The persistent negative CDS-bond basis during the 2007/08 financial crisis

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Abstract

I study the behavior of the CDS-bond basis - the difference between the CDS and the bond spread - for a sample of investment-graded US firms. I document that, since the onset of the 2007/08 financial crisis it has become persistently negative, and I investigate the role played by the cost of trading the basis and its underlying risks. To exploit the negative basis an arbitrageur must finance the purchase of the underlying bond and buy protection. The idea is that, during the crisis, because of the funding liquidity shortage and the increased risk in the financial sector, which exposes protection buyers to counter-party risk, the negative basis trade is risky. In fact, I find that basis dynamics is driven by economic variables that are proxies for funding liquidity (cost of capital and hair cuts), credit markets liquidity and risk in the inter-bank lending market such as the Libor-OIS spread, the VIX , bid-asks spreads and the OIS-T-Bill spread.

Results support the evidence that during stress times asset prices depart form frictionless ideals due to funding liquidity risk faced by financial intermediaries and investors; hence, deviations from parity do not imply presence of arbitrage opportunities.

Keywords: CDS; bond spread; funding rate, liquidity risk; counter-party risk; financial crisis.
JEL Classification Numbers: (General Financial Markets)

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1 Introduction

The CDS-bond basis is defined as the difference between the CDS and the bond spread, with equal maturity, written on the same entity. Whenever this difference is large, it is attractive to implement a basis trade, buying (selling) credit risk in the cash market and selling (buying) it in the derivative market if the basis is negative (positive), in order to profit from price discrepancies. In early 2009, Boaz Weinstein, a trader and co-head of credit trading at Deutsche Bank was down \$1bn, Ken Griffin of Citadel was down 50% and John Thain of Merril was said to be down by more than \$10bn. The big part of these losses is due to the so called ”negative basis trade”.

The aim of this paper is twofold. First, study the behavior of the basis during the 2007/08 financial crisis. Second, investigate why investors have lost money, on basis trades, during that period. I document that, during the crisis, the average basis on corporate entities has become strongly and persistently negative. Such a situation has never been reported in earlier studies. For example, Blanco et. al. (2005), find that the basis is usually positive and narrow and that short-term deviations are due to CDS spreads leading bond spreads in the price discovery process. If two markets price credit risk equally then their prices should be the same in levels and should move together. Instead, I find that, during the crisis, CDS and bond spreads have deviated form the parity condition. Implications have been dramatic for negative CDS-bond basis traders who where operating on the belief that bases deviation where risk-free and short-lived arbitrage opportunities.

The followings are among the possible explanations of the deviation from parity. First, a dramatic increase of funding costs affects the CDS' pricing by no-arbitrage and reduces the basis trading return for arbitrageurs. Second, when the basis has shifted into negative territory, basis traders where reporting mark-to-market losses. Due to liquidity shortage (funding liquidity risk) basis traders have been forced to de-leverage, closing their positions, driving the basis even more negative and realizing large losses. Third, protection sellers' (dealers) counter-party risk lowers CDS spreads. Fourth, investors facing redemptions tend to cut their most liquid position which include corporate bonds, and at the same time a higher funding cost makes it more expensive, for dealers, to provide liquidity in the bond market driving bond spreads larger. All this things may play a role in explaining the negative basis and are all related to funding liquidity conditions in the financial market.

The relation between bond yields and CDS is a close-to-arbitrage one that holds when markets are relatively liquid, i.e., when bid-ask spreads are narrow, market participants are able easily to find funding for purchases of bonds (leverage or repo) and the inter-bank-lending market is well functioning. Clearly, these conditions were much better approximated by the period leading up to the crisis than the period since the onset of the crisis in the summer of 2007.

If two financial variables are cointagrated (Engle and Granger (1987)) they share the same stochastic trend and are expected to drift not to far apart. The idea is that they will recover from deviations to their equilibrium relation. If this is not the case, the model describing the equilibrium relation should include the costs and risk factors that explain the deviation. I investigate the role played by economic variables that may capture cost and risk factors of implementing the negative basis trade, such as the Libor-OIS spread, the OIS-Tbill spread, the VIX and the bid-ask spread on CDS contracts, and show that, in the period during the crisis, these are the main drivers of the basis dynamics. The Libor-OIS spread captures all together (i) the funding cost and the funding liquidity risk faced by investors, (ii) counter-party risk implicit into CDS spreads and (iii) corporate bond market liquidity deterioration (Brunnermeier 2009). The OIS-Tbill spread is a measure of the "Flight to quality" phenomenon. The VIX is a measure of liquidity and risk premia in financial markets and is supposed to capture the cost of funding the negative basis trade given by the haircut and the margin requirement applied on the repo-transaction through which the bond is financed. According to Brunnermeier (2009) and Garleanu and Pedersen (2009), haircuts and margins act as market frictions that affects the implementation of price-correcting trades and give raise to price gaps between securities with identical cash-flows but different margin requirements. Finally, the bid-ask spread on CDS contracts is a measure of liquidity conditions in credit markets.

From the beginning of August 2007, when the crisis started, all these variables experienced a dramatic shift from their historic trends, i.e. they increased suddenly and become more volatile. Bond spreads have become larger than CDS spreads, and the basis has gone into negative territory. I find that the basis dynamics is driven by the economic variables, described above, that are proxies for liquidity conditions and risk in the inter-bank lending market. The idea that during stress times asset prices depart materially farther from frictionless ideals, i.e. from their fundamentals. The deviation from parity does not imply the presence and persistence of arbitrage opportunities, in fact the basis trading is faceing liquidity and counter-party risk, hence it is not risk-free.

This paper is organized as follows. Section 2 proposes a short review of the related literature and highlights the contribution. Section 3 discusses the conceptual framework that underlines the parity relationship between the CDS and the bond spread. Section 4 describes the data. Section 5 presents the empirical analysis: methodology and results. Final remarks are offered in section 6.

2 Review of the related literature

This paper is in line with previous studies on the dynamic relation between CDS and bond spreads, such as Blanco et.al. (2005) and Norden et.al. (2004) and De Wit (2006), but it covers a different time period, which goes from 1/3/2005 to 11/19/2009[1]. The focus is on the impact of the 2007/08 financial crisis and on how common factors explain a persistent deviation from parity. Using a sample of investment-graded firms, Blanco et.al. (2005) find that the theoretical arbitrage relationship linking credit spreads over the risk-free rate to CDS prices holds reasonably well on average for most of the companies they considered (especially for US firms) when the risk-free rate is proxied by the swap rate, though they may differ significantly in the short-run. I find similar results for the period before July 2007, instead during the crisis CDS and bond spreads drift apart.

Blanco et.al. argue that CDS forms an upper bound for credit risk because of the "cheapest to delivery option",[2] while credit spread forms a lower bound because of repo costs. This implies that in normal market conditions the CDS-basis is positive on average. Differently, this paper shows that during the crisis, the bond spread is an upper bound for the price of credit risk while the CDS is a lower bound. Cash bonds are funded instrument their so spreads are adversely affected by the cost of funding that drives yields larger, while CDS spreads, which are unfunded, are affected by counter-party risk being sold at discount.

Other studies such as Zhu (2004), Norden et.al. (2004) and De Wit (2006) reach similar conclusions of Blanco et.al. (2005). Concerning relationship between CDS and bond spreads, Blanco et.al. (2005) detect cointegration for 27 of 33 firms; Zhu (2004) detects cointegration for 15 out of 24 firms; Norden et.al. (2004) detect cointegration of spreads for 36 out of 58, and De Wit (2006) detects cointegration for 88 of 144 firms. In general, for the US market there is cointergation in

[1] For example Blanco et.al. (2005) data run from 2 January 2001 through 20 June 2002. De Wit (2006) data run from January 2004 to December 2006

[2] In practice the protection buyer will deliver the cheapest-to-deliver bond from the delivery basket. This option has a positive value, for this reason protection providers will quote higher CDS premiums.

75% of the cases. Longstaff et.al. (2005) study the default and non-default component of credit spreads using CDS information and find that both specific (to the bond) liquidity and overall (market) liquidity have an impact on the non-default component. The determinants of CDS and bond spreads have been studied by Collin-Dufresene et.al. (2001), Elton et.al. (2001) and also others who find that similar factors behind changes in CDS premium and the bond spread.

This paper is also related to the empirical literature on arbitrage, cointegration (Engle and Granger (1987)) and market efficiency. Cointegration is used extensively to study the link between spot and futures markets. Brenner and Kroner (1995) used a no-arbitrage cost of carry asset pricing model to explain why some markets are expected to be cointegrated while others are not. The idea is that cointegration depends critically on the time-series dynamics of the cost of carry. They showed that spot and future prices are cointegrated, in an efficient market, if the cost of carry is stationary, if it is not, the cointegrating relation should include the stock price, the future price and the cost of carry the arbitrage too. Following this line, persistent price discrepancies are explained by the cost of carrying the arbitrage trade.

I use the same idea to show that, during the crisis, the CDS and the bond spread wonder apart because of the explosion of the cost and the risk of trading the basis.To my knowledge, no empirical study has yet investigated the issue of price discrepancies in the market for credit risk during the crisis. I provide such an examination.

