10	37.25	31.08	6.18	94.81	119.25	-24.38
Electricite de France	37.43	17.83	19.60	13.35	-2.90	16.25	61.58	38.64	22.94
EnBW	32.00	44.16	-12.16	16.35	16.28	0.07	47.70	72.14	-24.38
Fortum	41.21	50.74	-9.54	19.62	19.41	0.21	62.85	82.18	-19.28
France Telecom	54.10	61.02	-6.92	34.73	29.63	5.10	73.53	92.51	-18.95
Holcim	143.45	109.02	34.43	31.16	29.28	1.87	256.11	189.04	66.98
Iberdrola	60.46	62.84	-2.39	20.91	50.05	-29.14	100.13	75.75	24.37
Koninklijke KPN	70.04	97.12	-27.08	58.62	59.23	-0.61	81.52	135.15	-53.54
Portugal Telecom	101.89	143.99	-42.10	92.05	79.84	12.21	111.83	208.38	-96.40
Repsol	89.07	174.00	-84.93	32.04	179.29	-147.25	146.24	168.83	-22.61
Societe General	44.96	81.82	-36.86	8.46	21.67	-13.21	81.56	142.19	-60.52
RBS	62.17	134.49	-72.31	7.84	7.30	0.53	116.67	262.11	-145.15
Unicredit	53.07	121.92	-68.85	13.20	25.04	-11.84	93.05	219.12	-125.86
Vivendi	85.99	131.23	-45.24	48.57	74.19	-25.62	123.54	188.51	-64.87
Vodafone	65.28	55.78	9.49	29.19	24.17	5.02	101.47	87.49	13.96
Volkswagen	90.96	64.54	26.42	32.15	15.26	16.89	149.96	114.00	35.94
Wolters Kluwer	57.62	109.45	-51.83	49.50	59.53	-10.02	65.78	159.58	-93.64
Average all entities	**63.31**	**79.84**	**-16.53**	**26.13**	**31.09**	**-4.95**	**100.61**	**128.78**	**-28.11**

The average basis is negative on average for the whole sample period as well as for both subsamples as shown in *Table I*. The overall pattern of negative basis in both periods and especially in the second time period is notable. Previous studies have found a positive basis when adjusting the bond spread with the swap rate (Zhu (2004), Blanco et al (2005), Dötz (2007) and Hull et al (2004) among others).

Not surprisingly, the average CDS and bond spreads are significantly higher in the second period (during the crisis) compared to the first period. The risk, or the perceived risk, of default increased for all companies during the crisis and the global appetite for risky assets decreased substantially. For all 30 reference entities, the average CDS spread is higher in the second period compared to the first period. Regarding the bond spread, the same is true for 29 out of 30 entities. For the exception Repsol, the average bond spread is considerably higher than the CDS spread during the first period. Below is a graphical presentation of Repsol's CDS and bond spread.

Graph 4 – CDS and bond spread in basis points for Repsol



As the graph shows, the bond spread is well above the CDS spread for the first two years of the sample period. It could be that one of the bonds used for calculating the bond spread traded at a significant discount compared to other Repsol bonds for some reason unknown to us. We have tried to find a reason for the extensive negative basis during the first two years but without success.

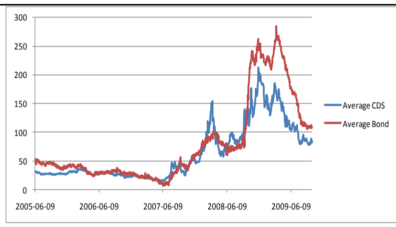
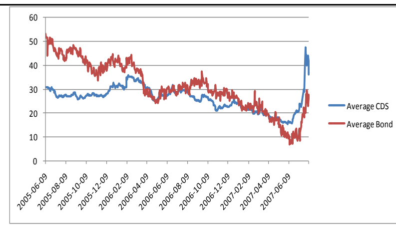
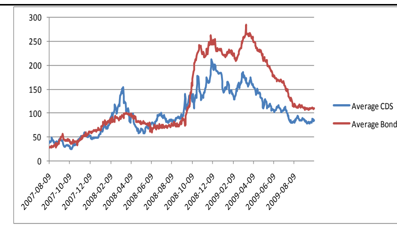
For some reference entities during the first time period, the average bond spread is negative, i.e. the bond yield is lower than the swap rate. A plausible explanation is that the credit quality of the bond issuer is considered to be exceptionally good. Another reason could be that the swap rate used for calculating the bond spread is not representative for all reference entities and that they should in fact have a lower cost of borrowing. There are seven reference entities that have a negative bond spread for more than 10% of the trading days.[8] Barclays, RBS and Vodafone are originated in the UK, a non-Euro country. Although only Euro denominated bonds are used for all entities, it could be that the Euro swap rate is not representative as the risk-free rate for these companies.

[8] Aegon, Banco Bilbao, Banco Santander, Basf, Commerzbank, Deutsche Bank and Electricite de France

To further illustrate the characteristics of our data sample, the spread evolvement over time is displayed in *Graph 5* and *6.*

Graph 5 – Average bond and CDS spreads

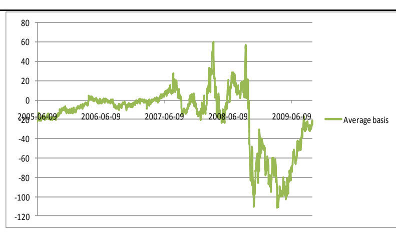
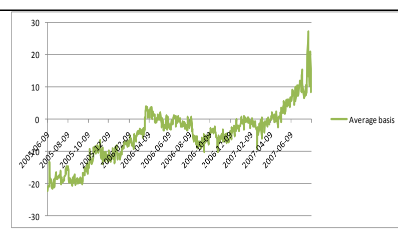
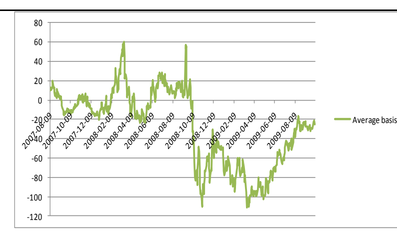
These graphs show the development of the average CDS and bond spread expressed in basis points for the entire sample period as well as for the separate time periods.

2005/06/09-2009/10/07	**2005/06/09-2007/08/08**	**2007/08/09-2009/10/07**
		

The average spreads have varied substantially during the sample period. The average sample minimum for the bond spread of 6.9 basis points was recorded on June 12, 2007 and can be compared with the average maximum notation of 284.3 basis points on March 18, 2009. The average CDS spread shows smaller movements with a minimum of 15.4 basis points on June 5, 2007 and a maximum of 212.8 basis points on December 5, 2008.

Graph 6 – Average basis

These graphs show the development of the average basis expressed in basis points for the entire sample period as well as for the separate time periods. The average basis is calculated as the CDS spread less the corresponding bond spread.

2005/06/09-2009/10/07	**2005/06/09-2007/08/08**	**2007/08/09-2009/10/07**
		

The average basis, measuring the difference between the CDS and bond spread, has varied to a large extent during the sample period. After October 2, 2008 the average basis has been strictly negative, indicating complications for traders trying to undertake a negative basis trade, since the trader might not expect the deviations to be temporary and narrow in the near future. Before this date, the basis has been fluctuating around zero, indicating that the arbitrage relationship holds in the sense that price fluctuations are temporary and market forces bring the spreads to equilibrium through, for example, negative basis trading. When examining the basis for all companies over the whole sample period, negative basis is observed at 55.2% of the observations. The number of trading days with negative basis varies greatly between reference entities from 16 days for Basf to 1,120 days for Credit Agricole (out of 1,130 trading days).