3 The CDS-bond basis

3.1 The connection between CDS and bond spreads: a "close-to-arbitrage" relation

CDS are the most liquid of the credit derivatives currently traded and form the basic building blocks for more complex structured credit products. They can be used to transfer credit risk from the investor exposed to the risk (the protection buyer) to an investor willing to assume that risk (the protection seller). A CDS is a bilateral contract where one counterparty buys default protection with respect to a reference credit event. This contract terminates at maturity or default, whichever comes first. In the event of a loss the protection buyer is compensated with the difference between the par value of the bond or loan and its market value after default. The protection seller, collects a periodic fee, and profits if the credit risk of the reference entity remains stable or improves while the swap is outstanding. CDS are almost exclusively traded over-the-counter. There are diverse participant in this market: banks, brokerage firms, insurance companies, pension funds, hedge funds and asset managers. The premium paid is quoted in basis points, per annum, of the contract's notional value; this is what we call CDS spread.

How does the pricing by arbitrage of a CDS work? Let's consider the most simple situation in which: the CDS counterparties are default free, the contingent payment amount specified in the contract is the difference $100 - Y(\tau)$ between the face value and the market value $Y(\tau)$ of the underlying note issued by C at credit event time τ and the underlying note is a floating-rate note. The underlying floating-rate note is initially issued at par, it is costless to short it and there are no transaction costs. The termination payment, given a credit event, is made at the immediately following coupon date of the underlying note. The contract is settled, if terminated by the credit event by physical delivery of the underlying note in exchange for cash in the amount of its face value. Under these assumptions the CDS price may be obtained by arbitrage. A synthetic (long) CDS can be created shorting a risky floating-rate note for an initial cash receivable of 100 and buying a par default-free floating-rate note for the same amount. This portfolio has to be held till maturity or default whichever comes first. One pays coupons on the risky bond and receives the coupons on the default free one. The difference between these two quantities is the spread S of the par note issued by C over the default-free floating rate. If default happens before maturity the value of the portfolio is the difference $100 - Y(\tau)$ between the market value of the default-free floating rate note and the market value of the note issued by C. In order to have no arbitrage the net constant annuity U, which is the CDS spread, has to be fixed such that U=S. When ever U and S differ substantially arbitrageurs' trading activities arbitrage away prices discrepancies, driving prices to their no-arbitrage relation.

What described above works in a theoretical setting, in practice CDS contracts are traded in OTC markets and provided by dealers. Dealers that sell a CDS (buy credit risk) hedge their position (buying protection) short-selling the risky bond that they obtain via repo. Instead, when they buy a CDS (sell credit risk) they hedge (selling protection) buying the risky bond that they finance paying a funding rate. When a particular bond is difficult to obtain as a collateral the associated repo rate may be below the risk-free rate rising the cost of shorting. If repos are special (lower than the risk free) it becomes more costly, for the dealer, to provide a CDS short-selling the risky bond. As a consequence the CDS spread is

$$U(ask) = Spread + (RiskFree - Repo) \tag{1}$$

Differently, the financing rate is generally above the risk-free, this makes it more costly for the dealer to buy CDS from customers. So

$$U(bid) = Spread - (FinancingRate - RiskFree) \tag{2}$$

Hence, if the repos are special the basis may be persistently positive, and if the funding cost is relevant, the basis is persistently negative.

The pricing relation discussed is a first order approximation, because bonds may default at any time, not just at coupon dates; moreover bonds have generally fixed, not floating, coupons hence they might trade away from par[3]. In general, even though cash flows on a long default-free bond and a short defaultable bond are not precisely those on a CDS, it's very close. Therefore, in a situation in which market frictions are negligible, the CDS is expected to be strictly connected the bond spread irrespective of how the bond yield is related to actual default intensity.

3.2 Why is the basis negative during the crisis?

How do market frictions and various risk factors influence the basis trade which makes the parity relation, between the CDS and the bond spread, hold? The main simple reason why the basis has deviated from zero is that CDS, which are derivatives contracts, and bonds, which are cash instruments, are exposed to different risk factors.

In principle, taking credit risk purchasing a corporate bond or shorting a CDS, on a reference entity, is equivalent. The point is that corporate bonds and CDS are not substitutes. Bond prices are exposed to: interest rate risk, default risk, funding risk and market liquidity risk, while CDS

[3]The approximation depends on how much the bond is away from par, on the coupon level, on the shape of the term structure of risk-free interest rates and on the shape of CDS curve. Departures from par and from a flat shape of the interest rate term structure deteriorate the approximation. For a detailed examination of these issues see Fontana (2009).

spreads are affected, mostly, by default risk and the related risk premia and counter-party risk. Funding risk is due to the fact that bonds are cash instruments, hence the return on the investment depends on the cost of funding, while liquidity risk to the fact that deterioration of liquidity in the corporate bond market may have an adverse impact on bond prices, hence on the cost of financing the purchase of the bond itself via a reverse-repo.

Being CDS unfunded derivatives contracts instead there is an issue of counter-party risk, since the protection seller may not be able to compensate the buyer, in the event of default of the underlying name. The connection between bond yields and CDS is a "close to arbitrage" relation that is expected to hold when, markets are relatively liquid, i.e. bid-ask spreads are relatively narrow and market participants are able to easily to find funding for purchases of bonds, moreover dealers who provide protection are not risky. Clearly these conditions where much better approximated by the period leading up to the crisis than the period since the onset of the crisis in the summer of 2007.

If a bond is trading more cheaply than the CDS an arbitrageur may profit implementing a negative basis trade in two ways. A first way is with a long run focus ("arbitrage-negative-basis-trade"). He buys the bond, buys protection, swaps the libor with a swap rate of the maturity of the bond (to hedge interest rate risk) and keeps this position till maturity to gain a "risk-free" yield. This strategy is "risk-free" in the sense that the investor does not care if the underlying name defaults, since what he looses on the bond he makes back from the short risk position in the CDS. A second way is with a short run focus (speculation). A trader may speculate on the variation of the basis in a short leg of time implementing a convergence trade type strategy. When the basis is negative he buys the bond, buys protection and hedges interest rate risk, as soon as the basis narrows he closes the position selling the bond and selling the CDS. This strategy is based on the belief that the basis is going to narrow whenever it is there.

The negative basis trade is not a perfect hedge, in fact it carries risks such as funding risk, mark-to-market loss risk[4] and counter-party risk[5]. Also, there is an issue of "coupon risk" and an issue of "recovery risk" [6]. I believe there are a number of possible reasons of why the behavior of

[4] Whenever traders leverage up their position they bear the risk they maybe forced to de-levarege in case of large market losses, or in case of an exogenous reason.

[5] Among other things, CDS buyers are often buying wrong way exposure; in fact, positive correlation between bond and counter-party default implies discount to the CDS premium.

[6] As highlighted in Fontana (2009) the basis trade is not a risk-free trade because, since default may happen at

the CDS-bond basis may have deviated from zero during the 2007/08 financial crisis and they are all related to the fact that the negative basis trade, as pointed above, is not a perfect hedge.

First, a dramatic increase of cost of financing has affected dealers' CDS pricing. The lower bound on a dealers bid price for protection is provided by the net cost of financing the purchase of the underlying cash bond[7]. Under normal conditions this cost approximates the bond spread and, in turn, the CDS spread. However, when the cost of financing increases the net cost falls and with it the CDS spread below which it is worthwhile for the dealer to bid for protection while hedging in the cash market. Lowering the bid price for protection also lowers the mid-price and, therefore, standard measures of the basis. The cost of financing affects investors trading activities in a similar way. In order to exploit a negative basis an investor must finance the purchase of the bond and buy protection. During the crisis the cost of financing, if indeed financing is available, has increased substantially thus reducing or eliminating the return to arbitrageurs. The cost of funding a negative basis trade is also given by the hair cut applied on the repo-transaction through which the bond is financed. Risk in financial markets has an adverse impact on the bond s' liquidity and on the value of the bond as a collateral and contributes to and increase of haircuts, i.e. an increase of the cost of funding.

Second, bond market liquidity deterioration. Investors, facing redemption and imposed reduction of the leverage, tend to cut their most liquid position which include corporate bonds, and to cut positions on basis trades driving the basis even more into negative territory. An increase in funding costs makes it also more expensive for dealers to hold corporate bonds into inventory and therefore lowers the liquidity of the market. It is possible that this lower liquidity is reflected in higher spreads and, if so, this would also contribute to a reduction of the basis.

Third, protection sellers' counter-party risk lowers CDS spreads. Selling protection may be achieved both via the CDS market and by buying cash bonds, but an important difference between the two is that in buying a bond the protection provided is funded, i.e., in the event of default the buyer of a bond simply accepts an amount (the recovery amount) that is lower than the nominal amount. Thus the provision of protection in this case does not depend on the creditworthiness of the bondholder. On the other hand the value of protection provided by a seller of protection via CDS

any time, the coupon is not hedged. Also when the bond is away from par there is a risk of recovery, since the amount invested in the purchase of the corporate bond is likely to be over or under-hedged.

[7]This refers to the pricing equation (2).

depends entirely on the sellers creditworthiness. Most protection sellers are financial institutions and the credit worthiness of many of these has clearly deteriorated markedly through the crisis. For example, A.I.G. and the monoline insurers, who were significant net sellers of protection, have suffered severe financial distress and, in the case of some monolines, failure. Sellers of protection are also exposed too, to some extent, to counterparty risk since they face mark-to-market losses in the event of the failure of the buyer.

4 Data

4.1 Data description

The analysis is conducted on a sample of 37 U.S. firms, that are listed on Table 1 with indication of sector and rating.

INSERT TABLE 1 HERE

Table 2 shows that 8 different sectors are well represented, but the majority of reference entities carry rating A and BBB. Data run from January 3, 2005 trough April 1, 2009, more than one semester after the "Lehman crash".

INSERT TABLE 2 HERE

CDS's are over the counter instruments traded mainly in New York and London. Indicative bid-ask quotes are provided by Thomson Financial Datastream. Prices hold at market closure at 5 p.m., are for a notional value of $10 million and are based on ISDA benchmark contracts for physical settlement. All CDS are of five years maturity, which is the most liquid one. Also corporate bonds are traded mainly over-the-counter in the US. Bond spreads over the swap rates are provided by Thomson Financial Datastream. These data are also at the close of the market at 5.50 p.m Eastern time, which is slightly later than the CDS market.

In order to match CDS's with bond spreads, I create a synthetic constant 5 years maturity bond spread. At every point in time in the sample, for each entity with suitable CDS data, I search for a bond with less than five years left to maturity, and another bond with more than five years to maturity. By linearly interpolating these spreads I approximate a five-year to maturity bond spread. When I have the choice I select the most liquid and most close to par bond. Only senior, straight bonds are used. Floating-rate notes and bonds that have embedded options, step-up coupons, or any special feature that would result in differential pricing, are not considered [8].

The bond spread is the difference between the bond yield and the risk-free rate. One possibility is to calculate the bond spread over US Treasuries yields. However, government bonds are no longer an ideal proxy for the unobservable risk-free rate. Taxation treatment, repo specials, legal constraint among others, make goverment bond yields artificially low for this purpose. As an alternative proxy for the risk-free rate is interest rate swap. Previous empirical studies on CDS, such as Houweling et.al (2003) and Blanco et.al (2005) have used swap rates as risk-free benchmarks. Swaps, being synthetic, are available in virtually unlimited quantities so that liquidity is not an issue, and they have the further advantage of being quoted on a constant maturity basis. However, swaps contain a risk premium because the floating leg is indexed to LIBOR, which is a default-risky interest rate and the presence of counter-party risk. Most importantly, investors do CDS-bond basis arbitrage using the swap rate as risk free rates.

CDS bid-ask spreads are provided by datastream. Time series data for the Libor curve and other variables used in the empirical analysis such as the T-Bill rate and the OIS (Overnight Indexed Swap) are also provided by the Federal Reserve. The VIX, i.e the implied volatility of S&P 500 index options, is downloaded from Datastream Thomson Financial.

4.2 The basis and the relevant economic variables: descriptive statistics

During the 2007/08 financial crisis the CDS-bond basis is persistently negative, i.e. bond spreads are on average larger than CDS spreads. [9] This is a signal that special factors are at work.

Figure 1 shows the time-series dynamics of then CDS, the bond spreads and the bases, for corporate entities, aggregated by rating group, separately for industrials and financials. Financials

[8]The idea is to neutralize as much as possible technical factors such as contractual specifications that affect the CDS-bond basis.

[9]Blanco et at (2005) report that the cross-sectional mean of the times series average of the CDS-bond bases, for a sample of 33 US firms, is + 6 basis points when using the swap rate as the reference rate, for AAA-AA, 0.5 bps for A and 14 bps for BBB; in general 3 bps. These result are in line with ours in the period before crisis.

entities are at the core of the crisis and default risk is much higher than for industrials, hence the CDS, the bond spread and the basis series are quite different. Spreads represent the creditworthiness and the risk of default of the underlying names and they are larger for lower ratings. Before the crisis, CDS and bond spreads where very low and the difference between them was neligeble. When the crisis started, around the beginning of August 2007, both CDS and bond spreads increased, but the basis has become negative. From September 15, 2008, when Lehman crashed, spreads exploded and the basis has become even more negative.

Table 3 shows the average and the median CDS-bond basis, across ratings, separately for the financial and the industrial sector, for three different periods: January 2005 to August 2007 is the pre-crisis period (Period 1), August 2007 to August 2008 is the pre-Lehmann crash period (Period 2) and August 2008 to March 2009 (Period 3) is the crisis period after Lehman collapsed. Before the crisis, there is evidence of the so called basis smile i.e. the average basis for the A rating category is the lowest, -4.9 bps.

INSERT TABLE 3 HERE

For AAA rating the average basis is positive, 12 bps, also because CDS are floored at zero, while bond spreads for highly rated entities are very low. For the BBB category, instead the average basis is 3.8 bps, the "Cheapest to Delivery option" increases the CDS premium with respect to the bond spread. In the second period, the basis is negative (on average -17.2 bps), except for the AAA rating. When Lehman crashed, on the 15th of September, the overall average basis went down dramatically to -147.5 bps.[10] Notice that for lower rated entities, the negative bases are larger pointing to the fact that economic and risk factors, that are at work, have different impacts across-ratings groups (collateral quality hypothesis). Also, for the financial sector spreads are generally higher, and the basis is more negative; in fact the crisis has originated from the financial sector.

Next, I discuss the variables used for explaining the CDS-bond basis and motivate their role.

Figure 2 shows the dynamics of the 3 month Libor minus the Overnight Indexed swap rate (Lib-OIS spread), and the dynamics of the difference between the OIS and the 3 month Treasury

[10] The average and the median are pretty much the same meaning the distribution is centered.

bill rate (OIS-Tbill spread). Figure 3 shows the VIX dynamics. VIX is the symbol for the Chicago Board Options Exchange Volatility Index, a popular measure of the implied volatility of S&P 500 index options. It is a measure of risk premia in financial markets. In this sense, a high value corresponds to a more volatile market. Figure 4 shows the dynamics of CDS's bid-ask spreads separately for industrial and for financials. What is the role played by the Libor-OIS spread, the OIS-Tbill spread, the VIX and the bid-ask spreads in CDS markets in our empirical analysis?

The **Libor-OIS** spread is an indicator of both the **counter-party risk** and the **funding liquidity risk** implicit in a negative basis trade[11]. The 3 month Libor is the rate at which banks declare they are willing to lend to each other unsecured. The OIS is the rate on a derivative contract on the overnight rate. In the US, the overnight rate is the effective federal funds rate and is considered risk-free. Changes in the Libor-OIS spread reflect both changes in the credit risk premium and changes in liquidity premium. The Libor-OIS spread is a measure of the risk in the inter-bank-lending-market because it reflects what banks believe is the risk of default associated with lending to other banks. When it increases, that means that lenders believe the risk of default on interbank loans is higher. As described in section 3.2, CDS providers are big banks and counter-party risk might be priced in CDS contracts.

From an economic point of view, funds are valued at the rate they could be invested in the money market; in general it is Libor plus a spread. So the funding cost to implement the negative basis arbitrage refers to the spread over the Libor rate. The problem is that during periods of financial turmoil the Libor itself dramatically increases with respect to the rate on government bonds, and often funding is even not available.

The funding cost hence refers not only to higher rates, but also to the value of the bond as a collateral. To earn an arbitrage profit an investor must use capital, and during a funding crisis capital is required to earn excess returns for constrained investors: price discrepancies between cash bonds and CDS are consistent with the margin-based asset pricing model by Garleanu and Pedersen (2009). "Typically, informed traders, such as dealers, hedge funds, or investment banks, use the purchased bonds as collateral and borrow (short term) against it, but they cannot borrow the entire price. The difference between the bond's price and collateral value, the margin, must be

[11]Counter-party risk refers to the risk that the protection buyer is not compensated, in case of default of the underlying bond, by the dealer providing the CDS contract.

financed by the traders own capital. An increase in margins or haircuts requires investors to use more of their own capital and forces traders to de-leverage their positions" Brunnermaier (2008). The idea is that the value of the bond and the margin requirements are crucial in order to determine the cost of the capital used in order to implement the negative basis trade and represent a friction that affects the implementation of price-correcting trades, i.e. margin requirements justify the price discrepancies between bonds, which are funded instruments and CDS which are unfunded instruments and can be bought without the use of capital. The **VIX** is supposed to capture, in addition to the time-dynamics of the risk premium on risky investments, the funding cost due to the deterioration of bond' s value as a collateral in the negative basis trade. In addition, risk in financial markets has an adverse impact on the bond s' liquidity, hence on the value of the bond as a collateral and contributes to increase haircuts further.

The **OIS-Tbill** spread is the spread between the Overnight Indexed Swap and the short term 3 month Treasury bill. Treasuries are the safest collateral and are particularly valuable in times of crisis. The OIS-Tbill spread dynamics captures the "flight to quality" phenomenon, and the corporate bond market liquidity deterioration. Fund managers prefer to switch to safe investments, which makes holding Treasury bonds more attractive and lowers the Treasury bond rate (Brunnermaier 2009) with respect to the OIS. Graphically these facts show up as spikes of the series. Liquidity deterioration in the corporate bond market drives yields high irrespective of the default intensity.

The **bid-ask spread** of CDS is a measure of liquidity of the CDS market. An increase of the bid-ask spread would reflect a deterioration of liquidity also in the corresponding bond market. A situation in which bonds and CDS values are uncertain because of market liquidity risk makes the basis trade more risky.