6. Econometric methods

This thesis aims to study the relationships between the CDS spread and the bond spread by using time series data. The most common procedure used when testing for relationships is regression techniques such as the Ordinary Least Squares (OLS). However, financial time series are usually not suited for these ordinary methods since their behavior and properties can lead to spurious regressions[9] if the series are non-stationary. Once the order of integration of our time series is investigated, further properties will be examined. If we cannot confirm the time series' stationarity, we will test whether the CDS and bond spreads of our reference entities are cointegrated, implying that there is a long-run equilibrium between the two as theory predicts. Furthermore, we will investigate which market leads in terms of price discovery. All tests will first be performed on the time period before the crisis and the crisis period together. Both time periods are then individually tested.

6.1. Stationarity

A series is stationary if its probability distribution is unchanged over time, i.e. the probability that the series value reaches a specific value today is identical to the probability that this value was reached in the past or is reached in the future (Brooks (2002)). These properties make using stationary series proper for ordinary regression analysis. For non-stationary processes, unexpected changes or "shocks" will have a non-declining effect on the process as time passes (Brooks (2002)). Consider the following equation:

$$y_t = \mu + \emptyset y_{t-1} + u_t \tag{5}$$

where u_t is a white noise disturbance term. If the shocks gradually decrease ($\emptyset$<1), the time series is stationary. If the shocks are persistent ($\emptyset$=1), the current value of the series (y_t) equals the starting value

[9] If two totally unrelated variables are trending over time, the regression results can still show significant coefficient estimates and high R^2, i.e. the regression results are useless. This is called a "spurious regression"

(y_0) plus an infinite sum of past shocks. The series then contains a unit-root and is said to be integrated of order one ($y \sim I(1)$), i.e. the series must be differenced once to become stationary.[10]

One of the earliest and most common techniques to test for a unit-root in time series was developed by Dickey and Fuller in 1976, where the basic objective is to test the null hypothesis that ø=1 in:

$$y_t = \emptyset y_{t-1} + u_t \tag{6}$$

This is tested against the alternative that ø<1, i.e. H_0: the time series contains a unit-root. H_1: the series is stationary (Brooks (2002)). The Dickey Fuller test is only valid if u_t is white noise. If there is autocorrelation in the dependent variable, one can use the Augmented Dickey-Fuller (ADF) test using *p* lags of the dependent variable to account for this:

$$ADF: H_0: y_t \sim I(1) \quad H_1: y_t \sim I(0) \tag{7}$$

To determine the optimal lags to include, we have chosen to use the number that minimizes the Bayesian information criterion (BIC). Each lag added will reduce the residual sum of squares but will on the other hand have an offsetting effect on the information criteria because of the added penalty due to the reduced degrees of freedom.

The ADF-test uses the classical hypothesis testing framework where the null hypothesis is either rejected or not, i.e. the null hypothesis could be correct or the sample just contained too little information to reject it, not necessarily indicating that the null hypothesis is in fact correct. We will use the Kwiatkowski-Phillips-Schmidt-Shin *test* (KPSS) to test for stationarity (Kwiatkowski et al (1992)) to control if we receive the same results as in the ADF test (confirmatory data analysis).

$$KPSS: H_0: y_t \sim I(0) \quad H_1: y_t \sim I(1) \tag{8}$$

6.2. Cointegration

Differencing the non-stationary data before running a regression removes the problem of spurious regressions, but at the cost of removing long-run relationships between the series, if any. To account for this, the cointegration between financial series is used (Harris (1995)). Cointegration implies that even though the individual series are non-stationary, a linear combination of the two are stationary, i.e. the series share one or more common stochastic trends (Baillie (2002)). The difference between the two variables will be stable and have a constant variance.

[10] We will not consider the possibility of the series being integrated of a higher order than one

The first step in the Engle-Granger test procedure for cointegration is similar to the ADF-test on raw data with the major difference being that the unit-root test is run on the residuals ($\hat{u}_t$) of the individual variables found to be I(1). If the residuals are I(1), a model containing only first differences can be estimated. On the other hand, if they are I(0), these residuals will be saved and used in the second step of the Engle-Granger test where they are inserted as a variable in an error correction model:

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2(\hat{u}_{t-1}) + \varepsilon_t \tag{9}$$

where ε_t is an independent and identically distributed (i.i.d.) error term and $\hat{u}_{t-1} = y_{t-1} - \hat{\tau} x_{t-1}$. This linear combination of stationary variables is called a cointegrating vector (1-$\hat{\tau}$ in this case, where $\hat{\tau}$ is the static OLS estimator of the cointegrating vector). Since all variables in the equation are stationary, values of the coefficients can be estimated from equation (9).

The coefficients of the linear combinations are referred to as cointegrating vectors. Another way to test for cointegration is thus to test for the existence of this vector with the Johansen Cointegration Rank Test (1991). The Johansen test is based on Vector Autoregression (VAR) models; VAR models describe the values of *k* variables as a linear function of their past values. The VAR model can be expanded to include more variables (y_{1t}, y_{2t}, y_{3t} *etc)* where each variable has an equation that is dependent on its past values as well as the values of the other variables. A VAR with one lag (p) and two variables (k) is written as:

$$\begin{array}{lllllllll} y_{1,t} & = & c_1 & + & A_{1,1}y_{1,t-1} & + & A_{1,2}y_{2,t-1} & + & e_{1,t} \\ y_{2,t} & = & c_2 & + & A_{2,1}y_{1,t-1} & + & A_{2,2}y_{2,t-1} & + & e_{2,t} \end{array} \tag{10}$$

If the variables are cointegrated, the error correction term has to be included in the VAR model, making the model used in the Johansen test a Vector Error Correction Model (VECM) of the form:

$$\Delta y_t = \Pi y_{t-p} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{p-1} \Delta y_{t-(p-1)} + u_t \tag{11}$$

where $\Gamma_i = \sum_{j=1}^{p-1} \beta_j - I_g$, $\Pi = \sum_{i=1}^{p} \beta_i - I_g$ and g is the number of variables considered to be cointegrated, in our case two (Brooks (2002)). The intuition behind a VECM model is that changes in a variable's value do not have to depend only on past changes or other variables. Changes can also depend on the degree of disequilibrium between the values of y_1 and y_2. The Johansen approach is based on examining the coefficient matrix Π that has a reduced rank equal to one if the series are cointegrated and an equilibrium price relationship exists between the variables. The Johansen test is sequential, first the null hypothesis of a rank equal to zero (no cointegration; r=0) is tested, and if this hypothesis is rejected, the test r=1 is conducted.

6.3. Price discovery

Even if a cointegrating relationship between the two markets can be detected, the short-run dynamics between the CDS and bond markets in terms of price discovery has not been considered, even though modeled in equation (11) by the terms $\Gamma_1 \Delta y_{t-1}$ etc. This addresses the adjustment in each market to new information concerning the credit risk of a reference entity. If the CDS market would lead the bond market in price discovery, lags of the CDS spread would be significant in the equation for the bond spread, as this market adapts slower to this information (Brooks (2002)).

We can test whether past values of y_2, help forecast values of $y_{1,t}$ after controlling for past values of $y_{1,t}$, or vice versa through the Granger Causality Test. This method is based on the VAR model presented in equation (10) and will be used to test the causality in series that are not found to be cointegrated in the previous tests. The test runs every possible pair wise combination of the following equations:

$$y_{1,t} = c_1 + \sum_{j=1}^{p} \alpha_j y_{1,t-j} + \sum_{j=1}^{p} \beta_j y_{2,t-j} + \varepsilon_t \qquad y_{2,t} = c_2 + \sum_{i=1}^{p} \alpha_i y_{2,t-j} + \sum_{i=1}^{p} \beta_i y_{1,t-j} + \varepsilon_t \quad (12)$$

y_1 does not Granger cause y_2 if $\beta_i = 0$ for all i. Similarly, y_2 does not Granger cause y_1 if $\beta_j = 0$ for all j. A two-way Granger causation is present if the test implies that y_1 also Granger-causes y_2. In this case, price discovery takes place in both markets.

For cointegrated series, tests based on Vector Error Correction Models of the variables should be used. The common factor models developed by Gonzalo and Granger (1995) will be used to measure the contribution of each market in terms of price discovery. Gonzalo and Granger rely on the error correction process by measuring permanent shocks that lead to disequilibrium in the sense that the rate of how each market process news differ, based on the Vector Error Correction Model:

$$\begin{bmatrix} \Delta bspr_t \\ \Delta cds_t \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix} [cds_{t-1} - \alpha_i - \beta_i bspr_{t-1}] + \begin{bmatrix} \sum_{j=1}^{p} \gamma_{1,j} \Delta cds_{t-j} \\ \sum_{j=1}^{p} \gamma_{2,j} \Delta cds_{t-j} \end{bmatrix} + \begin{bmatrix} \sum_{j=1}^{p} \varphi_{1,j} \, \Delta bspr_{t-j} \\ \sum_{j=1}^{p} \varphi_{2,j} \, \Delta bspr_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,j} \\ \varepsilon_{2,j} \end{bmatrix} \quad (13)$$

The additional term $[cds_{t-1} - \alpha_i - \beta_i bspr_{t-1}]$ to the underlying VAR model is the error correction term added. By running this model, we obtain estimates for the adjustment coefficients λ_1 and λ_2, the coefficients that measure to what extent a particular market is contributing to the price discovery of credit risk. The coefficients measure the speed at which the markets move towards their long-run equilibrium. If λ_2 is negative and statistically significant, this would imply that the bond market is leading in terms of price discovery and that the CDS market moves to adjust for this information (Zhu 2004)). Both coefficients can possibly be significant and then both markets contribute to price discovery and the coefficients' relative size will reflect which one of the markets leads is leading in price discovery:

$$GG = \frac{\lambda_2}{\lambda_2 - \lambda_1} \tag{14}$$

When the Gonzalo Granger (GG) measure is above 0.5, the CDS market leads in terms of price discovery and if this measure is below 0.5, the bond market leads. If the measure is approaching 1 (0), price discovery only takes place in the CDS (bond) market. When the measure is close to 0.5, both markets are contributing to price discovery and it is not evident which one of the markets leads (Dötz (2007)).

7. Empirical findings

We will present and analyze our results in three parts, with all parts including test results for the whole period, the first period and the second period. We begin by testing the series for stationarity to continue testing for a cointegration relationship between the CDS and bond spreads. To finish, we examine the short-run dynamics of the two markets by testing which one dominates the price discovery process.

7.1. Stationarity

Table II – Output of stationarity tests

This table presents the t-statistics of the ADF and KPSS tests for all reference entities for the two separate time periods and for the full sample period. For the second time period as well as for the full sample, all series are determined to be non-stationary (H_0 is not rejected in the ADF test but is rejected in the KPSS test). For the first time period, one CDS and six bond series are stationary. We refer to *Table VII* in the Appendix regarding further information about the ADF and KPSS tests in terms of optimal number of lags used for individual bond and CDS spreads.

Company	ADF test H_0: I(1) KPSS test H_0: I(0)											
	2005/06/09 - 2009/10/07				2005/06/09 - 2007/08/08				2007/08/09 - 2009/10/07			
	CDS		Bond		CDS		Bond		CDS		Bond	
	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS
Aegon	-2.311	0.505***	-1.880	0.667***	-0.880	0.336***	-1.508	0.218***	-2.428	0.341***	-1.843	0.280***
Allianz	-1.799	0.491***	-1.145	0.459***	-0.569	0.392***	-2.584*	0.259***	-2.606	0.295***	-1.553	0.321***
Banco Bilbao	-1.714	0.448***	-0.712	0.723***	-0.681	0.220***	-3.337**	0.222***	-2.886**	0.263***	-1.281	0.288***
Banco Santander	-1.629	0.452***	-0.823	0.651***	-2.045	0.229***	-2.811*	0.227***	-2.530	0.308***	-1.214	0.326***
Barlcays	-1.900	0.524***	-1.487	0.678***	-0.136	0.240***	-2.530	0.678***	-2.853	0.407***	-1.448	0.239***
Basf	-1.642	0.459***	-2.188	0.354***	-1.559	0.300***	-4.543***	0.225***	-1.809	0.362***	-1.614	0.280***
BNP Paribas	-1.746	0.448***	-0.091	0.935***	-0.689	0.292***	-4.091***	0.219***	-2.930**	0.219***	-0.950	0.303***
Bouygues	-1.324	0.462***	-1.174	0.378***	-1.277	0.224***	-1.946	0.396***	-1.477	0.402***	-1.430	0.430***
Carrefour	-1.574	0.422***	-1.713	0.298***	-1.808	0.433***	-2.038	0.224***	-2.055	0.415***	-1.411	0.731***
Casiono Guichard	-1.884	0.474***	-1.159	0.479***	-1.586	0.217***	-1.765	0.230***	-1.962	0.396***	-1.174	0.433***
Commerzbank	-2.067	0.437***	-0.422	0.844***	-2.748*	0.232***	-2.357	0.232***	-3.233**	0.240***	-0.747	0.502***
Credit Agricole	-1.437	0.513***	-0.818	0.662***	2.782	0.353***	-4.454***	0.225***	-2.779*	0.239***	-1.944	0.502***
Deutsche Bank	-2.025	0.620***	-1.414	0.926***	-0.737	0.292***	-1.801	0.663***	-3.201**	0.324***	-1.678	0.288***
Deutsche Telekom	-1.873	0.449***	-1.495	0.332***	-2.050	0.387***	-1.593	0.499***	-2.299	0.486***	-1.869	0.453***
Electricite de France	-1.473	0.424***	-1.117	0.631***	-2.347	0.249***	-2.754*	0.315***	-1.677	0.397***	-1.347	0.264***
EnBW	-1.196	0.584***	-1.150	0.395***	-2.108	0.229***	-4.085***	0.244***	-2.468	0.230***	-1.286	0.312***
Fortum	-1.802	0.420***	-1.147	0.420***	-1.315	0.234***	-2.861**	0.224***	-2.033	0.314***	-1.347	0.299***
France Telecom	-1.596	0.457***	-1.992	0.307***	-1.664	0.298***	-1.677	0.445***	-1.857	0.619***	-1.679	0.458***
Holcim	-1.350	0.418***	-1.237	0.380***	-1.744	0.288***	-1.557	0.358***	-1.286	0.389***	-1.132	0.428***
Iberdrola	-1.366	0.429***	-0.619	0.711***	-1.208	0.218***	-0.288	0.301***	-1.955	0.331***	-0.714	0.393***
Koninklijke KPN	-2.365	0.261***	-1.758	0.267***	-1.648	0.505***	-1.492	0.562***	-2.011	0.464***	-1.413	0.419***
Portugal Telecom	-2.584*	0.253***	-1.496	0.296***	-1.706	0.620***	-2.123	0.543***	-2.203	0.479***	-1.189	0.465***
Repsol	-1.718	0.309***	-1.792	0.673***	-0.471	0.221***	-1.502	0.519***	-1.443	0.309***	-1.355	0.315***
Societe General	-1.403	0.604***	-0.993	0.798***	-1.756	0.401***	-3.603***	0.221***	-2.72*	0.350***	-2.059	0.312***
RBS	-2.044	0.622***	-1.304	0.601***	1.054	0.297***	-1.915	0.282***	-2.879**	0.221***	-1.338	0.225***
Unicredit	-1.870	0.477***	-1.597	0.594***	-2.555	0.224***	-2.679*	0.315***	-2.266	0.233***	-1.703	0.279***
Vivendi	-1.883	0.507***	-1.177	0.674***	-3.974***	0.221***	-3.556***	0.710***	-2.323	0.340***	-1.383	0.414***
Vodafone	-1.496	0.372***	-1.734	0.249***	-1.285	0.364***	-1.075	0.495***	-1.601	0.469***	-1.183	0.453***
Volkswagen	-1.883	0.634***	-1.788	0.563***	-2.020	0.423***	-1.626	0.562***	-2.095	0.410***	-1.738	0.324***
Wolters Kluwer	-2.473	0.382***	-1.319	0.407***	-1.556	0.257***	-2.589*	0.284***	-2.082	0.521***	-1.473	0.394***
	CDS		Bond		CDS		Bond		CDS		Bond	
Sum of unit root series	30		30		29		24		30		30	
*** = rejected at 10% ** = rejected at 5% *** = rejected at 1%**												

As can be seen in *Table II*, when examining the whole sample period both the ADF and the KPSS tests indicate that the CDS and bond spreads are non-stationary, i.e. unexpected changes or "shocks" will have a non-declining effect on the series as time passes. The null hypothesis of non-stationarity cannot be rejected at a 5% significance level for all CDS and bond spreads with the ADF-test, a result further confirmed by the fact that the KPSS test results indicate that stationarity can be rejected at a 1% significance level for all series. Thus, we conclude that, when examining the whole period, all our data series are non-stationary and contain a unit-root.