Figures 1, 2, 3 and 4 show that from the beginning of August 2007, when the crisis started, all variables experienced a dramatic shift from their historic trends. CDS, bond spreads, the Libor-OIS spread, the OIS-Tbill spread, the VIX and CDS's bid-ask spreads increased suddenly and have become more volatile, while the basis has deviated from zero and has shifted dramatically into negative territory.

INSERT FIGURES 1, 2, 3 AND 4 HERE

5 Empirical analysis

5.1 The lead-leg relationship between CDS and bond spreads

The analysis of the relationship and the adjustment process between CDS and bond spreads, in the period that goes from January 2005 to April 2009, is conducted on 4 series given by the averages of CDS and bond spreads by rating groups (AA, A and BBB Industrials and AA Financials)[12]. The focus is on averages of spreads within rating groups because the focus is on the common factors that drive the basis.[13] Data consist of weekly observations.[14]

The existence of a cointegration relationship between the levels of two I(1) variables [15] means that a linear combination of the variables is stationary. Cointegrated variables move together in the long run, but may deviate from each other in the short run, which means they follow an adjustment process towards the no-arbitrage condition. A model that considers this adjustment process is the Vector Error Correction Model (VECM). Cointegration analysis is carried out in the framework proposed by Johansen (1988, 1991). This test is essentially a multivariate Dikey-Fuller test that determines the number of cointegrating equations, or cointagrating rank, by calculating the likelihood ratio statistics for each added cointegration equation in a sequence of nested models.[16] The Vector Error Correction Model is specified as follows:

$$\Delta CDS_t = \lambda_1(Z_{t-1}) + \sum_{j=1}^{q} \alpha_{1j}\Delta CDS_{t-j} + \sum_{j=1}^{q} \beta_{1j}\Delta BS_{t-j} + \epsilon_{1t} \quad (3)$$

$$\Delta BS_t = \lambda_2(Z_{t-1}) + \sum_{j=1}^{q} \alpha_{2j}\Delta CDS_{t-j} + \sum_{j=1}^{q} \beta_{2j}\Delta BS_{t-j} + \epsilon_{2t} \quad (4)$$

$$Z_{t-1} = CDS_{t-1} - \alpha_0 - \alpha_1 BS_{t-1} \quad (5)$$

Equation (3) and (4) express the short term dynamics of CDS and bond spread changes, while Z_{t-1} is the error correction term given by the long run equation (5), that describes deviations of CDS and bond spreads from their no-arbitrage relation. The model is specified with the optimal

[12] I do not implement the analysis on the industrials AAA rating group because of the lack of data.

[13] I have conducted the analysis on single entities and results are in line with results on averages within rating groups.

[14] I have conducted the analysis on daily data and results are in line with those on weekly data.

[15] I(1) refers to non-stationarity given by the presence of a unit root.

[16] If the test does not reject the hypothesis that the number of cointerating vectors in none, the series are not cointegrated. If it can not reject the hypothesis of at most, one cointegrating vector, there is one cointegrating vector and the series are cointagrated.

number of lags for each cointegrating relation.

If the cash bond market is contributing significantly to the discovery of the price of credit risk, then λ_1 will be negative and statistically significant as the CDS market adjusts to incorporate this information. Similarly, if the CDS market is an important venue for price discovery, then λ_2 will be positive and statistically significant. If both coefficients are significant, then both markets contribute to price discovery. The existence of cointegration means that at least one market has to adjust by the Granger representation theorem (Engle and Granger 1987).

As a first step, I verify the supposed unit-root non-stationarity of the CDS and bond spread series. A stationary series follows a process which has a constant mean, variance and auto-covariance structure trough time. I apply the augmented Dickey-Fuller test to each of the 4 CDS and to each of the 4 bond spread series, independently. Results are summarized in Table 4.

INSERT TABLE 4 HERE

As expected, the test does not reject the null hypothesis of a unit root for all series in their levels, but it does for all series in their first differences, i.e. all series are integrated once, I(1).

The results of the Johansen cointagration test are shown in Table 5.

INSERT TABLE 5 HERE

The trace statistics strongly rejects the absence of cointegration, but do not reject the existence of one cointegrating relationship. Table 6, reports the estimated coefficients of the long-run regressions.

INSERT TABLE 6 HERE

The coefficients of CDS are restricted to unity, but the coefficients of bond spreads are positive, as expected, and well below unity, they are all between 0.37 and 0.49[17]. Also the constant term is significant and positive, for all rating groups. The parity relation does not hold, bond spreads

[17] A likelihood ratio (LR) test has been performed on the restriction of the coefficient of bond spreads to unity. The restrictions have been rejected. I do not report results for brevity.

are larger than CDS and the basis dynamics is affected by non-transient factors, but since CDS and bond spreads are cointegrated, i.e. they do not move in an unrelated way, the cash and the derivative market for credit risk are informationally integrated.[18] Table 7 reports results of the short-run regressions.

INSERT TABLE 7 HERE

Cross-responses of CDS and bond spreads, when significant they are generally positive, with values less than unity meaning that a movement in one market is transmitted to the other in the same direction, but with lower intensity. Also, for A and BBB industrials, the Adjusted R squared (0.38 and 0.47) is slightly higher for equation describing bond spreads changes (0.21 and 0.24), while for AA financial and industrials the Adjusted R squared (0.21 and 0.30) is slightly higher for the equation describing CDS changes.

The price discovery statistics are reported the bottom of Table 7. λ_1 is significantly positive for all rating groups, while λ_2 is significantly negative for most of the groups, indicating that both the CDS market and the bond market contribute significantly to credit risk price discovery. Following Blanco et.al., the method I use to investigate the mechanics of price discovery is a measure due to Gonzalo and Granger (1995) defined as defined as the ratio: $\frac{\lambda_2}{\lambda_2-\lambda_1}$. This approach attributes superior price discovery to the market that adjusts least to price movements in the other market. The Granger-Gonzalo measure for AA industrials, AA financials and A and BBB industrial is respectively: 0.752, 0.787, 0.599 and 0.429, meaning that for all rating groups except for BBB price discovery occurs mostly in the CDS market, eventhouh the value of GG is not much away from 0.5, meaning that new information flows into both markets, with a slight predominance of the CDS market. Price discovery occurs in the market where informed investors trade at most. CDS are unfunded instruments so they are the easiest way to trade credit risk. Because of their synthetic nature they do not suffer from the short-sales constraints seen in the cash-bond market, and buying (or selling) relatively large quantities of credit risk is possible (Blanco et. al 2005). Hence, price discovery is very much related to the market liquidity and does not give rise to systematic profitable opportunities.

[18]Concerning single relations, we find cointegration for most of the names, 20 out of 37 (with a 10% level of significance); these results are in line with those of Blanco et.al. (2005), Norden et.al (2005) and Zhu (2004), who find, for US entities, that 2/3 of the relations are cointegrated.

5.2 Explaining the negative basis during the crisis

To study the risk factors that drive the negative basis during the crisis, I apply the Engel-Granger two-step estimation approach using dummies for the crisis period. The idea is to account for the structural break that has characterized the parity relation between CDS and bond spreads and to study the different impact of the relevant economic variables, before vs. during the crisis.

I proceed as follows. First, I estimate the model using the variables in levels. The long run relationship between bond spreads, CDS and the other variables, such as the Libor-OIS spread, the OIS-TBill spread, the VIX and the bid-ask spread on CDS contracts, is the following[19]:

$$BS_t = \alpha_0 + \alpha_1 CDS_t + \alpha_2 LibOIS_t + \alpha_3 OISTbill_t + \alpha_4 VIX_t + \alpha_4 BidAsk_t + u_t \qquad (6)$$

If I reject the hypothesis of a unit root in the residuals then there is a long run relationship between the variables (the variables are cointegrated). I check for stationarity of the residuals by mean of the Augmented Dickey Fuller Test:

$$\Delta \hat{u}_t = a_0 + a_1 t + \beta \hat{u}_{t-1} + \sum_{i=1}^{K} \gamma_i \Delta \hat{u}_{t-1} + \mu_t \qquad (7)$$

Rejection of $\beta = 0$ means that u_t has no unit root, so that the variables in equation 6 are cointagrated. In this case the OLS estimator is super consistent and there are no spurious regression problems when I estimate the vector of parameters α in (6).

When residuals are unit-root stationary, I estimate the short run regressions, using first differences of the variables and the lagged error, obtained in the long run equation (6), by mean of the following Error Correction Model:

$$\Delta BS_t = \gamma_0 + \gamma \hat{u}_{t-1} + \sum_{i=1}^{p} \gamma_{1i} \Delta BS_{t-1} + \sum_{i=0}^{p} \gamma_{2i} \Delta CDS_{t-1} + \sum_{i=0}^{p} \gamma_{3i} \Delta LibOIS_{t-1} +$$

$$\sum_{i=0}^{p} \gamma_{4i} \Delta OISTbill_{t-1} + \sum_{i=0}^{p} \gamma_{5i} \Delta VIX_{t-1} + \sum_{i=0}^{p} \gamma_{6i} \Delta BidAsk_{t-1} + \epsilon_t (8)$$

[19] I implement the multivariate Johansen cointegration test on all the variables and I find that there is only one cointegration vector; this allows to use the more simple univariate model. I regress bond spreads on CDS because CDS slightly dominate price discovery, as shown in paragraph 5.1. and gives to the model a better fit.

Again, I apply the analysis on CDS and bond spreads averages for the four rating groups: AA, A and BBB industrials and AA financial. I use dummies for the two periods: (i) the period before the crisis that goes from January 2005 to end of July 2007, (ii) and the period during the crisis that goes from the beginning of August 2007 to April 2009.

Table 8 reports results for the long run regressions (6). In the analysis, I use interaction variables, to control for joint effects between independent variables with respect to the dependent variable. Adjusted R-squared are reported on the bottom of table.

INSERT TABLE 8 HERE

During the crisis the relation between bond spreads and CDS is generally not significant, while it becomes significant and it is positive during the crisis, as expected, given they are proxy for the risk of default of the underlying entites. Apparently CDS and bond spreads move in an unrelated way before the crisis; this is due to the fact that the basis is small, i.e. the parity approximately holds, but there is little variation, hence arbitrage forces do not enter into play to bring the credit spreads back to their equilibrium relation: they move within the arbitrage bounds determined for example by bid-ask spreads and transaction costs.[20] Moreover, the relevant economic variables, namely the Libor-OIS spread, the OIS-Tbill spread, the VIX and the bid-ask spread on CDS are all significant, only in the period during the crisis, with the expected sign.

The Libor-OIS spread, the CDS bid-ask and the VIX spread drive the bond spread larger, hence the basis more negative as expected. The bid-ask spread on CDS is a proxy for liquidity. Liquidity in the bond and in the CDS market are generally positively cross-correlated. The VIX captures the deterioration of the value of the bond as a collateral. The cost of funding a negative basis trade depends on the hair cut applied on the repo-transaction through which the bond is financed. Excessive volatility in financial markets has an adverse impact on the value of the bond as a collateral and contributes to and increase of haircuts. Along this lines the VIX has the highest impact (coeff 2.4) on the basis for the AA financials which is the most risky group and it has

[20] Also the structural break is modeled accounting for the change of the mean of the variables, not for the change of the variance. High variance, of the variables, in the crisis period lowers the significance of the cointegrating vector in the period before the crisis where the variance is low. The focus of the study is on the behavior of the spreads during the crisis.

the lowest impact (coeff 0.6) on the basis AA industrials which is the most creditworthy group. The OIS-Tbill spread makes an exception. In two cases, for AA financials and BBB industrials, which are the more risky rating groups in the analysis, it has an unexpected negative sign, for A industrial it is not significant while for AA industrials it has a positive sign. This variable is expected to capture the "flight to quality" effect driving bond spreads larger, but it turns out not to be the case for all rating groups. The economic impact of these variables is the highest for bond spreads of the financial sector, which has been the one at the core of the crisis. Also the constants are generally significant during the crisis, meaning that non-transient unobservable factors influencing the relation between bond spread and CDS have come into play .

Notice that interaction variables are significant, relevant and has homogeneous signs across rating groups. The Libor-OIS*VIX variable has a negative sign meaning that when the Libor-OIS spread and the VIX increase jointly their total effect on spreads is slightly lower than the sum of the two respective parameters. Differently the OIS-Tbill*VIX variable has a positive sign meaning that when the OIS-Tbill spread and the VIX increase jointly their total effect on spreads is slightly higher than the sum of the two respective parameters. Most importantly these interaction variables act as controls for our relevant economic variables. All the other interaction variables have been tried, but they turned out to be irrelevant.

The ADF test statistic, reported on the bottom of Table 8, rejects the null hypothesis of a unit root in the residuals of the long run regression, therefore I estimate the short run regressions using the Error Correction Model Specification. Results are reported in table 9. For brevity of exposition, in the table, I show only those variables that are significant[21]. Adjusted R-squared are reported on the bottom of table.

INSERT TABLE 9 HERE

As for the long run regression, also in the short run regression, the relevant economic variables tend to be significant, with expected signs, during the crisis period, moreover the signs of the estimated parameters are generally consistent across the long and short run regressions. The error

[21]Having 8 variable with 2 dummies and approximately 4 lags each, in the ECM estimation, the table would be to big.

correction terms are significant with a negative sign, meaning that whenever bond spreads are larger than CDS spreads they tend to revert to the long run equilibrium. This result is in line with the results of paragraph 5. Further, as expected bond spread changes are positively related to CDS changes to lagged bond spread changes, to Libor-OIS spread changes, to VIX changes and to bid-ask spread changes. For AA financial and BBB industrials, for which the OIS-Tbill variable has a negative impact in the long run regression, but also for AA industrials it has again a negative impact in the short run regression.

Graphs 5 and 6, report the actual-fitted and residuals and show that the estimated model fits the data quite well. The adjusted R-squared is on average 0.98 for the long run regression and around 0.65 for the short run regression.

INSERT FIGURES 5 AND 6 HERE

5.3 Interpretation of the results

Since the beginning of the crisis, in July 2007, the perceived credit risk in the economy has increased al well as the risk of default on interbank loans.

First, because of the general increase of default risk in the economy, CDS dealers (which are financial institutions such as banks, insurance companies or hedge funds) are paying higher funding rates. This effect is captured by the evolution of the Libor-OIS spread. A dramatic increase of cost of financing has affected dealers' CDS pricing as explained in section 3.2.[22] The cost of financing affects investors trading activities in a similar way. In order to exploit a negative basis an investor must finance the purchase of the bond and buy protection. During the crisis the cost of financing, if indeed financing is available, has increased substantially thus reducing or eliminating the return to arbitrageurs. Also, because of the high market volatility, measured by mean of the VIX, margin requirements (i.e. haircuts) for purchasing risky bonds (via repo transactions) have dramatically increased (deterioration of funding liquidity); this has reduced the profitability and the possibility,

[22]The lower bound on a dealers bid price for protection is provided by the net cost of financing the purchase of the underlying cash bond. In normal conditions this cost approximates the bond spread and, in turn, the CDS spread. However, when the cost of financing increases the net cost falls and with it the CDS spread below which it is worthwhile for the dealer to bid for protection while hedging in the cash market. Lowering the bid price for protection also lowers the mid-price and, therefore, standard measures of the basis.

for investors, to implement basis trade, and explains the cross-sectional difference in the basis across ratings, i.e. lower rated bonds and financials exhibit the most negative basis. It turns out that funding liquidity constraints provide a source of commonality (Acharya and Pedersen 2005) in explaining bond prices and returns, hence also the basis dynamics.

Second, liquidity has migrated from corporate bond market to the Treasury bond market, driving risky bond yields larger. This ”flight to quality” effect is captured jointly by the evolution of the OIS-Tbill spread and by the sharp increase of the VIX and CDS's bid-asks spread.

Third, being CDS contracts an unfunded way of selling protection[23], counterparty risk has contributed driving bond spreads larger than CDS spreads. In fact, during the crisis protection sellers (dealers which are mostly big banks) have higher default correlation to the assets being protected. Default risk in the inter-bank lending market is captured, not only by the dynamics of the CDS on banks, but also by the evolution of the Libor-OIS spread. This risk is priced into CDS contracts of both financials and industrials driving their spreads lower irrespective of the actual default intensity (discount).

Overall, results support the evidence that during the crisis the negative basis trade is largely exposed to risk factors such as funding liquidity risk and counter-party risk, i.e. it is not risk-free. The size of the basis is the return asked by investors on negative basis trades, hence it is a premium due to exposure to systematic risk factors not an idiosyncratic arbitrage opportunity.

5.4 Robustness checks

The analysis reported above has been implemented also on single entities and results are similar to those obtained on averages of credit spreads within rating groups. Investors carry out basis trades on single entities, but common risk factors affects bases with similar underlying risks in the a similar way. Also, results using daily data are similar to those obtained on weekly data. Bond and CDS prices refers to mid-quotes not to real transactions. The focus of the paper is on the systematic factors which drive discrepancies between CDS and bond spreads. Quotes are well-behaved averages of transaction prices and are cleaned from the noise due to idiosyncratic factors.

[23]While, bond being cash instruments, buying a corporate bond is a funded way of selling protection, hence counterparty risk is not an issue. But the issue is the cost of financing the purchase of the bond itself.

Univariate analysis of the credit spreads time-series shows the presence of conditional heteorskedasticity (ARCH and GARCH Engle (1982)). For this reason I implement a cointegration test that is robust to GARCH effects. I study the dynamic relationship between CDS and bond spreads by the mean of a Vector Auto Regression, with the introduction of a tractable multivariate GARCH formulation, such as the "BEKK", proposed by Engel and Kroner (1995). Results show that the incorporation of the GARCH part allows to conclude more clearly that cointegration exists. The presence of heteroskedasticity makes it more difficult to reject the null of no cointegration, but since cointegration between CDS and bond spreads is found anyway, even without controlling for GARCH effects, I do not implement this methodology in the analysis proposed in the paper.

The choice of the specification of the model in (section 5.2), has been for the univariate ECM, which allows to easily account for the structural break by mean of period dummy variables. I run the multivariate Johansen cointegration test on all the economic variables variables of equation (6) jointly and I find that there is only one cointegration vector; this allows to use the univariate model. The reason why I regress bond spreads on CDS is because CDS slightly dominate price discovery, as shown in paragraph 5.1. and gives to the model a better fit. The analysis has also been carried out estimating separately, for the pre-crisis and the crisis period with, the multivariate VECM and gives results that are in line with those obtained using the univariate framework.