The ADF and KPSS tests give in some cases contradictory results in the first time period. When this occurs we rely on the strongest result in terms of statistical significance. As an example, the ADF test for the Banco Bilbao bond spread rejects the hypothesis of the series containing a unit-root at a 5% significance level whilst the KPSS test rejects that the same series is stationary at a 1% level. We have chosen to rely on the KPSS test in such cases since it rejects at a lower significance level and hence conclude that there are indications of the series containing a unit-root. In the cases when the two tests give contradictory, equally strong results from a statistical point, we have decided to rely on the ADF test as this is the more widely used.[11] Overall, six bond spread series are stationary and one CDS spread series is stationary. Since the CDS series being stationary is for Vivendi, which also has a stationary bond spread series, we can test for a co-integrating relationship for 24 out of 30 entities. For the six entities containing at least one stationary series, we will use Granger-Causality to test for any interrelationship between the two spreads.

Using the same methodology as outlined above for the second time period, we find that all 60 series contain a unit-root. Thus, the series are non-stationary, implying that we have to proceed to test for cointegration in order to examine any relationship between the CDS and bond spreads.

[11] Among the related papers covered in the Literature Review only Dötz (2007) uses the KPSS test

7.2. Cointegration

Table III – Output of cointegration tests

This table shows test results for the Engle-Granger test (t-statistics) and Johansen cointegration rank test (trace stat) for all sample periods. Series previously determined to be stationary in the first time period are excluded. If one test indicates cointegration, the CDS and corresponding bond spreads are determined to be cointegrated. The Engle-Granger procedure tests the null hypothesis of no cointegrating vector. The Johansen test is sequential, first the null hypothesis of zero cointegrating vectors must be rejected and then the second hypothesis of one vector should not be rejected for the spreads to be cointegrated. For the full sample period, 24 out of 30 entities' CDS and bond spreads are cointegrated. The corresponding numbers for the first and the second time period is 9 out of 24 and 19 out of 30, respectively.

Engle-Granger H_0: No cointegrating equation									
Johansen H_0: r=1 cointegrating vector exists									
	2005/06/09 - 2009/10/07			**2005/06/09 - 2007/08/08**			**2007/08/09 - 2009/10/07**		
Company	**Engle-Granger**	**Johansen trace stat[1]**		**Engle-Granger**	**Johansen trace stat[1]**		**Engle-Granger**	**Johansen trace stat[1]**	
	ADF	Rank = 0	Rank = 1	ADF	Rank = 0	Rank = 1	ADF	Rank = 0	Rank = 1
Aegon	-4.676***	29.830**	1.892	0.956	25.855**	0.019	-4.034***	41.871**	3.411
Allianz	-4.914***	59.070**	1.513	-0.691	23.908**	0.860	-4.236***	39.518**	2.779
Banco Bilbao	-3.659**	37.294**	0.842	3.533	20.146**	3.859**	-3.643**	32.899**	1.959
Banco Santander	-3.666**	38.246**	0.916	1.931	28.500**	8.578**	-3.345*	31.077**	1.977
Barlcays	-3.385**	18.866**	2.779	0.033	11.676	0.353	-3.668**	42.245**	2.165
Basf	-5.103***	41.188**	2.253	*I(0)*	*I(0)*	*I(0)*	-3.939**	23.129**	2.174
BNP Paribas	-3.295*	17.306**	0.396	*I(0)*	*I(0)*	*I(0)*	-3.018	14.282	2.152
Bouygues	-5.621***	43.285**	3.051	-1.251	9.245	1.567	-4.112***	31.232**	1.589
Carrefour	-4.367***	18.854**	1.877	-1.679	13.671	4.196**	-3.698**	15.358	2.337
Casiono Guichard	-4.558***	56.541**	1.541	-3.797**	31.219**	2.146	-3.549**	42.316**	2.020
Commerzbank	-3.384**	11.507	0.248	-3.352*	19.615**	6.044**	-3.244*	11.217	0.727
Credit Agricole	-3.986**	16.994**	0.748	*I(0)*	*I(0)*	*I(0)*	-3.097*	14.256	4.193**
Deutsche Bank	-3.408**	16.905**	1.997	-0.301	6.519	0.142	-4.127***	23.068**	3.159
Deutsche Telekom	-4.384***	32.879**	1.300	-1.729	8.538	3.107	-3.387**	20.532**	2.859
Electricite de France	-2.087	29.509**	3.337	-1.86	22.974**	3.925**	-1.648	17.131**	3.886**
EnBW	-2.729	13.165	0.941	*I(0)*	*I(0)*	*I(0)*	-2.766	13.130	1.842
Fortum	-3.897**	24.527**	1.214	-0.613	12.813	0.457	-3.079*	15.477**	1.785
France Telecom	-3.003	13.756	1.896	-1.214	6.369	2.048	-2.124	8.969	2.498
Holcim	-5.345***	94.281**	2.863	-1.702	18.711**	3.457	-3.768**	46.129**	1.830
Iberdrola	-1.831	12.916	3.768	-0.61	5.419	0.782	-1.918	8.658	2.035
Koninklijke KPN	-2.967	21.897**	3.176	-2.232	13.766	2.180	-2.186	14.422	3.121
Portugal Telecom	-2.740	11.337	1.720	-3.075*	16.981**	2.549	-2.885	20.325**	1.515
Repsol	-2.055	8.150	3.415	0.367	20.051**	0.964	-3.569**	19.727**	2.388
Societe General	-5.267***	43.479**	1.091	*I(0)*	*I(0)*	*I(0)*	-3.924**	27.209**	4.225**
RBS	-4.110***	16.522**	2.372	0.982	5.113	0.117	-4.115***	28.428**	2.304
Unicredit	-5.751***	33.408**	2.040	-0.822	27.296**	6.990**	-4.437***	35.306**	2.987
Vivendi	-3.685**	16.666**	1.302	*I(0)*	*I(0)*	*I(0)*	-3.275*	13.245	1.907
Vodafone	-3.689**	12.920	1.844	-1.423	8.505	1.208	-2.992	14.414	1.144
Volkswagen	-5.355***	28.641**	3.807**	-2.642	17.206**	3.893**	-3.700**	20.057**	2.855
Wolters Kluwer	-3.362*	13.781	1.937	-3.735**	43.843**	1.662	-2.479	8.982	2.120
Cointegrated series	Engle-Granger	Johansen Rank Test		Engle-Granger	Johansen Rank Test		Engle-Granger	Johansen Rank Test	
	21	**21**		**5**	**7**		**16**	**17**	
	Combined			*Combined*			*Combined*		
	24			**9**			**19**		
1) Only 5% critical values available									
*** = rejected at 10% ** = rejected at 5% *** = rejected at 1%**									

As described in the methodology section, two separate tests are conducted in order to determine whether the CDS and bond spreads are co-integrated. Following the framework of Zhu (2004), when one test indicates that the series are cointegrated, we rely on this. Hence, if either the Engle-Granger or the Johansen rank test results are in favor of cointegration, we determine the series to be cointegrated. When examining the whole time period, we find that 24 out of 30 (80%) pairs of spreads are cointegrated as seen in *Table III*. This supports the theoretical equilibrium relationship of the CDS and bond spreads moving together.