The structural break of August 2007 is modeled exogenously, because there is a general consensus on the timing of the start of the 2007/08 financial crisis. One could think of modeling the structural break by mean of a switching regime model, but in the sample period under study (2006-2009), there is clear evidence of two states and there is no evidence of a switch between good and bad states of the credit market conditions; it would be interesting to apply switching regime models on credit spreads on longer samples which contain more crisis periods.

6 Conclusion

This paper documents that during the crisis, from July 2007 on, there are relevant price discrepancies in the markets for credit risk: the basis is persistently negative, meaning that it would be cheaper to take credit risk in the cash market, which has been quite infrequent in the past. In principle, in such a situation, arbitrageurs could buy risky bonds hedge against default risk and earn more that the risk free rate. Results show that during the crisis the negative basis trade is largely exposed to risk factors such as funding liquidity risk and counter-party risk, i.e. it is not risk-free. The size of the basis is the return asked by investors on negative basis trades, hence it is a premium due to exposure to systematic risk factors not an idiosyncratic arbitrage opportunity.

Variables that capture the cost and risk factors of implementing the negative basis trade, such as the Libor-OIS spread, the OIS-Tbill spread, the VIX and the bid-ask spread on CDS contracts, are the main drivers of the basis dynamics in the period during the crisis. The Libor-OIS spread captures all together (i) the funding cost and the funding liquidity risk faced by investors, (ii) counter-party risk implicit into CDS spreads and (iii) corporate bond market liquidity deterioration (Brunnermeier 2009). The OIS-Tbill spread is a measure of the "Flight to quality" phenomenon. The VIX is a measure of liquidity and risk premia in financial markets, but most importantly it explains the bond value deterioration as a collateral. Finally, the bid-ask spread on CDS contracts is a measure of general liquidity conditions in credit markets.

Results support the evidence that during stress times asset prices depart form frictionless ideals due to funding liquidity risk faced by financial intermediaries and investors; hence, deviations from parity do not imply presence of arbitrage opportunities. Funding liquidity constraints provide a source of commonality (Acharya and Pedersen 2005) in explaining bond prices and returns, hence also the basis dynamics.

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Table 1: **List of the 37 reference entities**. The ratings are from S&P at 8/1/2008.

Entity	Code	Sector	S&P Ratings
JpMorgan Chase	JPM	Financial	AAA
Citigroup Inc	CIT	Financial	AA
Morgan Stanley	MST	Financial	AA
Wachovia Corp	WAC	Financial	AA
Merrill Lynch	MLY	Financial	A
Textron	TXT	Manifacturing	A
Caterpillar	CAT	Manifacturing	A
Deere	DEE	Manifacturing	A
Emerson Electric	EMR	Manifacturing	A
United Technologies	UNT	Manifacturing	A
Tyco International	TYC	Manifacturing	BBB
Procter&Gamble	PRG	Consumer	AA
Colgate Palmolive	CLG	Consumer	AA
Avon protucts	AVN	Consumer	A
Whirlpool Corp	WRP	Consumer	BBB
Mattel Inc	MTT	Consumer	BBB
Newell Rubbermaid	NLL	Consumer	BBB
Waste Mgmt Inc	WST	Consumer	BBB
PPG Industries	PPG	Chemicals	A
Air Products	AIR	Chemicals	A
Dow Chemical	DOW	Chemicals	BBB
Lubrizol	LBZ	Chemicals	BBB
Hess	HSS	Petr&Gas	BBB
Sunoco	SUN	Petr&Gas	BBB
Valero	VAL	Petr&Gas	BBB
Archer-Daniels	ARC	Food&Beverage	A
Kraft	KFT	Food&Beverage	A
Coca Cola Co	CCL	Food&Beverage	A
General Mills	GML	Food&Beverage	BBB
ConAgra	CAG	Food&Beverage	BBB
Anheuser-Bush Cos	ANH	Food&Beverage	BBB
AT&T/SBC	SBC	Telecomunications	A
BellSouth	BEL	Telecomunications	A
Johnson&Johnson	J&J	Pharma	AAA
Pfizer	PFZ	Pharma	AAA
Abbott	ABB	Pharma	AA
Hospira	HOS	Pharma	BBB

Table 2: **Number of reference entities by rating and by sector**.

Sector / Rating	AAA	AA	A	BBB	Total
Financial	-	4	1	-	5
Manifacturing	-	-	5	1	6
Consumer	-	2	1	4	7
Chemicals	-	-	2	2	4
Petr&Gas	-	-	-	4	4
Food&Beverage	-	-	3	3	6
Telecomunication			2	-	2
Pharmaceutical	2	1	-	1	4
Total	2	7	14	14	37

Table 3: **Average and median basis before and during crisis**. This table provides the average and the median of the CDS-bond basis, defined to be the difference between the CDS spread and the bond spread. For each reference entity and expressed in basis points. The bond spread is calculated as the difference between the 5-year interpolated yield on the risky bond and the 5-year swap rate. Sample period is divided into three parts: 1/3/2005 to 7/31/2007 is the period before crisis (Period 1), 8/1/2007 to 7/31/2008 is the crisis period (Period 2) Lehman and 8/1/2008 to 4/1/2009 (Period 3) is the crisis period after Lehman collapsed. Crossectional mean and median are provided, for groups of entities according to rating, separately for the financial and industrial sector

Average Basis (Median)	1st Period	2nd Period	3rd Period
Industrials			
AAA	12.0	0.5	-60.0
	(11.1)	(0.9)	(-77)
AA	7.3	-9.2	-77.1
	(8.9)	(-8.8)	(-88.5)
A	-4.9	-25.9	-126.1
	(-5.2)	(-24.4)	(-143)
BBB	3.8	-32.8	-165.8
	-4.2	(-32.1)	(-206.4)
Financials			
AA	-7.3	-18.7	-308.4
	(-5.5)	(-21.2)	(-394.4)
Average all	2.2	-17.2	-147.5

Table 4: **ADF unit root tests**. Sample period 1/3/2005 - 4/1/2009. Automatic selection of lags based on SIC: 0 to 14. * Means 1% level rejection based on MacKinnon (1996) one-sided p-values.

Statistics	CDS	Bond Spread
ADF - Level		
AA Industrials	0.971	0.936
AA Financials	0.977	0.997
A Industrials	0.999	0.982
BBB Industrials	0.996	0.999
ADF - First difference		
AA Industrials	0.000*	0.000*
AA Financials	0.000*	0.000*
A Industrials	0.000*	0.000*
BBB Industrials	0.000*	0.000*

Table 5: **Cointegration tests**. Sample period 1/3/2005 - 4/1/2009. Unrestricted Cointegration Rank Test (Trace test). Trace test indicates 1 cointegrating eqn(s) at the 0.05 level. Automatic selection of lags based on SIC: 0 to 17. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values.

Group	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
Industrials AA	None *	0.086	19.504	15.892	0.012*
N. lags (4)	At most 1	0.005	1.296	9.164	0.908
Financials AA	None *	0.134	33.490	20.261	0.000*
N. lags (4)	At most 1	0.010	2.209	9.164	0.735
Industrials A	None *	0.124	30.717	20.261	0.001*
N. lags (6)	At most 1	0.010	2.209	9.164	0.735
Industrials BBB	None *	0.122	30.006	20.261	0.001*
N. lags (6)	At most 1	0.009	1.975	9.164	0.782

Table 6: **Long-run regressions.** Sample period 1/3/2005 - 4/1/2009. This table reports the estimates of the equation that describes the long run relationship between CDS and bond spreads, given by $CDS_t = \alpha_0 + \alpha_1 BS_t$, for each of the four rating groups. T-statistics in ( )

	Industrials AA	Financials AA	Industrials A	Industrials BBB
CDS	1	1	1	1
Bond spread	0.372	0.448	0.498	0.467
	(16.407)***	(19.055)***	(28.269)***	(30.479)***
Constant	11.031	16.127	8.292	-23.452
	(8.513)***	(2.602)*	(4.349)**	(11.421)***

Table 7: **Short-run regressions** This table reports the estimates of the short run dynamics of CDS and bond spread changes. Sample period 1/3/2005- 4/1/2009. The measure is based on the following Vector Error Correction Model regressions:

$$\Delta CDS_t = \lambda_1(CDS_{t-1} - \alpha_0 - \alpha_1 BS_{t-1}) + \sum_{j=1}^{q} \alpha_{1j}\Delta CDS_{t-j} + \sum_{j=1}^{q} \beta_{1j}\Delta BS_{t-j} + \epsilon_{1t}$$

$$\Delta BS_t = \lambda_2(CDS_{t-1} - \alpha_0 - \alpha_1 BS_{t-1}) + \sum_{j=1}^{q} \alpha_{2j}\Delta CDS_{t-j} + \sum_{j=1}^{q} \beta_{2j}\Delta BS_{t-j} + \epsilon_{2t}$$

The final lines report the "Adjusted R Squared" of each regression and the Granger-Gonzalo measure, which is a measure of the contribution of the two markets to price discovery and is defined as: $\frac{\lambda_2}{\lambda_2 - \lambda_1}$ and is bounded between 0 and 1. T-statistics in ( )

	Industrials AA		Financials AA	
	CDS	Bond spread	CDS	Bond spread
CointEq1	-0.076	0.233	-0.084	0.314
	(-3.318)**	(2.697)*	(-1.013)	(3.481)**
D(CDS(-1))	0.258	1.146	0.174	0.002
	(3.813)**	(4.536)***	(2.087)*	(0.024)
D(CDS(-2))	0.061	-0.068	-0.058	0.109
	(0.855)	(-0.253)	(-0.693)	(1.207)
D(CDS(-3))	0.104	-0.735	-0.034	-0.008
	(1.461)	(-2.747)*	(-0.437)	(-0.106)
D(CDS(-4))	0.026	0.527	-0.171	-0.003
	(0.387)	(2.046)*	(-2.226)*	(-0.047)
D(Bond spread(-1))	0.045	0.262	-0.240	-0.468
	(2.415)*	(3.750)**	(-3.213)*	(-5.810)***
D(Bond spread(-2))	0.009	0.053	0.232	-0.098
	(0.491)	(0.737)	(2.898)*	(-1.133)
D(Bond spread(-3))	-0.050	0.048	0.280	0.023
	(-2.638)*	(0.676)	(3.396)**	(0.263)
D(Bond spread(-4))	0.012	0.048	-0.308	-0.127
	(0.688)	(0.692)	(-3.709)**	(-1.424)
Adj. R-squared	0.210	0.189	0.306	0.212
GG Measure	0.752		0.787	

	Industrials A		Industrials BBB	
	CDS	Bond spread	CDS	Bond spread
CointEq1	-0.182	0.272	-0.201	0.151
	(-2.642)**	(4.024)**	(-3.648)**	2.539*
D(CDS(-1))	-0.056	0.071	0.141	0.198
	(-0.664)	(0.847)	(1.804)	(2.329)**
D(CDS(-2))	0.125	0.054	0.180	0.118
	(1.563)	(0.698)	(2.332*)	(1.417)
D(CDS(-3))	0.167	0.032	-0.052	0.341
	(2.135)*	(0.418)	(-0.675)	(4.082)**
D(CDS(-4))	0.181	0.191	-0.124	-0.091
	(2.324)*	(2.509)*	(-1.520)	(-1.031)
D(CDS(-5))	0.017	0.036	0.145	-0.499
	(0.220)	(0.477)	(1.788)	(-5.659)***
D(CDS(-5))	0.114	-0.207	0.338	-0.079
	(1.504)	(-2.777)*	(3.881)**	(-0.846)
D(Bond spread(-1))	0.096	0.263	0.091	0.251
	(1.355)	(3.748)**	(1.359)	(3.452)**
D(Bond spread(-2))	-0.098	0.204	0.072	0.221129
	(-1.386)	(2.920)*	(1.07785)	(3.049)**
D(Bond spread(-3))	-0.375	0.024	-0.197	-0.058
	(-5.412)***	(0.354)	(-2.930)**	(-0.800)
D(Bond spread(-4))	-0.032	-0.001	-0.081	0.144
	(-0.439)	(-0.017)	(-1.361)	(2.244)*
D(Bond spread(-5))	0.131	0.149	0.117	0.200
	(1.814)	(2.094)*	(1.927)*	(3.050)**
D(Bond spread(-6))	0.242	0.133	0.105	-0.015
	(3.455)**	(1.929)*	(1.852)	(-0.257)
Adj. R-squared	0.215	0.386	0.241	0.476
GG Measure	0.599		0.429	

Table 8: **Long-run regression.** Sample period 1/3/2005 - 4/1/2009. P-value in ( )

Bond Spread	AA Industrial	AA Financials	A Industrial	BBB Industrial
Dum1	19.339	19.552	57.344	26.103
	(0.1253)	(0.795)	(0.029)**	(0.380)
Dum2	-58.506	-251.917	-124.763	-94.378
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Dum1*(CDS)	-1.002	-0.436	-0.117	0.264
	(0.035)**	(0.642)	(0.828)	0.383
Dum2*(CDS)	1.000	0.473	0.413	0.969335
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Dum1*Lib-OIS	-0.418	-0.333	-3.131	0.760
	(0.208)	(0.970)	(0.294)	(0.786)
Dum2*Lib-OIS	0.186	1.280	0.525	0.492
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Dum1*OIS-Tbill	-0.075	0.508	-0.212	0.082
	(0.838)	(0.750)	(0.151)	(0.913)
Dum2*OIS-Tbill	0.273	-1.336	-0.009	-0.606
	(0.000)***	(0.000)***	(0.947)	(0.000)***
Dum1*VIX	-0.140	0.808	-1.395	-0.054
	(0.871)	(0.867)	(0.380)	(0.979)
Dum2*VIX	0.688	2.417	1.557	1.052
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Dum1*Bid-Ask	0.850	4.972	1.225	1.043
	(0.414)	(0.054)*	(0.446)	(0.486)
Dum2*Bid-Ask	7.284	44.854	23.806	19.891
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Dum1*Lib-OIS*VIX	0.047	0.036	0.134	-0.035
	(-0.667)	(0.956)	(0.538)	(0.863)
Dum2*Lib-OIS*VIX	0.000	-0.012	-0.007	-0.009
	(-0.813)	(0.001)***	(0.000)***	(0.000)***
Dum1*OIS-TBill*VIX	0.007	-0.042	0.013	-0.009
	(0.786)	(0.706)	(-0.801)	(0.856)
Dum2*OIS-TBill*VIX	-0.013	0.031	-0.006	0.012
	(0.000)***	(0.003)***	(0.1370)	(0.005)***
Adj. R-Squared	0.97	0.98	0.97	0.98
ADF Test on resid	(0.00)	(0.00)	(0.00)	(0.00)

Table 9: **Short-run regression.** Sample period 1/3/2005 - 4/1/2009. P-value in ( )

	AA Industrial	AA Financials	A Industrial	BBB Industrial
ECM1(-1)	-0.673	-	-0.231	-0.259
	(0.042)**	-	(0.044)**	(0.058)*
ECM2(-1)	-0.368	-0.131	-0.122	/
	(0.0003)***	(0.021)**	(0.091)**	/
Dum2*D(CDS)	-	2.243	-	0.260
	-	(0.017)**	-	(0.007)***
Dum2*D(CDS(-1))	0.727	0.282	0.254	0.176
	(0.013)**	(0.000)***	(0.001)***	(0.058)*
Dum2*D(CDS(-2))	-	0.395	-	-
	-	(0.000)***	-	-
Dum2*D(CDS(-3))	-	0.167	-	0.283
	-	(0.041)**	-	(0.005)***
Dum2*D(CDS(-4))	0.822	-	0.248	-
	(0.021)**	-	(0.007)***	-
Dum2*D(Bond spread(-1))	0.277	-0.152	0.235	-
	(0.009)**	(0.077)*	(0.018)**	-
Dum2*D(Bond spread(-3))	-	0.304	-	-
	-	(0.009)**	-	-
Dum2*D(Bond spread(-4))	-	-0.202	-	-
	-	(0.025)**	-	-
Dum2*D(Lib-OIS(-2))	-	0.655	-	-
	-	(0.009)***	-	-
Dum2*D(Lib-OIS(-3))	-	-	-	0.158
	-	-	-	(0.052)*
Dum2*D(Lib-OIS(-4))	-	-	-	0.161
	-	-	-	(0.037)**
Dum2*D(OIS-TBill)	-	-1.625	-	-0.375
	-	(0.000)***	-	(0.000)***
Dum2*D(OIS-TBill(-2))	-	-	-	-0.193
	-	-	-	(0.092)*
Dum2*D(OIS-TBill(-3))	-0.180	-	-	-
	(0.0133)**	-	-	-
Dum2*D(OIS-TBill(-4))	-	-0.561	-	-
	-	(0.025)**	-	-
Dum2*D(VIX)	-	-5.646	-	-
	-	(0.000)***	-	-
Dum2*D(VIX(-2))	-	3.288	-	-
	-	(0.000)***	-	-

	AA Industrial	AA Financials	A Industrial	BBB Industrial
Dum2*D(Bid-Ask)	2.917	-	-	-
	(0.041)**	-	-	-
Dum2*D(Bid-Ask(-1))	-	-	4.255	4.097
	-	-	(0.080)*	(0.055)*
Dum2*D(Bid-Ask(-2))	-	-	-4.674	4.977
	-	-	(0.032)**	(0.031)**
Dum2*D(Bid-Ask(-4))	-	14.394	-	-
	-	(0.000)***	-	-
Dum2*D(Lib-OIS*VIX)	-	0.013	-	-0.004
	-	(0.056)*	-	(0.038)**
Dum2*D(Lib-OIS(-1)*VIX(-2))	-	-0.022	-	-
	-	(0)***	-	-
Dum2*D(Lib-OIS(-1)*VIX(-3))	0.006	0.010	-	-
	(0.006)***	(0.018)**	-	-
Dum2*D(Lib-OIS(-1)*VIX(-4))	-	-	-	-0.004
	-	-	-	(0.005)***
Dum1*D(VIX(-1)*OIS-TBill)	-	0.066	-	0.011
	-	(0)***	-	(0.007)***
Dum2*D(VIX(-2)*OIS-TBill(-2))	-	-	-0.010	-
	-	-	(0.0337)**	-
Dum2*D(VIX(-4)*OIS-TBill(-4))	-	0.026	-	-
	-	(0.003)***	-	-
Adj. R-Squared	0.43	0.89	0.51	0.76

Figure 1: **CDS, bond I-spread and basis.** This figure shows the time series of the cross-sectional averages of the CDS, the bond I spreads (5y YTM - 5y swap rate) and the basis (CDS - I spread) by rating, separately for industrials and financials. The series are expressed in basis points. Sample period 1/3/2005 - 4/1/2009.