However, as we study the subsample of the first period, we only find support for cointegration for 9 out of the 24 (37.5%) entities left after removing the entities where at least one series was stationary. Using the same procedure as for the first time period, we find a co-integrated relationship for 19 out of 30 (63.3%) entities in the second time period. We refer to *Table VIII* in the Appendix for the number of lags used in the cointegration tests.

7.2.1. Discussion of cointegration results

Our test results imply that a majority of the CDS and corresponding bond spreads appears to not be cointegrated in the first period, indicating that the two markets may not price credit risk equally in the long-run. One possible explanation is that the arbitrage forces between the markets are weak. However, a majority of the series are considered to be cointegrated during the crisis period (second period), supporting the theoretical equilibrium relationship between the two spreads for this time period.

Deviations from equivalence should trigger actions by arbitrageurs, quickly bringing the market back to equilibrium. In practice, however, several assumptions and approximations that the theoretical model relies upon are violated. The presence of transaction costs allow for small differences between the two spreads without arbitrage forces coming into effect, interest rates are not constant as the example provided in the introduction part of the thesis and floating rate notes are not widely traded. The bonds used in the dataset are fixed coupon notes and are almost exclusively not priced at par. Moreover, the bonds are for the most part synthetically constructed through interpolation and not traded in the market. Therefore, the lack of cointegration is not conclusive evidence that credit risk is priced differently in the CDS and bond markets.

A striking difference between our dataset and data used in previous papers lies in the characteristics of the basis (CDS spread less bond spread). In the majority of previous studies, the average basis has been found to be slightly positive over time (Dötz (2007)) and (Zhu (2004)), whereas the average basis is negative and of greater magnitude for the investigated time periods in our study. The average basis is considerably lower in the second period compared to the first (-28.11 vs. -4.95) and the average basis has been strictly negative following the autumn of 2008. However, the test results still indicates a higher degree of cointegration during this period. An econometrical explanation to this rather counter-intuitive result lies in the specification of the cointegration tests, where allowance is made for a non-zero basis, i.e. the basis does not have to be zero or close to zero in order for the spreads to be cointegrated. Several factors tend to eliminate the arbitrage opportunities when the basis is different from zero. Even though the basis has increased in absolute numbers during the crisis for reasons further examined shortly, it seems as if the interrelationship between the markets has strengthened as indicated by the higher degree of cointegration. The presence of a persistent negative basis may thus not involve presence of arbitrage opportunities. Consider a negative basis trade where the investor buys the bond and the corresponding CDS contract. Profits are made when the investor reverses the trade as the basis narrows. However, if the basis for some reason does not narrow and remains negative within the investment horizon, the trade will be unprofitable.

In a negative basis trade as outlined above, the investor's cost of carrying is the short-term rate. If this rate increases rapidly during the crisis without the basis narrowing, the trade may have to be liquidated. If liquidated, the trader sells the CDS and the bond, thus removing the arbitrage forces intended to narrow the basis. This may result in the basis being allowed to be driven even more negative as several investors conduct similar trades, i.e. the demand for selling CDSs increases. Thus, the funding risk itself may be one of the reasons that we observe a persistent negative basis. Connected with this increased funding risk in periods of financial distress are differences in counterparty risk (counterparty credit risk and the timing of payments), that is also likely to affect the relative spreads. Counterparty risk is likely to be higher in unfunded structures such as the CDS market as opposed to the funded bond market. Hence, the protection buyer will tend to pay a lower CDS spread to be compensated for this risk. Unfortunately, there are to us no known methods to quantify these risks in our study, but the development of these factors in the overall economy will be discussed.

The TED-spread, measured as the difference between the 3-month Libor and the 3-month T-bill, functions as an indicator of the perceived credit and counterparty risk in the economy (Eichengreen et al (2009)). The Treasury rate is considered to be risk-free whilst the Libor rate reflects the counterparty risk involved in lending to commercial banks. Thus, the TED-spread is increasing in perceived risk. The TED-spread for our sample period is plotted in *Graph 7* in the Appendix. The pattern is obvious; the spread is significantly higher during the crisis (average TED-spread in basis points: whole period 80.16, first period 37.76, second period 122.48), indicating that the funding risk has increased substantially during the crisis. An insurance buyer taking the increased counterparty risk into account will pay less for the protection, thus making the CDS spread lower and the basis more negative. The higher credit and counterparty risks, as shown by the development of the TED-spread, provide a plausible explanation to the extensive time period of a negative basis found in our sample. If not taking this into account, one would expect the CDS and bond spreads to converge in order to eliminate arbitrage opportunities.

Taking the above factors into account, the arbitrage is still only approximate since we use constructed synthetic five year bonds not traded in the market. Another factor potentially weakening the arbitrage forces in the market is the fact that fund managers usually are not allowed to enter into CDS contracts, and even if bondholders would enter the market, their bond holdings will probably not be large enough compared to the large notional amounts traded in the CDS market (Blanco et al (2005)).

The above factors cause potential problems in measuring the true bond and CDS spreads. Since there are no known methods to incorporate and measure these factors when calculating the spreads, the theoretical equivalence relying on the market forces may not be violated in real life.

7.2.2. Differences between time periods

The fact that the full sample period indicates cointegration to a greater extent than the individual periods can potentially be an undesirable effect of having large sample sizes. A large sample size is often needed in order to make scientifically significant effects statistically significant, whereas the problem lies in that a large sample size also has the tendency to make effects of small scientific importance statistically significant (Lenth (2001)). Because of this, small and possibly non-notable deviations can be found to be statistically significant.

Research have found results supporting strengthened linkages between financial markets during crisis periods (Kasa (1992)). The equity markets in the US, Europe, Asia, Latin America, Eastern-Europe and Middle East exhibited no signs of long-run relationships before the Asian-crisis period of 1997-1998, but a significant cointegrating vector was observed during the crisis period (Ratanapakorn and Sharpa (2002)). The same phenomenon was observed after the October 1987 stock market crash and the Mexican Peso crisis in 1994, where international co-movements between stock markets increased substantially in the post crash period (Choudry et al (2007)). As the CDS and bond spreads are prices of the credit risk of the same entity, we expected that linkages between them should be strong to start with. It is however not evident how the interrelationship between these spreads would be affected by the crisis. One possible interpretation is that the two markets have become more cointegrated similar to what has been observed in equity markets. An interesting finding of Moon's (2001) study of the European stock markets after the Exchange Rate Mechanism crisis in 1992-1993 is that the stock market linkage only increased during the crisis period to later return to previous levels. In order to be able to draw any conclusions to whether this also holds for the CDS and bond markets, one must include a period after the crisis, which will hopefully be possible to do in a few years time.

According to the standard definition, two series are cointegrated if they share the same stochastic trend, i.e. a stochastic factor that leads to co-movement between the two series. The test results that imply an increased level of cointegration during the crisis can be interpreted as the stochastic trend being more powerful during the crisis period. Similar observations have previously been recorded between international stock markets and exchange rates during crisis periods (Choudry (2007)). If the same stochastic shock (in this case the crisis) affects both markets, they will exhibit similar reactions to that shock. This seems plausible since the financial crisis of 2007-2009 in particular changed investors' view regarding the credit quality of corporations. Moreover, it is possible that the lack of cointegration in the first time period to some extent is caused by misspecifications in the true bond spread due to the variety of factors discussed above, leaving the arbitrage arguments un-violated in real life. However, it can also be the effect of the dataset exhibiting nonlinear characteristics that cointegration analysis cannot capture during the first period, and that the co-movements between the markets become statistically significant in the second time period as a result of both spreads increasing rapidly.

7.3. Price discovery

Table IV – Output of Gonzalo-Granger test

This table displays test results of the Gonzalo-Granger price discovery test. For the full sample period, the CDS market is leading the price discovery process, i.e. a change in the CDS spread is more likely to be followed by a similar change in the bond spread than vice versa, for 20 out of 24 entities. This is represented by a GG value higher than 0.5 for 20 out 24 entities. The corresponding numbers for the first and the second time periods are 7 out of 9 and 11 out of 19, respectively.

	Gonzalo-Granger								
Company	2005/06/09 - 2009/10/07			2005/06/09 - 2007/08/08			2007/08/09 - 2009/10/07		
	λ_1	λ_2	GG	λ_1	λ_2	GG	λ_1	λ_2	GG
Aegon	-0.002	0.029***	0.94	0.030***	0.040**	3.90	-0.005	0.053***	0.92
Allianz	-0.029***	0.056***	0.66	0.004**	0.008***	2.07	-0.047***	0.070***	0.60
Banco Bilbao	-0.019***	0.020***	0.50	-0.021**	0.055***	0.73	-0.048***	0.024***	0.33
Banco Santander	-0.019***	0.020***	0.52	-0.060***	-0.038	-1.74	-0.044***	0.023***	0.34
Barlcays	0.001	0.020***	1.03				-0.030***	0.065***	0.68
Basf	-0.013**	0.052***	0.80				-0.021**	0.052***	0.71
BNP Paribas	-0.021***	0.040**	0.66						
Bouygues	-0.068***	0.000	0.01				-0.077***	0.000	0.00
Carrefour	-0.024***	0.026**	0.53				-0.040***	0.024	0.37
Casiono Guichard	-0.032***	0.045***	0.58	-0.057***	0.040***	0.42	-0.040***	0.063***	0.61
Commerzbank	-0.016***	0.014	0.46						
Credit Agricole	-0.018***	0.031***	0.63						
Deutsche Bank	-0.011***	0.016***	0.58				-0.050***	0.020	0.28
Deutsche Telekom	-0.029***	0.037***	0.56				-0.034***	0.039***	0.54
Electricite de France	0.000	0.023***	1.00						
EnBW									
Fortum	-0.013***	0.031***	0.71				-0.019**	0.036***	0.65
France Telecom									
Holcim	-0.064***	-0.009**	-0.17	0.007	0.043***	1.19	-0.054***	-0.017***	-0.44
Iberdrola									
Koninklijke KPN	-0.014**	0.026***	0.65						
Portugal Telecom				-0.013	0.032*	0.71	-0.023**	0.042***	0.64
Repsol				0.016**	0.055***	1.42	-0.043***	0.004	0.08
Societe General	-0.035***	0.075***	0.68				-0.050***	0.066***	0.57
RBS	-0.004	0.025***	0.87				-0.036***	0.060***	0.62
Unicredit	-0.006	0.071***	0.92				-0.019	0.108***	0.85
Vivendi	-0.013***	0.020***	0.59						
Vodafone	-0.011**	0.019***	0.64						
Volkswagen	-0.032***	0.012**	0.28				-0.044***	0.013	0.23
Wolters Kluwer				-0.009	0.125***	0.93			
Sum of significant λ	19	22		6	7		17	14	
Average[1)]			**0.61**			**0.75**			**0.48**
Median[1)]			**0.63**			**0.93**			**0.57**
Series with GG > 0.5	**20**			**7**			**11**		
Total number of series	*24*			*9*			*19*		

*** = rejected at 10% ** = rejected at 5% *** = rejected at 1%**

[1)] Based on adjusted GG measures. GG>1 and GG<0 has been adjusted to 1 and 0 respectively

Table V – Output of Granger Causality test

This table shows the Granger Causality test results for those entities where the CDS and corresponding bond spreads were found not to be cointegrated or where the series were determined to be stationary. For the full sample period, the CDS spreads leads the price discovery process. This can be seen from the number of significant coefficients, which are 4 for the CDS market and 3 for the bond market. The causality seems to operate in the same direction for the first time period, whereas the bond spread slightly dominates the price discovery process for the entities not found to be cointegrated in the second time period.

Company	Granger Causality											
	2005/06/09 - 2009/10/07				2005/06/09 - 2007/08/08				2007/08/09 - 2009/10/07			
	CDS	*P-value*	*Bond*	*P-value*	*CDS*	*P-value*	*Bond*	*P-value*	*CDS*	*P-value*	*Bond*	*P-value*
Aegon												
Allianz												
Banco Bilbao												
Banco Santander												
Barlcays					6.848	0.009	32.715	0.000				
Basf					1.291	0.256	0.690	0.406				
BNP Paribas					68.004	0.000	0.343	0.558	3.271	0.071	4.898	0.027
Bouygues					9.545	0.002	4.278	0.039				
Carrefour					9.693	0.002	0.385	0.535				
Casiono Guichard												
Commerzbank					16.216	0.000	2.603	0.107	1.804	0.179	6.130	0.013
Credit Agricole					19.008	0.000	3.394	0.065	1.433	0.231	1.207	0.272
Deutsche Bank					1.465	0.226	9.168	0.002				
Deutsche Telekom					1.039	0.308	3.114	0.078				
Electricite de France					5.948	0.015	4.816	0.028	47.728	0.000	10.947	0.001
EnBW	14.171	0.000	10.493	0.001	72.781	0.000	4.754	0.029	4.050	0.044	9.590	0.002
Fortum					10.654	0.001	19.646	0.000				
France Telecom	29.068	0.000	6.962	0.008	0.115	0.734	3.747	0.053	11.945	0.001	1.290	0.256
Holcim												
Iberdrola	41.275	0.000	14.280	0.000	2.248	0.134	13.232	0.000	18.362	0.000	3.622	0.057
Koninklijke KPN					16.489	0.000	0.193	0.661	32.050	0.000	0.021	0.886
Portugal Telecom	1.378	0.241	1.430	0.232								
Repsol	4.642	0.031	1.017	0.313								
Societe General					20.918	0.000	2.946	0.086				
RBS					4.389	0.036	0.484	0.487				
Unicredit					100.650	0.000	20.048	0.000				
Vivendi					2.883	0.090	0.158	0.691	3.772	0.052	15.293	0.000
Vodafone					22.120	0.000	0.206	0.650	11.230	0.001	12.504	0.000
Volkswagen					56.955	0.000	1.114	0.291				
Wolters Kluwer	2.822	0.093	3.168	0.075					1.475	0.225	4.738	0.030
Sum of significant coefficients	**4**		**3**		**15**		**8**		**6**		**7**	

The test results for the Gonzalo-Granger (GG) test is presented in *Table IV*. For the majority of the entities (22 out of 24), λ_2 is statistically significant at a 5% significance level for the full sample period, indicating that the CDS market contributes to price discovery in 22 cases. The corresponding number for the bond market is 19. For 20 out of the 24 firms, the Gonzalo Granger test results indicate that the CDS market leads in terms of price discovery. Nevertheless, the bond market is contributing to price discovery in 15 of those cases. With an average GG value of 0.61 and a median value of 0.63, the CDS market dominates the price discovery process for the series shown to be cointegrated during the whole sample period.[12] For the subset of the six entities in the whole sample where the equivalence relationship could not be verified, we rely on the Granger Causality test (*Table V*) to study the price dynamics between the markets. For EnBW, France Telecom and Iberdrola a relationship between lagged values of the CDS spread and the current bond spread cannot be ruled out and vice versa, indicating that both markets are contributing in the price discovery process. For Repsol, the CDS spread Granger-causes the bond spread but not the other way around. For the other two reference entities (Portugal Telecom and Wolters Kluwer), no relationship in either direction is found. In those cases where the test showed a bi-directional relationship, the coefficients on lagged CDS spreads were larger, indicating that the CDS market leads the price discovery process for the whole sample period.