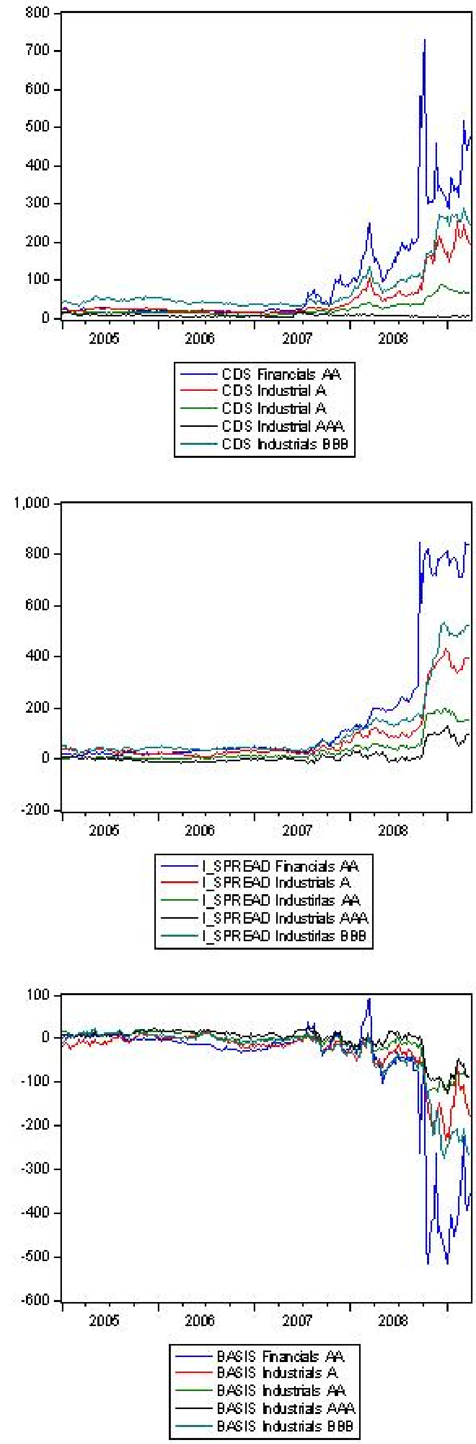

Figure 2: **Libor-OIS spread and OIS-TBill spread**. The Libor-OIS spread is the difference between the interest rate on interbank loans (Libor) with a maturity of 3 months and the Overnight Indexed Swap. The OIS-TBill spread is the difference between the Overnight Indexed Swap and short-term U.S. government debt (”T-bills”) with a maturity of 3 months.

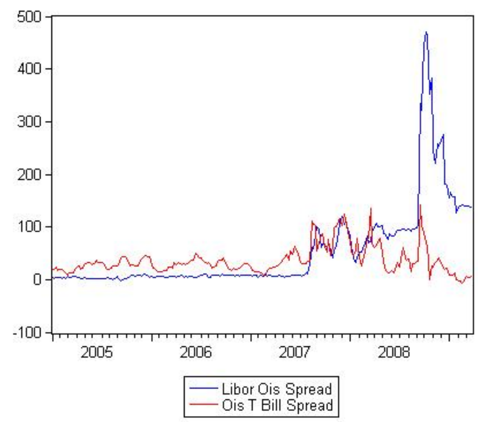

Figure 3: **Time series of the VIX**. The VIX is the Chicago Board Options Exchange Volatility Index. The volatility is implied from options written on the SP500 Stock Index.

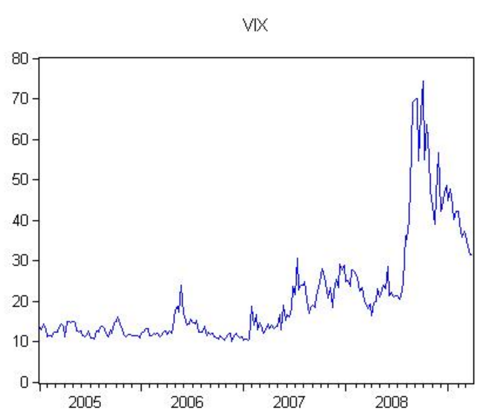

Figure 4: **Time series of the bid-ask spread on CDS contracts**. The series cross-sectional time-series for indutrials and financials and are expressed in basis points.

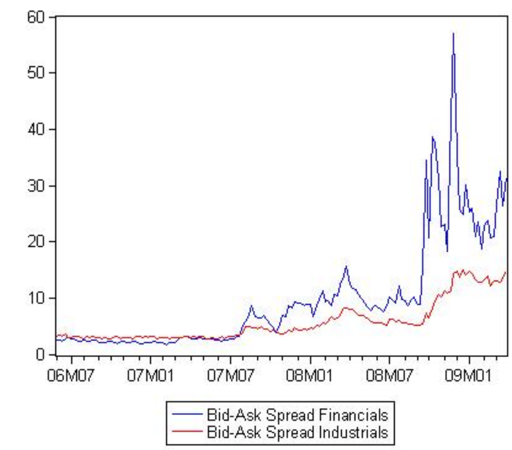

Figure 5: **Long run regressions estimation.**

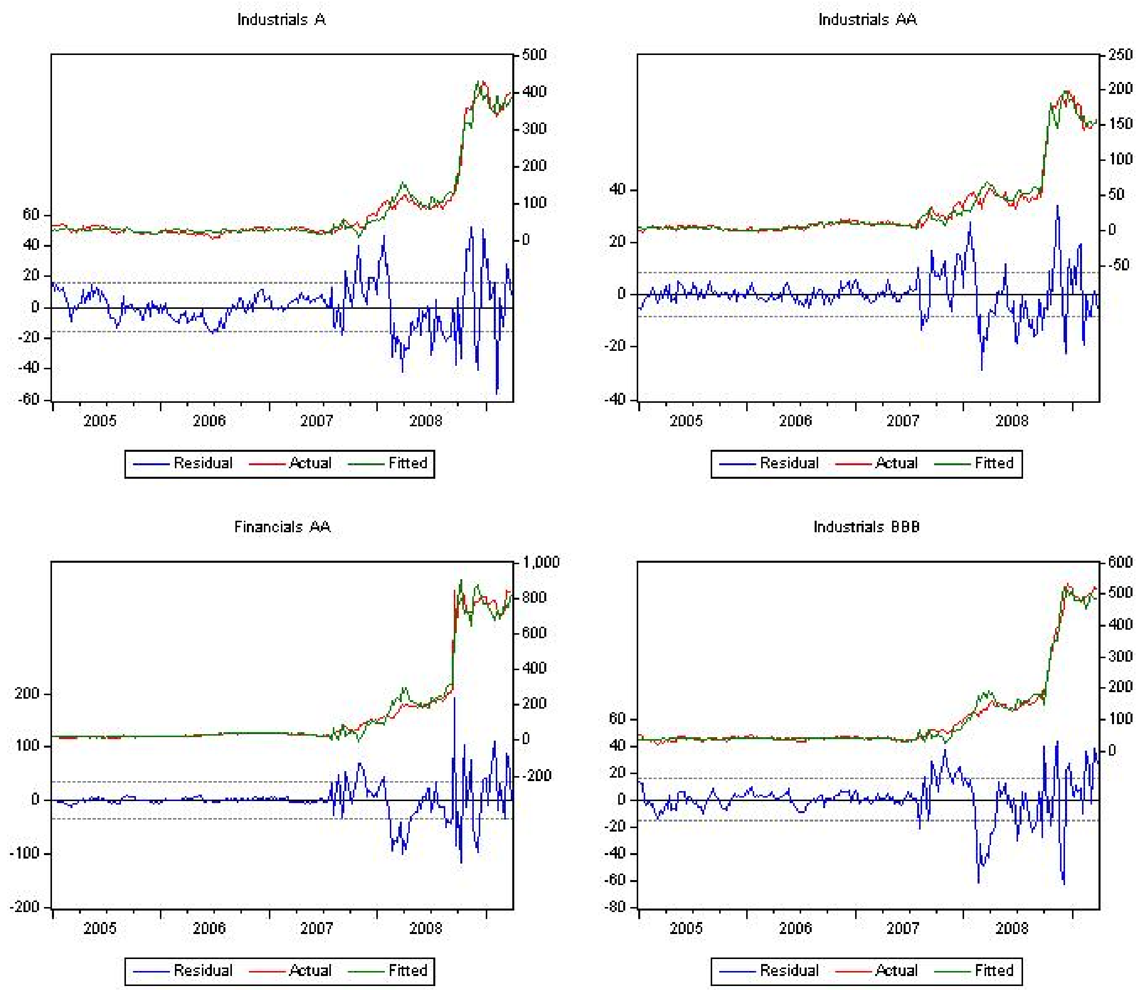

Figure 6: **Short run regressions estimation.**