When examining the first period, we are only allowed to perform the Gonzalo Granger test on the 9 pairs of bond and CDS spreads found to be cointegrated in the previous tests. Out of these, λ_2 (CDS) is statistically significant in seven of the cases and λ_1 (bond) in six of them. While both the CDS and bond market contribute jointly in five cases, the CDS spread dominates for all but one entity, Banco Santander. In total, the bond market only dominates the price discovery process for Casiono Guichard and Banco Santander, resulting in an average GG value of 0.75. For the remaining 21 entities, where either at least one of the time-series was determined to be stationary or where cointegration was rejected, the same pattern as for the full sample period is observed when testing for Granger Causality. The CDS spread Granger-causes the bond spread for 15 entities, whereas the bond spread only Granger-causes the CDS spread for eight of them (*Table V*). For the six entities where a two-way causality relationship is observed, the CDS spread is dominating in four of the cases. For the remaining four entities, no statistically significant relationship in either direction could be verified. Hence, the Granger Causality results are consistent with the result observed for the cointegrated series with the Gonzalo Granger procedure, implying that the CDS spreads lead bond spreads.

The Gonzalo Granger results for the 19 entities' spreads shown to be cointegrated during the second time period indicate that the CDS market is leading in a majority of the cases (11 out of 19), but the results exhibit some notable differences. The bond market is shown to be significant in the price discovery process for 17 entities, whereas the CDS market only contributes for 14 entities. This is in contrast to the full sample as well as the first period where the CDS market contributed in 22 of out of

[12] When GG is less than zero it is adjusted to zero and when it is above one it is adjusted to one (1) when calculating average and the median values.

24 and 7 out of 9, respectively. Furthermore, price discovery appears to take place exclusively in the bond market for the entities Bouygues and Holcim. Even though the CDS market dominates in the majority of the cases, the average GG value is 0.48. For the remaining 11 entities, we again have to rely on Granger Causality to measure the short-run dynamics between the markets. During the crisis period, the bond spread Granger-causes the CDS spread for seven entities, whereas the CDS spread only Granger-causes the CDS spread for 6 entities. For the three entities where there is a two way causality relationship between the spreads, the bond spread dominates.

7.3.1. Discussion of price discovery results

The results indicate that the CDS spreads lead bond spreads for the whole sample period, and especially for the first period, but not without contribution by the bond market. This is contradictory to Zhu's study (2004), where this relationship reflected the US data, but the bond market dominated the price discovery process for the European firms. However, a more recent study confirms that the importance of the CDS spread has increased and that the CDS market dominates the price discovery process by a slight margin for European firms (Dötz (2007)). This is consistent with other observations of pricing processes in derivatives markets, for example Upper and Werner's (2002)[13] and Hodgson et al's (2003)[14] observations of the more liquid futures markets dominating the corresponding spot markets in price discovery.

According to our results and Dötz (2007), it could be suggested that the CDS market is leading the price discovery process in the European credit risk market, just like its US counterpart and other derivatives markets have been proven to do previously. Possible explanations for these observations are numerous. The relatively high cost of shorting corporate bonds caused by market illiquidity and other short-sales constraints present in the bond market favors price discovery in the CDS market. Furthermore, the fact that the CDS market is unfunded and less constrained than the bond market in terms of transaction quantity makes the CDS market well suited for responding quickly to new information. The CDS market imposes a certain counterparty risk that cannot be found in the bond market. The effect of this is that many of the trades in the CDS market are done by institutions with high credit quality (Blanco et al (2005)). Previous research on credit rating announcement's effect on the bond and CDS market has observed a larger effect on the CDS spread with larger changes around the event dates compared to

[13] German federal bonds and their respective futures during 1998
[14] Share price index futures and share prices in Australia

bond markets, a liquidity advantage applicable to all information potentially affecting the credit risk of an entity (Daniels et al (2005)).

As stated in our second hypothesis, we suggested that the bond market's importance in terms of price discovery could increase during the financial crisis and even though the results do not explicitly speak in favor of bond market dominance, the difference between the periods is obvious. An argument against our hypothesis is that the demand for credit protection from investors with long positions in corporate bonds increases sharply during periods of financial distress, implying that the liquidity should shift even further to this market. As an entity's credit worthiness takes a turn for the worse, it seems natural that the demand for credit protection on that particular entity should increase. However, the Bank for International Settlements (2003) argue that even though the demand for credit protection increases, liquidity actually takes a turn for the worse since protection sellers are no longer willing to sell from a certain threshold value. The limited number and homogeneity of participants (usually characterized by high leverage) in the CDS market is another factor affecting the liquidity negatively in crisis periods, since their herding behavior[15] puts strain on liquidity, increases volatility and prohibits price discovery in the market (Bank for International Settlements (2005)).

The results are contradicting to the 1998 Long Term Capital Management recapitalization crisis, where price discovery almost exclusively took place in the futures market in Germany and the bond market made seemingly no contribution at all. Our results are more in line with the observations made during the credit market uncertainty in 2005 following Standard & Poor's downgrade of Ford and General Motors, where the price discovery contribution by the CDS market fell rapidly (Dötz (2007)).

Our results of the short-run dynamics between the CDS and bond market favor price discovery dominance by the CDS market. However, the limited number of participants and the resulting herding behavior reduces liquidity and price discovery contributions in periods of financial distress, even though we cannot provide a clear cut answer to whether an actual shift in price discovery dominance has occurred.

[15] In periods of financial distress this can be characterized by heavy sell-offs without real fundamental changes having occurred.

7.4. Robustness

Common for the majority of previous research on the subject is the lack of robustness checks. The papers by Norden & Weber (2005), Dötz (2007), Chan-Lau & Kim (2004) and Hull et al (2004) are all examples of research without any extensive robustness checks on either the data method used or the econometric method. What could be interpreted as such a test is the use of different benchmarks for the risk-free rate, namely the swap rate and the Treasury rate (Houweling and Vorst (2005)). As previously explained, the literature shows that the swap rate is the best estimator for the risk-free rate and we have decided to not include this aspect in our paper as the level of contribution to research of such an approach would be limited.

Zhu (2004) includes a section concerning the robustness of his results where he puts emphasis on the interpolation methods used. In his particular dataset, there are missing observations for the CDS spread and the robustness check is in essence different methods to fill these gaps. As our dataset is complete, i.e. without missing values for either spread, a similar test becomes obsolete.

A major problem of testing for a cointegrating relationship between the credit and CDS spread is that the bond spreads used are generic and not that of a traded bond. The interpolation method used to construct these generic bonds, in which a shorter (than five years) dated bond is combined with a longer (than five years) dated bond such that the residual maturity is five years, could potentially create biased results. However, this method is used in previous research and the opportunity to use different methods seems limited.

7.5. Further research

Following a bill[16] passed in December 2009 in the House of Representatives, one of the legislative organs in the US, clearing-houses for CDSs should be set up to guarantee certain contract specifications and CDS dealers will be required to register with the Securities and Exchange Commission, SEC. The bill also proposes minimum capital requirements for protection sellers. In light of this, we find it interesting to study the effect that such legislation would have on the interrelationship between the CDS and bond markets. Will the capital requirements implicitly limit the price discovery dominance of the previously unfunded CDS market and will the SEC registration provide further homogenization between the two markets, possibly tightening the no-arbitrage relationship between them?

[16] HR 4173

In light of the current European debt crisis involving a huge financial rescue package to Greece and severe budget deficits in Spain and Portugal, it would be interesting to see whether the cointegrating relationship between the sovereign CDS and bond market exhibits similar patterns as the corporate examined in this thesis. Is negative basis present in the sovereign markets and is the interrelationship more pronounced during financial turmoil?

8. Concluding remarks

This paper has examined the theoretical equivalence between CDS and bond spreads and the interaction between the two. The objective was to investigate this in light of the financial crisis of 2007-2009 and its implications on this relationship.

Hypothesis 1: **As bond and CDS spreads are prices of the same risk, there should be a long-run equilibrium relationship between them.**

Our study confirms the theoretical long-run relationship between the markets, as stated in our first hypothesis, reasonably well for the whole sample period, which is in line with the arbitrage arguments provided throughout the thesis. However, the relationship could not be verified for the first sub-period in our study, where a majority of the firms were found not to be cointegrated. The statistical properties of the sample, the generic bonds used for the survey as well as several other factors have been mentioned as arguments that could result in a lack of cointegration without arbitrage opportunities being present. On the other hand, a majority of the dataset (19 out of 30 reference entities) has cointegrated CDS and bond spreads during the second period, implying that the common stochastic trend is more readily observable during the crisis period compared to the more stable first period. The crisis period is characterized by a hefty negative basis. The negative basis can be attributed to the period's increased funding costs and counterparty risk, as shown by the TED-spread. These factors may allow for a negative basis without the equilibrium relationship being violated. To summarize, we find evidence of a long-run relationship as predicted by theory for the majority of the companies during the whole sample period and the period characterized by financial turmoil. For the first sub-period of our study, this relationship cannot be confirmed.

<u>Hypothesis 2:</u> **The CDS market incorporates new information faster than the bond market and is thus leading in terms of price discovery.**

The bond market's contribution to price discovery is increasing during the crisis.

Even when cointegration analysis confirms the two spreads' long-run relationship, significant deviations in the short-run are present. With this in mind, this paper aimed to investigate the short-run dynamics between the markets and if there is evidence of differences in information processing reflected by variation in the speed of price adjustment. Consistent with our second hypothesis, the price discovery process is dominated by the unfunded and less constrained CDS market, but not without contribution by the bond market. This relationship is especially representative for the whole sample period and the first period. However, differences in the short-run dynamics between the periods are evident. Even though we cannot find support for the price dominance shifting to the bond market during the crisis, the bond market's relative contribution increased significantly. This phenomenon could partly be explained by herding behavior caused by the highly levered participants in the CDS market, reducing liquidity and the price discovery contributions in periods of financial distress. Given the often observed liquidity advantage, the absence of short-sale restrictions and the unfunded nature, the CDS market should be better suited to adjust to new information than the bond market. The CDS market should be expected to continue to dominate the price discovery process in Europe to a larger extent, just like its US counterpart. However, with the current composition of its market participants, periods of financial distress may put constraints on the liquidity and the corresponding price discovery contribution.

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Appendix

Table VI – List of reference entities

This table shows the reference entities included in the sample, the entities' industry sector as well as their geographical origin.

Company	Sector	Country
Aegon	Insurance	Netherlands
Allianz	Insurance	Germany
Banco Bilbao	Financial	Spain
Banco Santander	Financial	Spain
Barlcays	Financial	UK
Basf	Chemical	Germany
BNP Paribas	Financial	France
Bouygues	Building and Construction	France
Carrefour	Food	France
Casiono Guichard	Food	France
Commerzbank	Financial	Germany
Credit Agricole	Financial	France
Deutsche Bank	Financial	Germany
Deutsche Telekom	Telecom	Germany
Electricite de France	Energy	France
EnBW	Energy	Germany
Fortum	Energy	Finland
France Telecom	Telecom	France
Holcim	Cement	Switzerland
Iberdrola	Energy	Spain
Koninklijke KPN	Telecom	Netherlands
Portugal Telecom	Telecom	Portugal
Repsol	Energy	Spain
Societe General	Financial	France
RBS	Financial	UK
Unicredit	Financial	Italy
Vivendi	Multimedia	France
Vodafone	Telecom	UK
Volkswagen	Auto	Germany
Wolters Kluwer	Publishing	Netherlands

Table VII – Number of lags used for ADF and KPSS test

Company	Number of lags used for stationarity tests											
	2005/06/09 - 2009/10/07				**2005/06/09 - 2007/08/08**				**2007/08/09 - 2009/10/07**			
	Lags for CDS		**Lags for bond**		**Lags for CDS**		**Lags for bond**		**Lags for CDS**		**Lags for bond**	
	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS	ADF	KPSS
Aegon	5	22	5	22	5	18	5	17	5	18	5	18
Allianz	3	22	2	22	3	18	4	18	1	18	1	18
Banco Bilbao	3	22	5	22	5	9	5	6	1	18	3	18
Banco Santander	5	22	4	22	4	7	5	14	3	18	3	18
Barlcays	5	22	4	22	5	18	4	18	1	18	4	18
Basf	5	22	5	22	1	18	5	18	1	18	1	18
BNP Paribas	3	22	5	22	1	18	5	16	1	17	3	18
Bouygues	1	22	5	22	1	14	5	18	1	18	5	18
Carrefour	1	22	4	22	1	18	5	14	1	18	1	18
Casiono Guichard	5	22	5	22	1	16	5	8	1	18	3	18
Commerzbank	2	22	4	22	5	18	5	7	1	5	1	18
Credit Agricole	4	22	5	22	1	18	5	7	1	18	2	18
Deutsche Bank	3	22	4	22	5	18	4	18	1	18	2	18
Deutsche Telekom	5	22	5	22	1	18	5	18	1	18	4	18
Electricite de France	5	22	2	22	1	4	5	18	1	18	2	18
EnBW	3	22	5	22	1	10	5	18	1	18	1	18
Fortum	1	22	5	22	4	18	5	17	1	18	1	18
France Telecom	3	22	5	22	1	18	5	18	1	18	2	18
Holcim	4	22	5	22	5	18	5	18	1	18	3	18
Iberdrola	3	22	1	22	2	15	5	18	1	18	1	18
Koninklijke KPN	2	22	5	22	1	18	5	18	2	18	2	18
Portugal Telecom	4	22	5	22	4	18	5	18	1	18	4	18
Repsol	5	22	4	22	3	9	4	18	1	18	4	18
Societe General	5	22	5	22	5	18	5	10	1	18	2	18
RBS	5	22	5	22	3	18	5	18	1	17	3	16
Unicredit	1	22	5	22	5	6	5	18	1	18	4	18
Vivendi	2	22	4	22	3	9	4	18	1	18	1	18
Vodafone	1	22	5	22	3	18	5	18	1	18	1	18
Volkswagen	5	22	5	22	1	18	4	18	1	18	3	18
Wolters Kluwer	1	22	4	22	2	18	5	18	1	18	1	18

Table VIII – Number of lags used for Engle-Granger and Johansen tests

Company	Number of lags used for cointegration tests					
	2005/06/09 - 2009/10/07		2005/06/09 - 2007/08/08		2007/08/09 - 2009/10/07	
	Engle-Granger	Johansen	Engle-Granger	Johansen	Engle-Granger	Johansen
Aegon	5	13	4	4	5	2
Allianz	5	2	5	3	5	2
Banco Bilbao	4	4	5	7	3	3
Banco Santander	5	4	5	7	5	3
Barlcays	5	7	5	3	5	2
Basf	5	2	*I(0)*	*I(0)*	2	2
BNP Paribas	4	3	*I(0)*	*I(0)*	3	2
Bouygues	5	7	5	3	5	2
Carrefour	1	3	2	3	1	3
Casiono Guichard	5	3	5	1	5	3
Commerzbank	2	1	5	11	4	1
Credit Agricole	1	4	*I(0)*	*I(0)*	1	2
Deutsche Bank	1	2	5	3	5	2
Deutsche Telekom	3	2	4	3	5	2
Electricite de France	4	2	2	3	5	2
EnBW	3	2	*I(0)*	*I(0)*	3	2
Fortum	1	2	5	3	1	2
France Telecom	5	3	5	3	5	3
Holcim	5	5	5	3	5	2
Iberdrola	5	2	5	1	5	2
Koninklijke KPN	4	3	5	3	4	3
Portugal Telecom	4	2	5	2	4	2
Repsol	5	5	3	1	5	5
Societe General	4	2	*I(0)*	*I(0)*	5	2
RBS	5	11	3	5	5	3
Unicredit	5	7	5	6	5	1
Vivendi	4	2	*I(0)*	*I(0)*	4	2
Vodafone	5	4	4	3	5	2
Volkswagen	5	7	4	3	4	4
Wolters Kluwer	1	2	4	1	3	2

Graph 7 – TED-spread in basis points for the sample period

This graph shows the development of the TED-spread, measured as the difference between the 3-month Libor and the 3-month T-bill, for our sample period.